Value activity monitoring

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To my parents,

José de Alencar and Elza Tiago

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Contents

Chapter 1: Introduction

The beginning is the most important part of the work.

Plato (427 BC – 347 BC)

1.1 Research Context

The research reported in this thesis is about *Service Monitoring*. More specifically, this is an attempt to improve how this operation is *designed* nowadays. Service Monitoring is essential for the management of the modern Enterprise. To have a notion of the purpose and relevance of this work, it is worth to elaborate on some of the major research challenges in Service Management in general, which is part of a comprehensive research agenda in the field of Service-Oriented Computing (SOC).

A Research Agenda in Service-Oriented Computing

According to Papazoglou et al. (2008), the research field of Service-Oriented Computing can be classified in four major sub-areas: (1) *Service Foundations*; (2) *Service Composition*; (3) *Service Management*; and (4) *Service Design* and *Development* (or *Service Engineering*). These areas are not mutually disjoint. Therefore, it is possible that a research instance falls into the intersection of two or more of these areas. This is the particular case of this research, which interleaves *Service Management* and *Service Design*. Moreover, each of these areas poses its own research challenges, which in turn call for specific research contributions.

Still according to the view of the referred authors, *Service Management* operations ought to be enriched with autonomic capabilities so as to cope with dynamic requirements for managing modern enterprises and their respective Service systems. This view is consonant with the vision of Autonomic Computing, proposed by Kephart and Chess (2003), which predicted an increasing need to reduce the participation of human actors in the management of Service systems. This would demand substantial effort to enrich Service systems with autonomic management capabilities, including: (1) *self-configuration*; (2) *self-adaptation*; (3) *self-healing* or *self-repair*; (4) *self-optimization*; and (5) *self-protection*. Each of these capabilities poses a plethora of new challenges for Service Management in general. Specifically in *Service Monitoring*, a research direction worth of attention comprises the possibility of enriching Service Monitoring systems with autonomic capabilities.

In *Service Design and Development*, many other challenges have been identified by the authors. The ones of relevance for this work comprise: (1) *Design Principles for Engineering Service Applications*; and (2) *Service Governance Techniques.* From the perspective of the first challenge*, Service Monitoring* can be envisioned as a *subject of design*, and therefore, may demand a proper Service Design approach. From the perspective of the second challenge, Service Monitoring can also be envisioned as a *subject of governance* (perhaps more than any other Enterprise management operation). In this work, these challenges are taken in combination, for as it is aimed here to treat Service Monitoring as a mechanism restricted by governance policies.

At this point, it is worth to provide a brief reality check on existing frameworks for Service Design, more specifically on *Business Service Design* alternatives.

Business Service Design

A *Business Service Design* defines how the business works in business terms. It constitutes a proper architectural viewpoint built on top of the business process layer. In software systems, an architectural *viewpoint* normally comprises a set of alternative architectural *views* (IEEE Std. 1471-2000). Hence, a Business Service Design *viewpoint* can be used as a basis to drive the configuration of Enterprises' business processes, business services, and successively, their realizing (physical) infrastructure (Papazoglou et al., 2008, p. 248). In this same viewpoint, specific views can be built to represent specific requirements critical to the businesses (e.g. economic, legal, organizational, communication and information disclosure requirements).

Some Business Service Design frameworks related to the scope of this work include: (1) the Resource-Event-Agent (REA) model (McCarthy, 1982); (2) the *e3value* framework (Gordijn, 2002); (3) the Business Model Ontology (BMO) (Osterwalder, 2004); (4) the Enterprise Ontology (Dietz, 2006); and (5) the Business Reference Ontology (Andersson et al., 2006). The first two models provide *specific views* on Business Service Design, whereas the three last ones, *viewpoints*. The Business Model Ontology and the Enterprise Ontology can be considered as *integrated viewpoints*, whereas the Business Reference Ontology, an *integrating* one. These models have different ontological foundations, which conflict, converge or overlap in many points. These models are briefly described as follows.

The *Resource-Event-Agent* (REA) framework is aimed to describe business collaborations from an *accounting view*. It does so by explaining business collaborations in terms of economic agents performing operations on shared resources. The result of these operations is typified in terms of business events, which in turn are assigned to their corresponding participant agents. The focus of REA, therefore, is to provide a parsimonious description of *who does what for whom and to whom,* in business collaborations. Hence, this framework can be classified as a *specific view* on Business Service Design.

The *e3value* framework focuses on describing business collaborations from a *profitability view*. In this framework, the notion of *value* is purely economic, realized by the concrete definition of *business profit*. The framework can be used to configure business collaborations in networked forms of organization, so-called *value constellations*. Value constellations comprise a set of actors exchanging objects of economic value in order to satisfy a consumer's need (Normann and Ramírez, 1993). Objects of economic value are transformed by value activities (i.e. produced, used and consumed), which correspond to *core business competences*. Actors, value activities and respective value objects communicate (in economic affairs) through *exchanges*. The guidelines to configure value constellations have been provided initially by Gordijn (2002). More recently, companion research has provided means to automate this process (Rázo-Zapata et al., 2012). In summary, this framework can be classified as a *specific view* on Business Service Design.

The *Business Model Ontology* (BMO) is aimed to describe the relationships that a single enterprise has with the macro-economic *context* in which it operates. It much resembles an elaboration of the Stakeholder Theory (Donaldson and Preston, 1995). This framework provides modeling constructs to specify management operations for the external (context) relationships. It does so by using four internal management views that are consonant with the Balance Scorecard (Kaplan and Norton, 1996; Parmenter, 2007). The focal phenomenon of analysis is on how these relationships are driven by customers' demands. The framework can be classified as an *integrated viewpoint* on Business Service Design.

Another comprehensive viewpoint on Business Service Design is the *Enterprise Ontology*, proposed by Dietz (2006). Grounding on a Language Action Perspective (LAP), this framework can be used to build the structure of an individual enterprise, according to its internal *actors, operations, transactions* and *communication constructs.* A brief description of the theory follows. An enterprise is composed of three basic constructs: *actors, production acts and coordination acts*. Actors engage on performing *production acts* via commitment of *competence*, and on *coordination acts*, via commitment of responsibility. A production operation relates an actor to the object to be produced. A coordination operation relates two actors by the object they communicate. Production and coordination acts are classified by their internal state: before being performed, they constitute *acts*, whereas, after successful execution, they constitute *facts*. These basic concepts and relationships define the first of four axioms of the theory: the *operational axiom*. The other ones comprise the *transactional axiom* (describing how Enterprise operations conform to a transactional pattern), the *composition axiom* (describing how Enterprise transactions can be composed) and the *distinction axiom* (describing how human actors perform coordination acts on the *ontological, infological* and *datalogical* levels). The ontology has also an *organizational theorem*, which defines the assignment of the realization of ontological, infological and datalogical acts to different subsystems within the Enterprise. The focal phenomenon of analysis is the *communication aspect* that connects actors to production and coordination acts. Although not explicitly stated, the framework is architecture viewpoint-agnostic, but provides extensive demonstration on how it can be used to model business collaborations on the *business* *process* layer. The framework can be classified as an *integrated viewpoint* on Business Service Design.

Finally, the *Business Reference Ontology*, proposed by Andersson et al. (2006), represents an effort to merge some of the existing ontological views and architectural viewpoints on Business Service Design toward an *integrated architectural viewpoint*. The ontology has explicit references to REA, *e3value* and the Business Model Ontology, previously described. However, it has no explicit reference to the Enterprise Ontology. It provides insight into some of the commonalities and differences between its encompassed (imported) ontology models. Regarding the commonalities, for instance, some have been identified between the *e3value* modeling constructs of *value object* and *value exchange* and the REA constructs of *resource* and *event*, respectively. However, the Business Reference Ontology lacks parsimony, and the representation of the mappings between the integrated ontologies remains on a rather semi-formal level. Research endeavours like this, though, have a high relevance for Business Service Design in general, by providing integration points of mapping between ontologies that cover the same viewpoint. However, from the best knowledge available in this research, there has been no progress on maintaining the Business Reference Ontology after its initial proposal. Such an endeavour could comprise, for instance, a work of continuous ontology alignment and merging with new ontologies for Business Service Design. In sum, the framework can be classified as an *integrating viewpoint* on Business Service Design.

In summary, Business Service Design frameworks can be combined in many ways so as to cover alternative business views on Service Design. The list of frameworks provided here is not exhaustive, and the complexity and dynamics of business collaborations is likely to impose new requirements for Business Service Design.

Value-Oriented Business Service Design

An issue of increasing research demand and interest is the *sustainability* of business collaborations. Sustainability analysis may demand an entire Business Service Design viewpoint. This would be very complex, though, as sustainability as a research field is cross-disciplinary by nature. However, one of the critical views on sustainability in general comprises the *economic profitability* view. Such a view is to a certain extent covered by the *e3value* framework, previously mentioned. Nonetheless, the economic sustainability of business collaborations depends not only on the analysis of their initial profitability, but also on how such collaborations are managed *ex post*, so as to mitigate risks on non-performance. A critical source of business risk comprises, for instance, that a value model expresses only *promises* (and not *assurances*) of value creation. In order to mitigate such an information asymmetry, monitoring information is needed. Such a need can be used as a potential source of market exploitation (e.g. a market of monitoring services). It is in this context that this research is situated.

1.2 Research Problem

The research addressed here is oriented by a Design Science perspective (Hevner et al., 2004). Therefore, it is driven by the need of solving a problem that has a practical relevance for business practitioners. Research problems can be translated into research questions of *theoretical* or *practical* relevance (Wieringa, 2010).

Hence, assuming that a value constellation is configured, and its initial profitability share is prospected, the umbrella research question considered here is:

How to manage a value constellation?

Such a comprehensive research question has been posed as a research agenda for expanding the modeling capabilities supported by the *e3value* framework (Gordijn et al., 2008). From this research proposal, other research questions have been derived, comprising different research directions, which have been developed along the course of this research (Silva and Weigand, 2011b; Silva and Weigand, 2012) and companion ones (Fatemi, Sinderen and Wieringa, 2010; Rázo-Zapata et al., 2012). These questions include:

1. *How to configure a value constellation automatically?*
2. *How to coordinate a value constellation and its corresponding business process models?*
3. ***How to monitor a value constellation?***
4. *How to adapt a value constellation?*
5. *How to coordinate the reconfiguration of a value constellation?*

The last three questions comprise the problems addressed by the research reported here. Its original research design has been published in (Silva and Weigand, 2009), including related sub-problems and corresponding research directions. As such problems are still comprehensive, the question on *adaptation* of value constellations has been postponed for future research. The monitoring question has been merged with the *coordination* question into a single question of service monitoring (coordination is considered here as a supporting mechanism for monitoring). Therefore, the research questions finally addressed here are:

1. *How to monitor value constellations?*
2. *How this type of monitoring could be coordinated?*

From a cross-disciplinary perspective, these problems are still relatively comprehensive. From an Information Systems perspective, these problems can be redefined in terms of more specific research questions. Such a redefinition is stated as follows:

1. What are the *requirements* for monitoring value constellations?
2. How to *represent* these requirements?

3. How *effective* is the *representation of these requirements*, from both practical and theoretical perspectives?
4. How *efficient* is it?
5. What *quality* attributes distinguishes it from rival approaches?

For the sake of tractability, research problems can be decomposed and classified according to respective imposed requirements (Wieringa, 2009). The questions raised above demand at least four types of requirements from a (solution) design artifact: (1) *knowledge requirements*; (2) *strategic requirements*; (3) *technological requirements*; and (4) *practical* requirements. *Knowledge requirements* are normally related to ontological questions to be answered by the design artifact, which in the particular case of this research is an *ontology*. *Strategic requirements* are referred here to as the perspective embedded in the ontology for solving the research problem, e.g. the internal/external viewpoints and views adopted. *Technological requirements* can be related to the fourth guideline of Design Science – that a design artifact should be assessed according to its *representational fidelity* and *implementability*. Finally, *practical requirements* pose questions on how useful the ontology could (potentially) be according to the perspective of practitioners.

According to this classification, the problems mentioned above have been decomposed even further, what produced the following classification of research questions:

1. **What are the *requirements* for monitoring value constellations?** (Knowledge/Strategy question)
   1.1. *Who* wants to monitor whom in a value constellation?
   1.2. *What* has to be monitored?
   1.3. *Why* to monitor?
   1.4. *How* to monitor?
2. **How to *represent* these requirements?** (Knowledge/Technology question)
   2.1. How is the candidate ontology *represented*?
   2.2. What are the *resources* used to build the ontology?
3. **How *effective* is the ontology?**
   3.1. How *effective* is the ontology *in theory*? (Knowledge question)
      3.1.1. What are the criteria of *theoretical effectiveness* used to evaluate the ontology?
      3.1.2. From which *theories* do these criteria come from?
      3.1.3. How to *evaluate* the ontology according to these criteria?
   3.2. How *effective* is the ontology *in practice*? (Practical question)
      3.2.1. What are the criteria of *practical effectiveness* used to evaluate the ontology?
      3.2.2. From which *practical scenarios* do these criteria come from?
      3.2.3. How to *evaluate* the ontology according to these criteria?
4. **How *efficient* is the ontology proposed?**
   4.1. How *efficient* is the ontology *in theory?* (Knowledge question)

4.1.1. What are the criteria of *theoretical efficiency* used to evaluate the ontology?
4.1.2. From which *theories* do these criteria come from?
4.1.3. How to *evaluate* the ontology according to these criteria?
4.2. How *efficient* is the ontology in practice? (Practical question)
4.2.1. What are the criteria of *practical efficiency criteria* to evaluate the ontology?
4.2.2. From which *practical scenarios* do these criteria come from?
4.2.3. How to *evaluate* the ontology according to these criteria?

5. **What *quality* attributes distinguishes this candidate ontology among its rival ontologies?** (Knowledge/Practical question)
5.1. What are the criteria of *quality* used to evaluate the ontology?
5.2. From which *standards* do these criteria come from?
5.3. How to *evaluate* the ontology according to these criteria?

This classification defines the problem space covered by this research. While **question 1** is related to requirements for monitoring value constellations, **questions 2-5** are related to the evaluation of the corresponding monitoring ontology.

1.3 Motivation

Research problems can be classified according to their respective motivating *goals*. A research goal, therefore, gives *relevance* to a certain research problem. A classification of sources of relevance for works in Design Science is provided by Wieringa (2010). According to this classification, practical research problems may fall into one or more of the following categories: (1) *achieving* some economic goal provided by stakeholders or a practical scenario; (2) *repairing* system failures; (3) *improving* system performance; (4) *flowing* down system goals; (5) *catching up* with large systems improvements; (6) *circumventing* predicted system performance *limits*; and (7) *meeting* predicted system *demand*. The research goal of this work is to *achieve* new design capabilities for Service Monitoring design. More specifically, it comprises the specification of an ontology that enables the construction of a structured Business domain viewpoint on Service Monitoring.

This claim has driven this research since the publication of a state-of-the-art in Service Monitoring (Silva and Weigand, 2011a), which is part of the results of this work. This study has revealed a potential *need* of frameworks for designing Service Monitoring requirements *from* a Business domain viewpoint. Currently, the design of Service Monitoring starts *from* the business process viewpoint. Often, business logic of Service Monitoring interleaves Business Process Monitoring mechanisms. Many Business-IT alignment problems may arise from such a practice. A critical one refers to that Business Process Monitoring does not provide proper guidance on what is relevant to be monitored from a business perspective.

Therefore, the motivation to build a structured Business domain viewpoint on Service Monitoring design is at least twofold. First, it is necessary to separate business requirements for Service Monitoring from its corresponding Business Process Monitoring capabilities. Secondly, it is also necessary to furnish business analysts with a framework for starting the specification of such requirements from a Business domain viewpoint, and not from the business process viewpoint.

The state-of-the-art is described in more detail in **Chapter 2**.

1.4 Claim

The central claim of this research is the proposition of a *candidate* ontology for designing a *value viewpoint* on Service Monitoring. The so-called Value Monitoring Ontology (VMO) provides means of *knowledge, technology, practice* and *strategy* for solving the respective research problem. How well these capabilities meet the problem requirements justifies the *utility* of the ontology itself. The definition of utility, in turn, normally depends on the type of design artifact it qualifies, and must be explicitly defined and justified (Venable, 2006).The utility functions considered here, therefore, are specific to the area of Ontology evaluation (Vrandesic, 2010).

There are three types of claims associated with the ontology proposed here: (1) *effectiveness claims*; (2) *efficiency claims;* and (3) *quality claims*. Each of these claims is validated through evaluation criteria from *theory* and *practice*. They are organized as follows, with the guidance of the research problem decomposition introduced in **Section 1.2**:

1. **Effectiveness Claims**
   1.1. **How *effective* is the ontology *in theory*?**
      1.1.1. What are the criteria of *theoretical effectiveness* used to evaluate the ontology?

      The ontology must represent one important *theoretical proposition* related to Service Monitoring, which comes from fundamental literature in Economics. It constitutes the proposition of *monitoring information as a purchasable commodity*.

      1.1.2. From which *theory* does this criterion come from?

      The theoretical proposition of *monitoring information as a purchasable commodity* is one of the fundamental principles of Agency Theory (Eisenhardt, 1989, p. 59; Shapiro, 2005, p. 280). It relates to Service Monitoring because it constraints how any private monitoring information can be obtained in a business collaboration. It states that monitoring information has a cost and must be provided *only* by competent monitoring parties.

      It is important to remark that the cost of monitoring, as addressed here, refers to the economic perspective. The cost of using the ontology as a modeling construct is part of the assessment of ontology quality. Nonetheless, this type of evaluation is not covered by this research.

1.1.3. How to *evaluate* the ontology according to this criterion?

This can be done in two steps. First, the ontology must be formalized, thereby following the sixth guideline of Design Science – on *design as a search process* (Hevner et al., 2004, p. 87). Second, it is necessary to assess if the formalization complies with the corresponding theoretical proposition for Service Monitoring. This requires an Ontology evaluation approach referred to as *standard-based ontology evaluation* (Brank, Grobelnik and Mladenic, 2005). Here, the “standard” corresponds to the original proposition provided by the economic theory. A *literature review*, as a research method, can support this specific type of evaluation by providing the original theories that serve as standards.

1.2. **How *effective* is the ontology in *practice*?**

1.2.1. What are the criteria of *practical effectiveness* of the ontology?

The utility of *cost-effectiveness* is critical in Service Monitoring. Technology alternatives such as Business Activity Monitoring (BAM) and Process Mining are typically *cost-oriented*. However, the assessment of *cost-effectiveness* of an ontology may assume at least two connotations. First, it may refer to the cost of using the ontology as an Enterprise knowledge asset. Second, it can also refer to the cost-effectiveness of the model represented by the ontology – which in this case is an organizational model. The latter connotation is the particular case of this research. Therefore, in order to be considered effective in practice, the ontology must support the *demonstration* of cost-effectiveness of the monitoring model (strategy) produced by the ontology.

1.2.2. From which *practical scenarios* does this criterion come from?

Real-world case studies have been used as a source of conditions of practice considered in this research. The cases come from critical business markets, including: (1) a case in Renewable Energy (Silva and Weigand, 2011b); (2) a case in Intellectual Property Rights in the music sector (Silva and Weigand, 2012); and (3) a case in Customs Control (Bukhsh and Weigand, 2011). The requirement of *monitoring cost effectiveness* has been referred to as critical in all of these cases.

1.2.3. How to *evaluate* the ontology according to this criterion?

This criterion can be evaluated through *demonstration* on the use of the ontology in practical scenarios. This type of evaluation is referred to as *application-based ontology evaluation* (Brank, Grobelnik and Mladenic, 2005; Sure, Staab and Studer, 2009). Such evaluation can be supported by *case study research*. Case studies are of critical relevance on evaluating practical research, for as they can provide: (1) perspective taking between researchers and practitioners (Mohrman, Gibson and Mohrman); (2) participation of organizations in defining problem areas of relevance for the industry (Darke et al., 1998); and (3) theoretical confirmation through model replication (Eisenhardt and Graebner, 2007).

2. Efficiency Claims

2.1. **How *efficient* is the ontology in *theory?***

2.1.1. What are the criteria of *theoretical efficiency* of the ontology?

The utility of *efficiency* considered here elaborates on the utility of *effectiveness* for Service Monitoring, previously defined. Efficiency criteria must allow an analyst to distinguish among alternative effective Service Monitoring designs. The criteria adopted here comprise theoretical propositions of: (1) *monitoring information as a value proposition*; and (2) *monitoring information as a value-in-use*. In order to be efficient from a theoretical point-of-view, the ontology must represent these aspects accurately.

2.1.2. From which *theories* do these criteria come from?

These criteria come from the literature in Service Science, specifically from fundamental premises in Service-Dominant Logic. Originally, these criteria constitute premises for characterizing services in general. The criteria considered here correspond to the seventh and tenth foundational premises of theory, respectively (Vargo and Akaka, p. 35). Here, these criteria are adopted to distinguish among alternative (and *effective*) Service Monitoring designs. In order to be effective, therefore, the ontology must somewhat represent these criteria.

2.1.3. How to *evaluate* the ontology according to these criteria?

Similar to the evaluation of the *effectiveness claim in theory*, the evaluation of the *efficiency claim,* as addressed here, can be performed through *standard-based ontology evaluation*, and supported by *literature review* (vide **question 1.1.3** above).

2.2. **How *efficient* is the ontology in practice?**

2.2.1. What are the criteria of *practical efficiency* of the ontology?

The utility of *monitoring reliability* is critical in Service Monitoring. Monitoring reliability is a practical view on *monitoring efficiency*. For instance, a monitoring service may be reliable or not. Reliability distinction is critical in Service Monitoring, as unreliable monitoring services create recursive (nested) monitoring problems. Hence, in order to be considered as efficient in practice, the ontology must support the *demonstration* of the utility of *monitoring reliability*.

2.2.2. From which *practical scenarios* does this criterion come from?

This criterion has been identified as of relevance in the business cases used in this research: the Renewable Energy case (Silva and Weigand, 2011b), the Intellectual Property case (Silva and Weigand, 2012) and the Customs Control case (Bukhsh and Weigand, 2011). These cases have indicated a business need for analysis of reliability of monitoring services dealing with indirect disclosure of private monitoring information in business collaborations (Cormier et al., 2010).

2.2.3. How to *evaluate* the ontology according to this criterion?

Similar to the evaluation of the *effectiveness claim in practice*, the evaluation of the *efficiency claim*, as addressed here, can be performed through *application-based ontology evaluation*, and supported by *case study research* (vide **question 1.2.3** above).

3. Quality Claims

3.1. **What quality attributes distinguishes the ontology among rival ontologies?**

3.1.1. What are the criteria of *quality* used to evaluate ontologies?

Current standards for ontology quality evaluation comprise more theoretical proposals than consolidated standards. The quality evaluation criteria considered as relevant here include: (1) *ontology correctness*, i.e. ontology syntax compliance with a formal ontology representation language (Guarino, 1998); (2) *ontology consistency*, i.e. the semantics of the ontology must be represented accurately so as to enable formal reasoning; and (3) *ontology completeness*, which refers to either how the ontology answers a set of knowledge competence questions or to the completeness of the consistency checking of the ontology (through automated reasoning). Ontology completeness, as evaluated here, refers to the completeness of the consistency checking, that is, whether it is possible for an automatic reasoner to find instances that fill all the constructs specified in the ontology. Nevertheless, these are only propositions of a candidate ontology. From a more practical side, these theoretical criteria can be somehow translated into actual *ontology applicability*.

3.1.2. From which *theories* do these criteria come from?

There seems to be some literature agreement on the importance of the above mentioned requirements for the quality of candidate ontologies (Brank, Grobelnik and Mladenic, 2005; Noy, Guha and Musen, 2005; Vrandesic, 2010). Such attributes, however, may qualify an ontology (e.g. as appropriate or adequate) only from a theoretical point of view. They represent only a *proposition* of ontology quality. In a practical context, an important attribute of ontology quality comprises its *applicability* in practical scenarios (Brank, Grobelnik and Mladenic, 2005). Ontology applicability is also indirectly referred to as *ontology usage* (Noy, Guha and Musen, 2005).

3.1.3. How to *evaluate* the ontology according to these criteria?

Currently, there is plenty of technology support for assessing ontology *correctness, consistency* and *completeness*. These include tools for specification, classification, consistency check and automated reasoning. This type of evaluation is referred to as *technology-based evaluation* of ontologies (Sure, Staab and Studer, 2009).

Regarding *ontology applicability*, this can be related to the number of successful applications of the ontology in practical scenarios (Noy, Guha and Musen). This can be part of the evaluation of ontology quality in general, which is subject of a *conformity check*. Conformity check here refers to compliance with some external benchmark or standard and requires human judgment. Some of these frameworks demand high Ontology Engineering expertise from the user, such as OntoClean (Guarino and Welty, 2002). Other ones, such as ONTOMETRIC (Lozano-Tello and Gómez-Pérez, 2004), require less Ontology expertise from the user. This type of ontology evaluation is also referred to as *user-based evaluation* (Brank, Grobelnik and Mladenic, 2005), which has been found appropriate to be used in this research, for the sake of practical relevance.

The framework developed to validate the claim of this research, as described above in detail, is summarized in **Table 1-1**.

Table 1-1: Ontology Claim Validation Framework

	Theoretical Evaluation Criteria	**Practical Evaluation Criteria**	**Ontology Evaluation Approach**	**Supporting Research Method**
Effectiveness Claim	**Representation** of Service Monitoring information as a *purchasable commodity*	**Demonstration** of Service Monitoring *cost-effectiveness*	Application-based and standard-based evaluation	Case study and literature review
Efficiency Claim	**Representation** of Service Monitoring information as a *value proposition*	**Demonstration** of Service Monitoring *reliability*	Application-based and standard-based evaluation	Case study and literature review
	Representation of Service Monitoring information as a *value-in-use*			
Quality Claim	**Proposition** *of ontology correctness, consistence and completeness*	**Demonstration** of ontology *applicability*	Technology-based and user-based evaluation	Prototype and conformity check

1.5 Methodology

The research design of this work is summarized as follows. The work is driven by a problem of Service Monitoring design. The problem has been decomposed along *knowledge, practice, strategy* and *technology* requirements. Its relevance consists on *achieving* the construction of a value viewpoint in Service Monitoring design. A candidate *ontology* is proposed to solve the problem. It *offers* capabilities demanded by the problem. The ontology has a proposition of *utility*, defined in terms of *effectiveness, efficiency* and *quality* claims. This utility justifies the *achievement claim* of the research. The verification of these utility claims requires specific *ontology evaluation types* and *ontology evaluation criteria*. Four types of ontology evaluation have been identified in the literature: *standard-based, technology-based, application-based* and *user-based*. The *effectiveness claim* has been evaluated through a combination of application-based and standard-based evaluation. This combination has also been applied for the evaluation of the *efficiency claim* of the ontology. The *quality claim* has been evaluated through a combination of technology-based and user-based evaluation. The ontology evaluation *criteria* have been extracted from theory (through *literature review*), and from practice (through *case studies*).

Ontology evaluation types can be supported by different research methods. The research methods employed in this research comprised: (1) continuous *literature review*; (2) multiple *case studies*; (3) a *prototype*; and (4) a *conformity-check*. These methods supported the standard-based, application-based, technology-based and user-based ontology evaluation, respectively. The research design has been aligned with an Ontology Engineering methodology. Candidate methodologies considered for adoption comprised the ones proposed by Gómez-Pérez (1996), Uschold et al. (1998), Schreiber et al. (1999), and Sure, Staab and Studer (2009). The last one has been chosen due to its level of maturity and flexibility – some of its steps can be performed in cycles, according to the purpose of the ontology. The application of the methodology is summarized as follows. First, a semi-formal model of the ontology has been derived from theory. Second, the model has been applied in three case studies. Case studies and literature review have been used in cycles, for refining the ontology. The resulting ontology has been formalized as a *prototype*. Finally, a user-based evaluation has been applied for comparing the proposed ontology with its rival theory.

Multiple case studies can be used for research hypothesis generation and confirmation (Benbasat, Goldstein and Mead, 1987). In this research, they have been used for both purposes. Finally, the research design cycle ends with the claim verification. The *achievement claim* is justified by the utility of the ontology. Utility here has been assessed through specific ontology evaluation criteria, mentioned before. The research design is depicted in **Figure 1-1**.

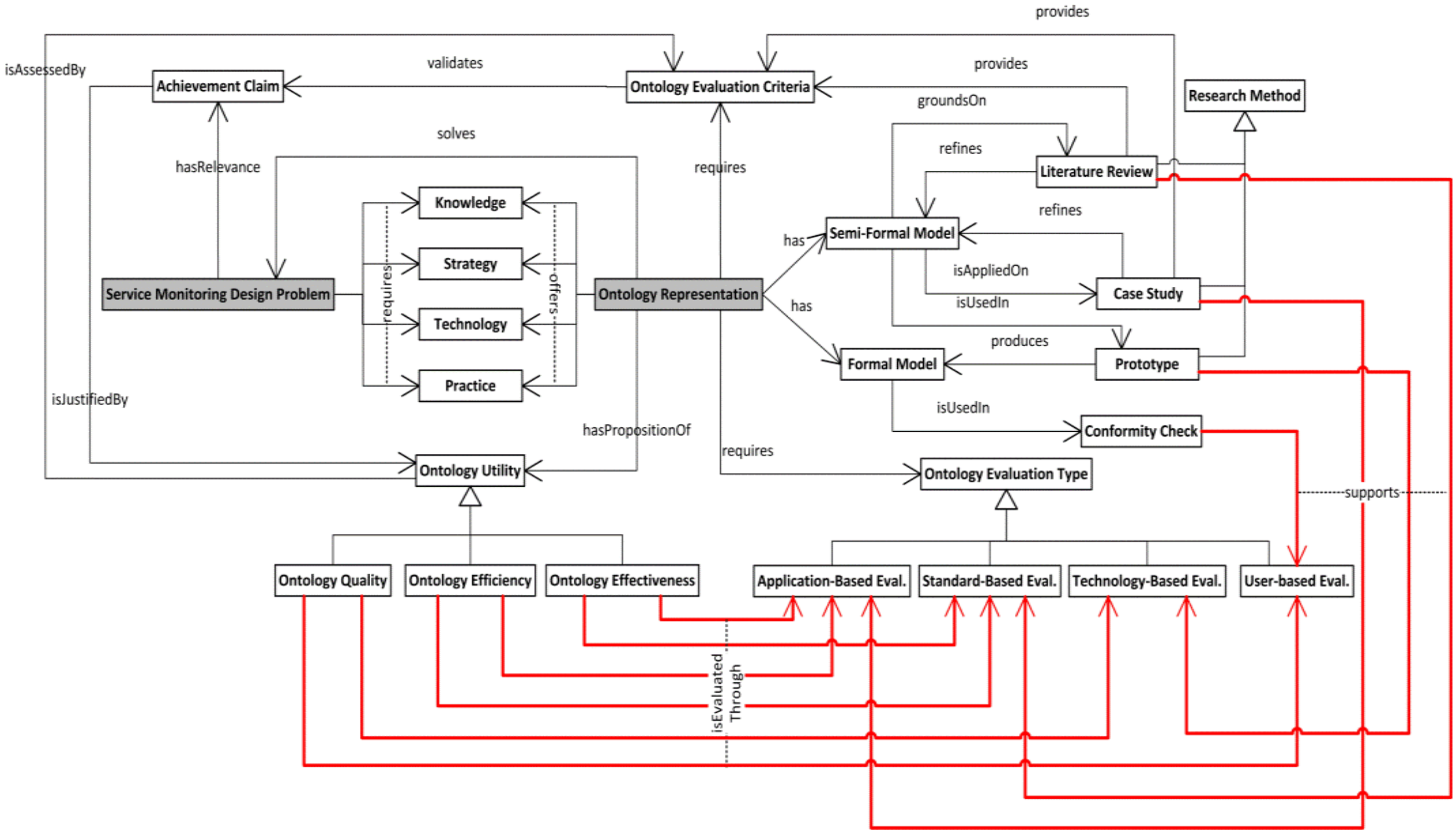

Figure 1-1: Research Design Model

1.6 Contributions

The contributions of this work are organized along three levels: (1) as a punctual contribution on *Value Modeling*; (2) as a more general contribution on *Business Service Design and Engineering*; and (3) as a contribution on *Service-Oriented Computing*. These levels are covered by a research agenda in Service-Oriented Computing (Papazoglou et al., 2008). The contributions are justified as follows.

Firstly, this research brings a contribution to the relatively recent research field of *value modeling*. More specifically, this is a contribution to the *e3value* framework. The framework initially published in Gordijn (2002) provides design capabilities for the configuration of value constellations. However, as previously discussed, *monitoring* is also essential for the sustainability of value constellations. Following this direction, a research proposal has been published by Gordijn et al. (2008), pointing to the need and vision of *self-managed* value constellations. Since then, a self-managed value constellation has been envisioned as an autonomic system, furnished with self-management capabilities, including *self-configuration*, *self-coordination*, *self-monitoring* and *self-governing* capabilities. From a Software Engineering perspective, a first step toward the pavement of such a vision comprises the construction of design artifacts that could support the specification of the respective autonomic capabilities. The Value Monitoring Ontology (VMO) extends the *e3value* framework with means for designing value constellations enriched with *self-monitoring* and *self-governing* capabilities.

It is worth to remark that *self-monitoring* and *self-governance*, as proposed here, have a meaning that is slightly different from the one proposed by the Autonomic Computing vision (Kephart and Chess, 2003). The meaning of self-monitoring here is not to reduce human participation on the process of configuring monitoring strategies for a value constellation. Actually, human judgment in this case is considered as essential. Instead, what is brought to light here is the possibility of monitoring a value constellation through a reconfiguration of its (internal) organizational roles. In other words, a value constellation can be monitored *per se,* without necessarily having to use external monitoring resources (e.g. external monitoring actors, value activities and value objects).

Secondly, from a more general perspective, this work brings a contribution to *Business Service Design and Engineering*. VMO aims to furnish business analysts with modeling constructs to build a value viewpoint on Service Monitoring. In practical terms, it brings the possibility to include this group of stakeholders effectively in the process of defining Service Monitoring requirements for business collaborations. As explained in detail before, Service Monitoring, as performed nowadays, is essentially business process and IT Services-oriented. Business Activity Monitoring (BAM), Process Monitoring and Complex Event Processing (CEP) already provide plenty of support for realizing these viewpoints. However, there is a need to fill the absence of structured viewpoints in Service Monitoring on the

Business domain (strategy) level. VMO is proposed to cope with this need. The views of VMO include organizational, economic, information and communication aspects of Service Monitoring on the Business domain viewpoint. These views comprise the so-called *Value Activity Monitoring* viewpoint.

Last, from an even more general perspective, this work also brings a contribution to the research agenda in *Service-Oriented Computing* published by Papazoglou et al. (2008). More precisely, this is a response to the call for contributions in *Service Design and Development* (Service-Oriented Engineering), in the intersection between Service Monitoring and Service Governance. From what has been apprehended from this specific research call, there is a need for defining governance boundaries on the design of Service Monitoring requirements of businesses. The boundaries that govern the use and distribution of monitoring information must be derived from the Business domain viewpoint toward progressive realization on the supporting business process and IT services viewpoints. From the best knowledge available in this research, governance rules in Service Monitoring are still primarily defined on the business process level. The description of such governance rules are rather technical, expressed through different business process jargons. Therefore, there is a need for separation of concerns on the definition of governance rules for Service Monitoring. VMO is also aimed to cover this need, incorporating basic governance modeling constructs on the Value Activity Monitoring viewpoint.

These comprise some of the immediate contributions of this work, which are demonstrated along the development of this thesis. More specific contributions are reported in **Chapter 7**, along with calls for research collaboration and realization with companion research initiatives.

1.7 Assumptions

The main assumptions on the contribution of this work comprise basically a delimitation of its conceptual *views* and corresponding (architectural) *viewpoints.* These constraints are elaborated as follows.

Viewpoint Assumption 1 – *On Service Monitoring as a value-driven Enterprise operation*: VMO is aimed to support the design of Service Monitoring requirements for *value constellations*. It can be used to treat Service Monitoring ultimately as a Business domain problem, which demands strategy in a collaborative context, to be specified by business analysts. Therefore, this assumption restricts the scope of this research contribution to the Business domain viewpoint.

Viewpoint Assumption 2 – *On the ex-ante configuration of value constellations*: VMO applies to the context of a *pre-configured* core business value constellation. That is, the logic behind this ontology is not to reinvent the definition of a value constellation, but to extend it with the inclusion of modeling constructs for Service Monitoring. It therefore poses the notion of a *monitoring value constellation*, which roughly put brings about the extension of an ordinary value constellation with self-monitoring capabilities. The configuration of value constellations has been already extensively addressed in (Gordijn, 2002) and enhanced through automation processes provided by (Rázo-Zapata et al., 2012).

Viewpoint Assumption 3 – *On the ex-post mapping of the value viewpoint on Service Monitoring to a business process viewpoint on Service Monitoring*: the claim of VMO is to fill the absence of business modeling viewpoints on Service Monitoring. It does not comprehend, though, a successive mapping of the developed value viewpoint on Service Monitoring to its corresponding business process viewpoint. In order to achieve this purpose, it is recommended here to use VMO in conjunction with mechanisms for mapping a value viewpoint to a process coordination viewpoint, which have been developed by companion research (Fatemi, Sinderen and Wieringa, 2010).

View Assumption 1 – *On the Agency orientation of the Service Monitoring views*: VMO incorporates Agency Theory propositions (Eisenhardt, 1989) as transversal to all of its conceptual views. Therefore, this organizational theory is the common ground for discussion on the aspects of monitoring *organization*, monitoring *rationale*, monitoring *mechanism* and monitoring *subject* that compose the ontology. In practical terms, the interpretation of the constructs of VMO assumes familiarity with the original propositions of the Agency Theory.

View Assumption 2 – *On the economic perspective as dominant in Service Monitoring*: VMO covers economic, organizational, information and communication action aspects of Service Monitoring. However, the economic aspect is dominant on the business logic described in the ontology. This is conformant with the *e3value* economic perspective on business Service configuration. It also means that the claims of cost-effectiveness and cost-efficiency of the ontology are grounded more on principles of Economics than properly on principles of knowledge representation.

These assumptions restrict the research contribution given through VMO to the Business domain viewpoint, more specifically on the economic and organizational aspects of Service Monitoring in value constellations.

1.8 Document Organization

In addition to this introduction, this thesis is organized in six more chapters, the description of which is summarized as follows.

Chapter 2 – Theoretical Background: this chapter provides information about the context that encompasses the Service Monitoring problem addressed in this thesis. It does so in four stages. First, it starts by reducing the problem of monitoring an entire value constellation to the one of monitoring its constituent transactions. Such a scenario brings about two actors exchanging objects of economic value through the performance of services owned by the actors. Second, it introduces the reader to the problem of information asymmetry, commonly referred in the literature in

Economics. The explanation of the problem is based on the Agency Theory, and a prelude of its solution is given in terms of conceptual views on Service Monitoring. Third, these views are aggregated in a prelude of a Business domain viewpoint on Service Monitoring. Such a prelude aims to furnish the reader with the basic Service Monitoring concepts that will be further explored in **Chapter 3** (which brings the main contribution of this thesis). Last, a state-of-the-art in Service Monitoring is provided. The purpose of which is to explore potential gaps and corresponding research opportunities in Service Monitoring. A business case in Intellectual Property Rights (IPR) is used as a leading example through the development of this chapter.

Chapter 3 – Value Monitoring Ontology: this chapter brings the main contribution of this work, the Value Monitoring Ontology (VMO). The construction of the artifact follows an Ontology Engineering methodology and is elaborated along five steps. First, the competence questions to be answered by the ontology are described in terms of corresponding requirements. Second, a formal representation of the ontology is provided. VMO is described in Web Ontology Language (OWL2). In order to allow readability of the constructs from both practitioners and engineers, the formal specification is presented in conjunction with semi-formal constructs. This is done by presenting the ontology in OWL2 abstract syntax, along with a set of rules described in RuleML abstract syntax. The full OWL2 specification is provided in the **Appendix** of this thesis. Third, an evaluation of ontology quality is provided, summarizing the results of the automated ontology classification and consistency checking. Fourth, a discussion on the theoretical effectiveness and efficiency of the ontology is proposed. Finally, some notes on the evolution of the ontology are provided.

Chapter 4 – A Case in Customs Control: this chapter reports on the application of VMO on a business case from the Customs Control sector. The original documentation of this case has been cordially provided by participants of the Extended Single Window (ESW) project, which includes Tilburg University and Dutch Customs Control authorities. The problem brought by this case comprised to monitor a value constellation of hidden (suspicious) value activities by using the least possible amount of internal resources. It is demonstrated in this chapter how VMO can be used so as to produce an alternative monitoring organization for the underlying value constellation.

Chapter 5: A Case in Renewable Energy: this chapter elaborates on a case study from the Renewable Energy sector. The case has been provided by practitioners involved in the VALUE-IT project, which has funded the development of this research. For a better understanding about the background of this case, the reader is reported to previous reports provided in (Werven and Scheepers, 2005; Kamphuis et al., 2007; Warmer et al., 2007; Kok, 2009). As addressed here, this case brings about a value constellation of energy suppliers and smart metering companies with problems of monitoring information disclosure and valuation. A monitoring value constellation is proposed as a business strategy to address these problems. This case closes the application-focused ontology evaluation of this research.

Chapter 6 – Related Work: this chapter brings about a comparison between the Value Monitoring Ontology and the *e3control* ontology, which is the main rival approach related to this work. These two ontologies are confronted through interpretive research, by applying a user-based ontology evaluation method. The rivalry addressed here is driven by a motivation of mutual improvement of these ontologies. Both models are part of the vision of leveraging the *e3value* framework to a more comprehensive Business Service Design viewpoint.

Chapter 7 – Conclusion and Future Work: in this chapter, the main contributions of this work are summarized, and a research agenda for extending the *Value Activity Monitoring* viewpoint is proposed. The research contributions are organized according to the research design proposed in the current chapter, accounting for the validation of the utility claims of the Value Monitoring Ontology. Specific calls for research collaboration are addressed to research communities working in the areas of Enterprise Engineering, Ontology Engineering and Value Modeling.

Chapter 2: Theoretical Background

So, let us not be blind to our differences – but let us also direct attention to our common interests and to the means by which those differences can be resolved.

John F. Kennedy (1917 – 1963)

2.1 Introduction

A *value constellation* has been originally referred to as a system of economic actors exchanging objects of economic value in order to satisfy a consumer's need (Normann and Ramírez, 1993). Such a definition somewhat explains why and how modern enterprises collaborate nowadays. Moreover, it has also provided the grounding concept behind frameworks and languages for the specification of strategies for business collaboration. This has been the special case of the *e3value* framework, which provides ontology and framework for the modeling and analysis of value constellations.

Since originally proposed in (Gordijn, 2002), the *e3valu*e framework has been used, in the most practical sense, as a communication tool, aimed to support decision-making among participants engaged in business collaboration in value constellations. This communication is supported by four modeling resources: (1) a basic ontology of economic production and exchange; (2) a corresponding graphical notation; (3) a mechanism for calculating profitability sheets; and (4) and a set of practical modeling guidelines. Altogether, these resources support the analysis of profitability share among the participants of a value constellation. This type of analysis is important to understand how a value constellation could explore a certain market opportunity.

Definitely, *profitability* is a critical indicator to be considered during the feasibility analysis of a value constellation. Actually, this is the main driving force motivating enterprises to engage in collaboration in this type of system. However, regarding the *sustainability* of a value constellation, some issues must be drawn thus far. First, that profitability as a value is only part of sustainability. There are other values maintaining enterprises together in collaboration. These values are normally subjective and result of long-term relationships, e.g. reliability and loyalty. Second, even if profitability is assumed to be equivalent to sustainability, it is still subject to internal and external assumptions constraining the dynamics of a complex system such as a value constellation. An assumption perhaps worth of critical attention is that a value model expresses only *promises* of value creation, but not *assurances* of such.

Probably by taking such a risk into consideration, a vision has been proposed to enhance the *e3value* framework with Service Management modeling capabilities (Gordijn et al., 2008). The goal of this research proposal has been the one of leveraging the *e3value* framework to the status of a consolidated management viewpoint in Service Design. Such an idea has been progressively paved by companion research. Some examples include the contributions given by Kartseva (2008), Hulstijn and Gordijn (2010), Pijpers et al. (2012) and Rázo-Zapata et al. (2012). These contributions can be classified according to the modeling purpose in focus. The latter two contributions are focused on the *configurational* phenomena *per se* that form a value constellation, whereas the former ones, on *controlling* mechanisms applicable on preventing opportunistic behavior in value constellations.

Following the business *control* and *management* line, the same research vision proposed in (Gordijn et al., 2008) has yet posed the *e3value* framework as a modeling tool for *strategic* business design. More specifically, the vision establishes the *e3value* modeling approach as a driver for configuring business processes and IT services supporting business collaborations. The vision poses critical research questions and challenges in Service Design and Management, among which is the one addressed by this research, which inquires *how a value constellation could be monitored.*

As originally stated in (Gordijn et al., 2008), the problem of how value constellations could be monitored has been relegated to a *purely technological* problem. According to this vision, the problem in question has been proposed as dependent solely on the configuration and use of supporting technologies for monitoring business processes and IT services. However, supporting technology for Service Monitoring is not anymore the most critical of the monitoring issues that could threat the sustainability of value constellations. Perhaps more than any other Service Management operation, Service Monitoring ought to be treated, at a first glance, as a *strategic* problem. Such a vision turnover has been one of the initial outcomes of this research, and has been published in (Silva and Weigand, 2011a).

Nevertheless, even if treated solely as strategic, the problem of monitoring a value constellation is still comprehensive. This can be attained mainly to the complexity of the *organizational structure* of a value constellation. Actually, the definition of a value constellation could be extended so as to include other factors that compose a complex business ecosystem, such as disclosure and organization of the monitoring information, which are also important factors to be considered in a monitoring system. Besides, these aspects may overlap or even conflict in practical situations. These factors become crucial when monitoring is treated in the context of networked business collaborations (Grundmann, 2002; Cormier et al. 2010). Therefore, for the sake of tractability, the problem of monitoring value constellations demands progressive simplification.

Simplification here is performed in two levels. First, from an *ontological perspective*, it is worth to identify which aspects or views are of critical relevance in monitoring networked business collaborations, which is the particular case of value constellations. Second, from an *architectural perspective*, it may become necessary to organize these views in an integrated architectural viewpoint, which will give a glimpse on how those views could be somewhat realized by the architecture of the modern Enterprise. Such a separation of concerns can provide a more precise notion of the Service Monitoring problem treated in this thesis.

This chapter is organized as follows. In **Section 2.2**, the problem of monitoring a value constellation is framed according to the micro-economic context of a bilateral contract scenario involving a service provider and a service consumer. In **Section 2.3**, the monitoring problem of information asymmetry is developed through theoretical guidance provided by the Agency Theory. The problem is decomposed along its ontological views, thereby constituting the grounding basis for defining the monitoring views relevant to the problem in discourse. In **Section 2.4**, the ontological views are organized as a prelude of a Business domain viewpoint in Service Monitoring. The structure of the viewpoint is consonant with the vision for Autonomic Computing. In **Section 2.5**, a state-of-the-art in Service Monitoring is provided, according to a classification of relevant views and viewpoints in Service Monitoring. Finally, **Section 2.6** closes this chapter highlighting the need of design artifacts aimed to be used to model Service Monitoring requirements *from* and *to* the Business domain viewpoint.

2.2 Service Monitoring Scenario

The rich organizational structure of a value constellation makes its monitoring particularly intriguing. The original idea of a value constellation, as proposed by Normann and Ramírez (1993) classifies this system as typically *consumer-oriented*. That is, although the business-to-business collaborations that compose this system may assume diverse forms of decentralized organization (which is specially the case of a liberalized market), the *nourishment* of this system is primarily dependent on the *consumer's market segment*. In practical terms, there is no value constellation without a potentially profitable market segment to be exploited. The identification of such a critical element actually comprises the beginning of a value constellation (Gordijn, 2002). The consumer's market segment can be considered, ultimately, as one of the critical *sustainability* points of a value constellation, if not the most. Hence, it sounds reasonable to start the analysis of monitoring scenarios in a value constellation from a service consumer's perspective.

The leading scenario used to conduct the discussion here brings about a case on the management of Intellectual Property Rights (IPRs) in the Digital Music industry. This is a real-world business case, which has been extensively explored as a research context by companion research, including (Gordijn, 2002), (Kartseva, 2008) and (Fatemi, Sinderen and Wieringa, 2010). In these works, the case has been used to explore problem hypotheses and solutions for *configuring*, *controlling* and *coordinating* value constellations, respectively. Here, the focus of analysis is on possible *monitoring* scenarios. The identity of the original actors involved has been kept anonymous so as to preserve agreements of non-disclosure of private verifiable information. The case is illustrated in **Figure 2-1,** through the use of the *e3value* notation.

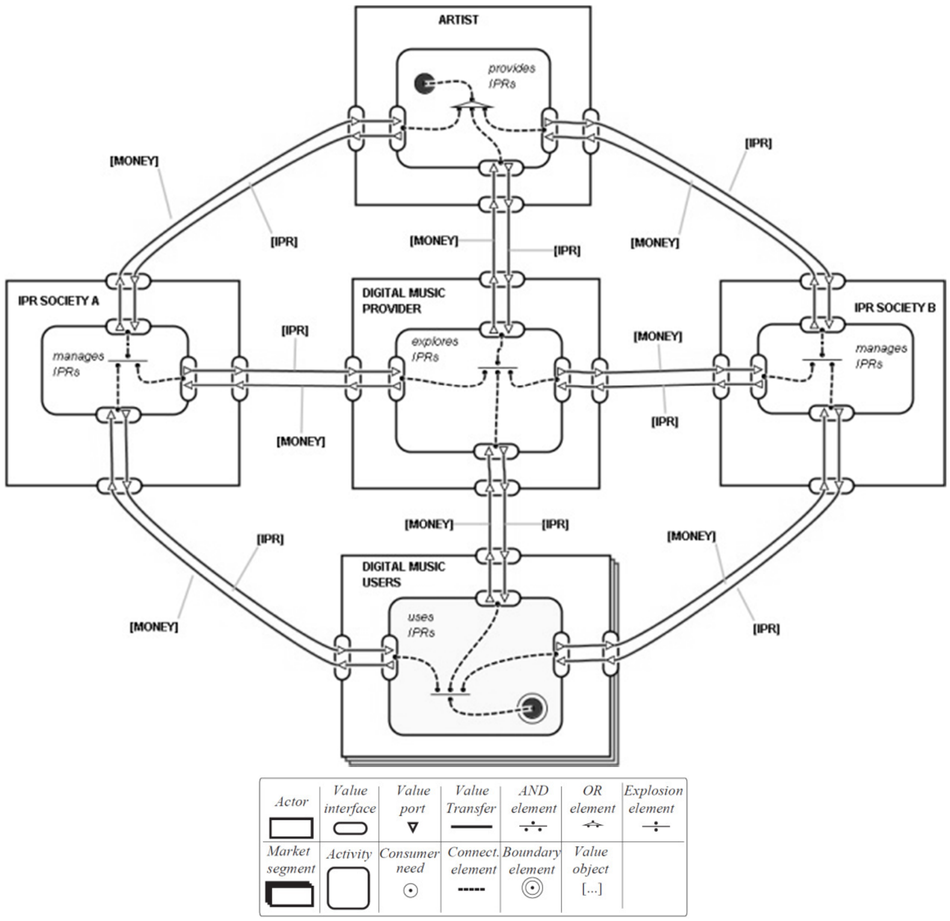

Figure 2-1: IPR value constellation model

In the market of Digital Music distribution, the main actors and market segments involved comprise *artists*, *digital music providers, digital music users* and *Intellectual Property Rights societies* (or Neighbouring Rights societies). Other supporting actors could have been identified, but the ones mentioned here comprise the main business representatives of this market (Ricketson and Ginsberg, 2006; Sterling, 2008). The organization of the value model depicted above is described as follows, according to its corresponding actors, performed value activities and exchanged value objects.

According to related work (Gordijn, 2002; Kartseva, 2008), IPR users have been referred to as the service consumers of this value constellation. Nevertheless, the case here refers to the situation where the underlying value constellation is configured from a business need of the *artistic sector*. This sector is represented by a single *artist* actor in **Figure 2-1**. It is worth to note how the value objects flow throughout this constellation. The object exchanges are reciprocal and symmetric, comprising exchanges of *IPRs* for *money*. The reason why IPRs are considered here instead of *digital music* is that, since a long while, the value of the digital music, as a *physical commodity*, has been dramatically reduced in this business. Value activities such as *reproduction* and *distribution* of digital music are often sources of fraud, relegating this economic object to the status of purely representative commodity. That is, the behavior of these value activities cannot be precisely monitored solely on the basis of the digital music produced by them.

Therefore, the main value object of this market is the *IPR*, which is provided in exchange of *money*. Different from digital music, IPRs can be traced and monitored, but yet demand a great effort in terms of business strategy and legal enforcement (Sterling, 2008). In the scenario depicted in **Figure 2-1**, IPRs are *produced* by the artists, *explored* by the Digital Music Provider, and finally *used* by the IPR users (e.g. public commercial establishments). As a counter-part, *money* flows from the final IPR users, being *managed* directly by the IPR societies (and indirectly by the digital music providers), ultimately reaching the artistic sector (simplified here as a single actor).

Although IPRs comprise a reliable evidence of performance in this business, there is still a very challenging monitoring point in this constellation. The value activity of *using IPRs* represents a possible point of risk and opportunistic behavior, threatening the sustainability of this value constellation. That is, while IPRs are reliable as an evidence of performance, the value activity of *using IPRs* performed by the IPR users is suspicious. There is no actual *assurance* that these IPRs will be used according to the promise. Moreover, only the IPR societies are assumed to be trusted, for as their business competence is normally granted by government authorities. In practice, these societies have the business competences of *distributing IPRs* provided by the artists to the users of digital music and *collecting money* from the digital music users to the artists. In the example depicted in **Figure 2-1**, these activities have been collapsed as a single value activity of *managing IPRs*. In sum, this is an example of an essentially *untrusted* value constellation, which provides relevant problems of Service Monitoring. Henceforth, this case will provide the leading example to guide the ontological discussion about monitoring value constellations, which is elaborated next.

2.3 Value-Oriented Views on Service Monitoring

The model depicted in **Figure 2-1** encompasses many problems of relevance in Service Monitoring. At this point in discourse, it is worth to reduce the monitoring problem addressed here according to its pertinent *ontological* questions. Here, these questions include *who, what, why* and *how* to monitor in a value constellation. Answering these questions may reduce the number of "narrative stories" providing irrelevant perspectives on the same focal phenomenon (Pentland and Feldman, 2007). These ontological views for monitoring are elaborated as follows.

2.3.1 Who wants to monitor whom?

On what regards possible mechanisms applicable to monitor business collaborations whatsoever, some theoretical frameworks are identified and classified by related literature in Organizational Science (Hung, 1998). For the purpose of *controlling* business collaborations, two opposite theories can be applied: the *Agency Theory* (Eisenhardt, 1989) and its counter-theory, the *Stakeholder Theory* (Donaldson and Preston, 1995).

The *Agency Theory* can be applied to analyze business collaborations as composed of atomic (concurrent) bilateral contracts, each one involving a dominant party (i.e. the *principal*), and a subordinated one (i.e. the *agent*). The principal uses his resources to control the agent, which in turn, produces counter-resources. From this perspective, a value constellation could be perceived as a set of principal-agent collaborations, each one with a *self-contained* management structure. In theory, each self-contained structure is responsible for its own monitoring.

Conversely, the *Stakeholder Theory* can be applied to analyze multi-party business organizations from a more centralized perspective. According to this theory, a value constellation could be perceived as a single *firm,* to which actors could bring their resources in exchange of reciprocal value-adding ones. The responsibility of managing a value constellation as such could be delegated to an external actor. In terms of monitoring, each actor could monitor the value constellation through the common shared firm. In this case, a firm institutionalizing the collectivity of a value constellation could operate as a public dashboard, and the performance report of its value creation would be of responsibility of an externally delegated actor.

The perspective adopted here is purely *Agency-oriented*, due to its potential applicability on modeling management operations in competitive liberalized markets. From this perspective, the monitoring of a value constellation can start from the monitoring of its constituent value activities, which are part of value transactions. In theory, any transaction can be chosen. However, a good source of monitoring analysis comprises critical transactions. Some examples of critical transactions include: (1) high-value transactions, e.g. transactions involving a high amount of monetary value; (2) high-risk transactions, e.g. the ones involving value activities that could be potential sources of opportunistic behavior; and (3) end-to-end transactions; i.e. transactions involving the consumer actor (or market segment) and the source of production of the main commodity of the value constellation. From a monitoring perspective, the latter type of transaction is rather comprehensive. This type of transaction involves the extreme points of a value constellation: on one side, there is the consumer's market segment, which is served by the value constellation, whereas, on the other side, there is the back-end actor or market segment, which provides the primary resources used by the services offered within the value constellation. This type of transaction can also be seen as a transversal path of value creation in a value constellation, for as, normally, a web of actors is necessary to mediate these two extreme points.

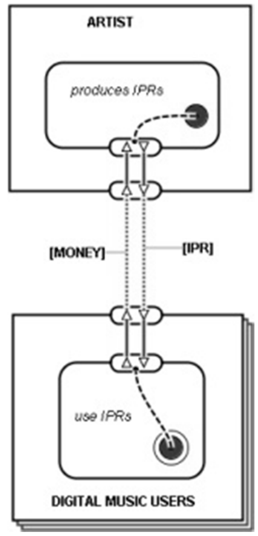

Figure 2-2: Basic Agency scenario

A value transaction from the IPR case introduced before is depicted in **Figure 2-2**. It involves the artist (as a single actor) and the digital music users (as a market segment). This transaction is depicted in dotted lines, representing that the actors involved collaborate only indirectly. As depicted previously in **Figure 2-1**, there are other actors mediating these two, i.e. *IPR societies* and *digital music providers*. Other transactions involving the artist and other actors of the constellation could have been chosen. However, this one is of special attention, for as it involves the ultimate service consumer and provider of the main value objects. In terms of monitoring, the main problem considered here is the difficulty to monitor the critical activity of *using IPRs*. Such a difficulty increases as indirect transactions are placed between these two actors.

Hence, the monitoring problem considered here starts by the service consumer (as a principal) willing to know if the service provider (as a third-party) performs its internal service accordingly. Therefore, the *service consumer* is the one who *wants to monitor* the *service provider*. However, it is also assumed that performance information, as desired by the service consumer (as a principal) is not regulated by the initial agreement of the collaboration. This brings to the first critical Agency assumption on monitoring – that monitoring information can also be treated as a *purchasable commodity* (Eisenhardt, 1989). In this case, in order to obtain the monitoring information wanted, the service consumer has the option to hire another agent, which has a granted capability to access and provide the monitoring information needed. From this perspective, the monitoring of business collaborations can be informally described here as *who wants to monitor whom through whom*. Recursively, the monitoring collaboration originated is itself an Agency relationship (Shapiro, 2005). Hence, the final scenario may optionally comprise the one of a principal engaging in two Agency collaborations: one for acquiring the main economic object in exchange and another one for acquiring information or evidence about the performance that will produce such an object.

This monitoring agency scenario is demonstrated through the leading example depicted in **Figure 2-3**. The consumer of this value constellation is the *artist*, who wants to monitor if the *digital music users* make appropriate use of the IPRs. For instance, the actual IPR use may be much higher than what is reported by the users. Therefore, in this case the artist assumes the role of a *monitoring principal*. In this role, the artist delegates the monitoring activity to an IPR society, which operates as a *monitoring agent*. By consequence, the IPR users operate as *monitoring third-parties*. Therefore, the value activity of *managing IPRs,* performed by the IPR society, operates as a *monitoring activity* (i.e. a monitoring service). The main resource used by this service is the money collected from the IPR users, which plays the role of a *monitored object*, i.e. the primary evidence of performance. The money transferred from the IPR society to the artist assumes the role of a *monitoring object*, i.e. a secondary evidence of performance.

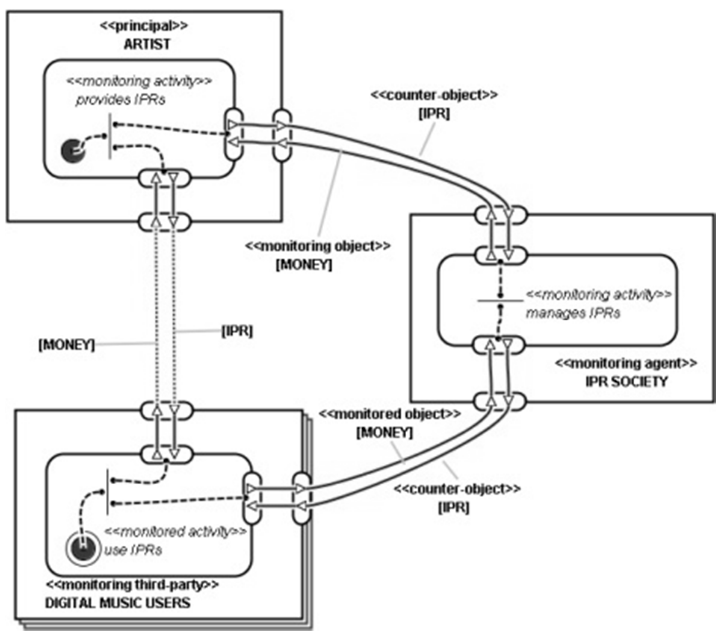

Figure 2-3: Monitoring Agency scenario

The roles played by the actors, activities and respective exchanged objects are annotated with UML-like stereotypes in the corresponding figure. It is important to note that what really matters here is the *organizational structure* of the monitoring elements. The identity of the actors, value activities and value objects have a secondary role, for as they comprise only the specification of the core value constellation, upon which a monitoring system can be built. Therefore, the same objects may assume different business roles. Reusing business objects as monitoring evidence is economically adequate (Schwartz, 2004; Pardo, 2005). For instance, although there is no direct flow of money from the IPR users to the artist, the same money flows indirectly through the IPR society. Adopting such a perspective, the artist can monitor (indirectly) the IPR user's activity through the IPR society.

This scenario can be further elaborated, according to the purpose of the principal. Such a purpose could be driven, for instance, by a potential high risk (or high value) that the underlying value transaction could generate. In this case, as a monitoring principal, the artist could hire multiple monitoring agents to acquire the monitoring information needed. This constitutes a case of *multiple Agency* (Arthurs et al., 2008). In this case, hypotheses can be generated on the *cost-effectiveness* of the monitoring, as many monitoring agents can be included in the collaboration. However, counter-hypotheses can also be generated, for as each monitoring collaboration could also be explored as source of profit. Hence, monitoring can also be strategically posed as an opportunity for market exploitation (Shapiro, 2005).

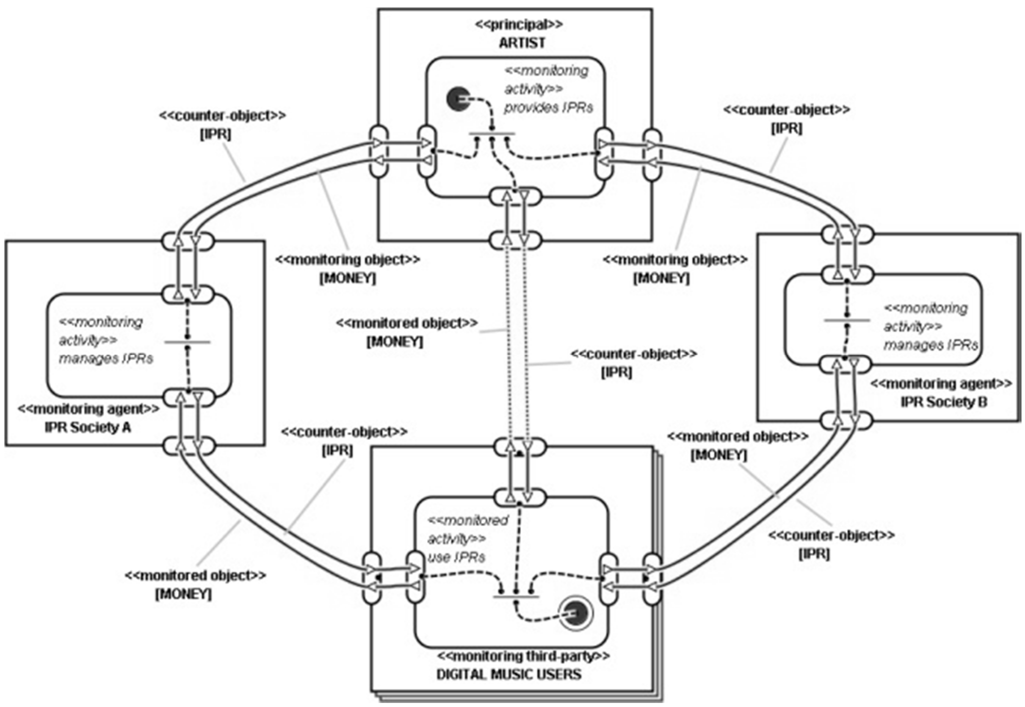

Figure 2-4: Multiple monitoring Agency scenarios

As depicted in **Figure 2-4**, a scenario of *multiple monitoring Agency* can be identified in the IPR case. Here, it is illustrated how an artist could obtain monitoring evidence *from* the digital music users *through* different IPR societies. It is worth noticing that the organization of the monitoring constructs here creates a *monitoring value constellation*, in which the involved actors could monitor one another directly or indirectly. Regarding the cost-effectiveness of the monitoring on the principal's side, this scenario is also dual. From one side, multiple monitoring Agency may increase the cost of monitoring. From another side, the same value constellation could be explored as a source of monitoring services. Such a scenario may approach the future of the market of digital music. As the IPR management market becomes more liberalized, artists will probably have the option to have their IPRs managed not only by local IPR societies, but also by international ones (Bhattacharjee, 2009).

In summary, from an Agency Theory perspective, these comprise some of the basic scenarios that can be used to frame the monitoring roles of the actors participating in a value constellation.

2.3.2 What to monitor?

The monitoring organization previously described still encompasses a wide range of monitoring problems. Therefore, the second restrictive monitoring view comprises *what has to be monitored*. Assuming that the value exchanges (i.e. the communication channels) are reliable, at least three basic constructs can be identified as possible targets of monitoring: (1) the *actors*, including both initial service consumer and the added monitoring agents; (2) the *value objects* – especially the ones produced by the monitoring agents, which are essential for the principal to produce his internal value; and (3) the *value activities*, specifically the third-party's, which is the main source of business risk considered here. Each of these potential monitoring targets may constitute an entire universe of analysis and discourse. However, the focal point of monitoring considered here is the *monitoring third-party's activity*. As shown in **Figure 2-5**, this corresponds to the value activity of *using IPRs*, which is performed by the IPR user.

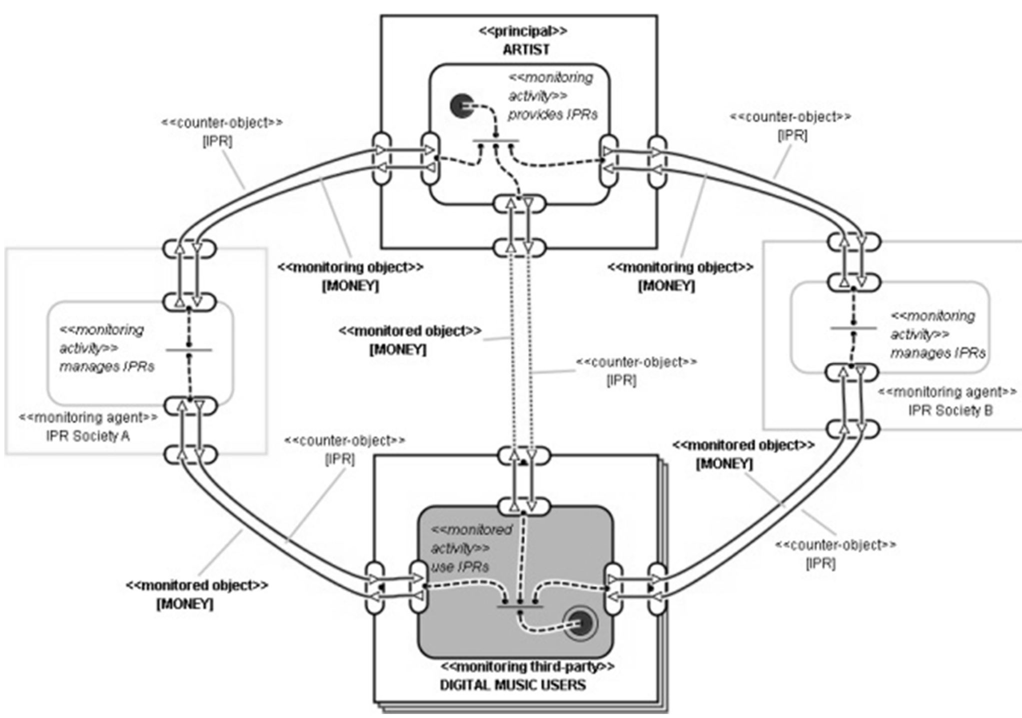

Figure 2-5: Value activity of the monitoring third-party as focal monitoring subject

In a value constellation, there are strong reasons for choosing this value activity as a focal monitoring point. First, it is assumed here that the service consumer of the constellation does not have a direct collaboration with the actor that performs this activity, but yet depends on the outcomes of this activity. This constitutes a risk taken by the service consumer. Second, the service consumer can monitor this activity indirectly, through monitoring services provided by monitoring agents. Hence, this is also a case of extended Agency (Jacobides and Croson, 2001), where the principal does not have a direct relationship with a third-party, but can still monitor this actor indirectly, through the information provided by corresponding agents.

2.3.3 Why to monitor?

From a Contract Theory perspective, monitoring is normally associated with risk mitigation (Bolton and Dewatripont, 2004). However, from an Agency perspective, risk mitigation is not the only motivation behind Service Monitoring (Jacobides and Croson, 2001). Although simple at a first analysis, the propositions of Agency Theory can be used to cover a multitude of possible contractual issues that may arise in collaborative markets. One of special interest here is the articulation of Agency Theory on the *exploitation of monitoring markets*.

From a purely risk mitigation perspective, monitoring objects can be considered as resources used to achieve a consumer's ultimate goal of value creation. That is, in order to accomplish his internal goals of value creation, a consumer may need not only the main value object in exchange (e.g. the money paid directly by the IPR user to the artist), but also, a corresponding monitoring object (e.g. the money paid indirectly *by* the IPR user, *through* the IPR society, *to* the artist). Therefore, these two types of value objects can be seen as complementary, as part of a bigger plan of creating value.

However, from a market exploitation perspective, the original premises of Agency Theory can be manipulated so as to produce diverse scenarios of Service Monitoring. The one considered here is the one in which the monitoring collaboration itself becomes a business in its own, subject of profitability and risk analysis. From such a perspective, the rationale of monitoring as a risk mitigation mechanism can be extended by monitoring as an opportunity for market exploitation. Such an extension comprises to treat *monitoring as a business*, with its own internal organization and economic structure (Shapiro, 2005).

A possible consequence of such a perspective turnover is that, instead of decreasing (potentially) the original consumer's profitability, multiple monitoring Agency relationships could be explored as a source of profit. The possibility of organizing the monitoring of value constellations as a business market in its own scope comprises an alternative rationale for monitoring value constellations.

2.3.4 How to monitor?

A subtle problem arises from the application of multiple (monitoring) Agency relationships in business collaborations. The problem is that *unreliable monitoring* may trigger recursive needs of monitoring, i.e. the monitoring of unreliable monitoring. This problem can be analyzed according to at least two perspectives. First, from an *organizational* perspective, collaboration between principals and unreliable monitoring agents may demand the inclusion of other monitoring agents between them, recursively. Second, from an *information* perspective on value creation – especially on what regards information asymmetry between agents and principals – monitoring agents can offer only *value propositions* of the monitoring objects they provide, but no *assurance* on the *value in use* that such information will actually have on the principal's side. Therefore, it is necessary to define a strategy to cope with these problems.

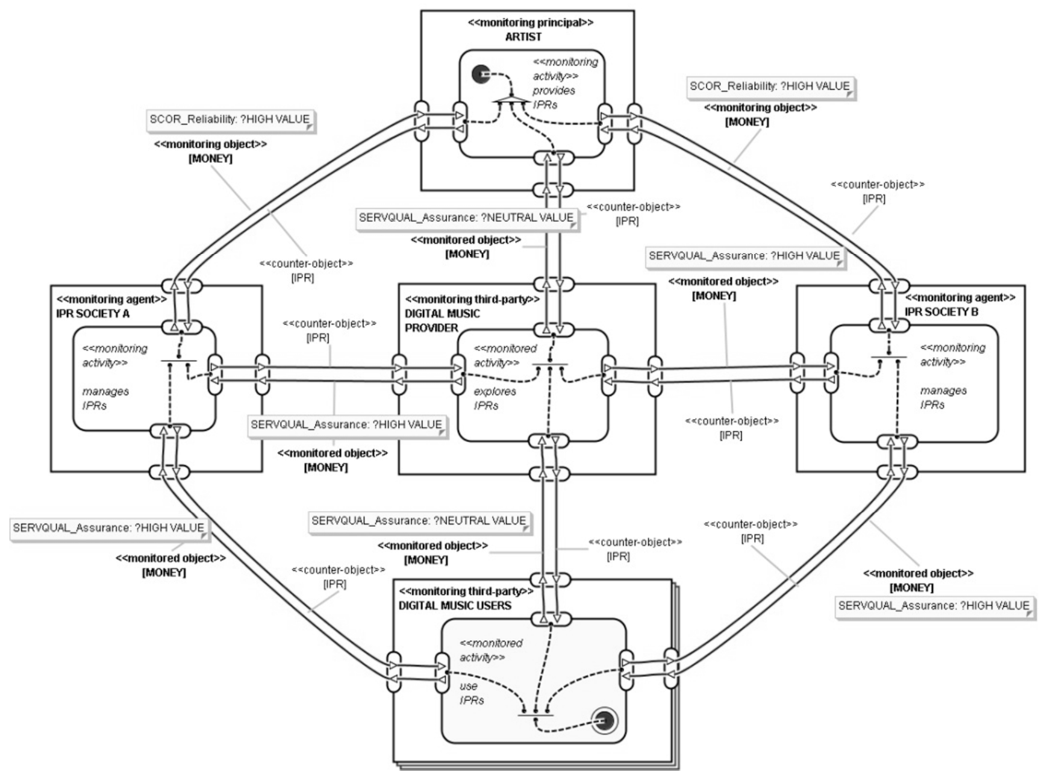

Figure 2-6: IPR monitoring value constellation: value proposition model

From the *organizational perspective*, the problem of unreliable monitoring among monitoring agents has been already partially addressed along this chapter. For the sake of example, let the discussion return to the IPR case. A more complete scenario is depicted in **Figure 2-6**. Here, the full scenario comprises again an artist, two IPR societies, a digital music provider and a market segment of digital music users. The artist has only indirect collaboration with the digital music users, but wants to monitor them. As a monitoring principal, the artist can use any of his direct collaborators and monitoring agents to monitor indirectly the digital music users, which are many (represented as a market segment). Hence, the digital music provider could also operate as a monitoring agent. However, in practice, only the IPR societies operate as authorized monitoring agents in this business (Ricketson and Ginsberg, 2006). Digital music providers and users are not trusted, and therefore comprise possible monitoring ending points. The resulting triangulation provides a closed *monitoring value constellation* in which the monitoring objects exchanged can be used for mutual risk mitigation. Notice that the scenario evolves on existing collaborations (as described in the beginning of this chapter). Hence, no extra collaborations are created to support the monitoring. Such a strategy can be used to cope with the first reliability problem, reducing the need to include more monitoring parties in the collaboration (Pardo, 2005). This structure has been named as *value monitoring policy* (Silva and Weigand, 2011b), which is part of the monitoring ontology described in detail in **Chapter 3**. This is a particular case of Multiple Agency, with agents watching other agents (Arthurs et al., 2008).

On what regards the *information perspective* on *unreliable monitoring*, some theoretical assumptions must be considered first. As previously discussed, monitoring is treated here as a business market, in which monitoring objects are exchanged as a *purchasable commodity*. Hence, monitoring *reliability* can be treated not only as an organizational strategy, but also as information (i.e. an *indicator*) about the potential value of the monitoring objects offered. Such information can be *expressed* in terms of *value propositions* offered by the monitoring agents to the monitoring principal. As illustrated in **Figure 2-6**, these propositions can be expressed in terms of subjective values to be generated through the use of the monitoring objects. As the case here is focused on the value of the monitoring, some indicators relevant for qualifying monitoring objects may include *assurance* and *reliability* (by coincidence). These indicators have been extracted from the SERVQUAL scale (Parasuraman, Berry and Zeithaml, 1991) and the SCOR model (SCOR, 2010). The SERVQUAL scale has been used to assess the quality of service provisioning in business-to-consumer collaborations, whereas the SCOR model has been more widely used in the context of business-to-business collaborations.

As the value constellation analyzed here represents a prelude of a monitoring agreement, this type of information can be assumed to be *disclosed* among the participants of the constellation. However, as discussed before, the monitoring objects offered by the monitoring agents comprise only propositions of monitoring value. There is no actual assurance on the value to be generated from such monitoring propositions. This is represented by instantiating the indicators with attributes of value, placing them on top of the value objects and prefixing them with a question mark (e.g. ?HIGH VALUE).

Still regarding the *information* aspect of monitoring reliability, the propositions of monitoring objects ought to be assessed in terms of the actual *value in use* of these objects, on the monitoring principal's side. The distinction between *value proposition* and *value in use* of business commodities is not new in the literature in Economics

(Barzel, 1982; Kohn, 2004). More recently, some clarification of this distinction has been provided by Vargo and Akaka (2009, p. 35), through the propositions of the Service-Dominant Logic. The point of the authors has been reinforced later on by Grönroos and Ravald (2011, p.15). This clarification has been translated in two fundamental premises, which are cited as follows.

> **FP7:** *The enterprise cannot deliver value, but only offer value propositions, i.e. the firm can offer its applied resources and collaboratively (interactively) create value following acceptance, but cannot create/deliver value alone.*

> **FP10:** *Value is always uniquely and phenomenological determined by the beneficiary, i.e. value is idiosyncratic, experiential, contextual, and meaning laden.*

From the first premise, it is possible to assume that the process of value creation is interactional, and value propositions *precede* actual value experiences (i.e. value in use), which are provided via the exchange of objects of economic value. From the second premise, it is possible to conclude that, although value creation is interactional, its assessment is done by the service consumer. This is also conformant with the view of Grönroos and Ravald (2011, p. 15), which poses the *service consumer as the ultimate value creator* in a business collaboration. Actually, these premises can be applied to any type of business object, including monitoring objects (considered here as purchasable commodities).

Based on these premises, some conclusions can be drawn so as to initially cope with the issue of monitoring reliability as an *information* problem. Basically, the difference between *value propositions* and *value experiences* comprises *who* discloses each information and *when*. Value propositions are important not only for the consumer, but also for all the actors involved in a value constellation. This information is useful to prospect overall value creation. However, only after the value propositions are delivered by the service providers and *experienced* by the service consumer, it becomes possible for the latter to *measure* his internal value creation. Therefore, while information about *value propositions* should be disclosed among the participants of a value constellation, information about actual *value experiences* could be kept as private at the consumer's side. Such a view on Service Monitoring is conformant with the Service-Dominant Logic.

For the monitoring scenario described in this chapter, the situation is not different. For instance, monitoring agents may offer monitoring objects as highly reliable. However, only the monitoring principal operating as a final consumer of monitoring objects can judge about the internal value generated by these objects. In other words, the value of the monitoring objects depends not only on how the monitoring agents propose these objects, but also on how the principal *uses* these objects to create internal value.

The model previously depicted in **Figure 2-6** represents possible value propositions of reliability and assurance of the monitoring objects in the IPR case. This type of model can be used as a public monitoring agreement between the actors involved in the constellation. That is, by engaging on a value constellation, the actors agree not only on the objects and activities (services) to be provided, but also on how the actors will be organized and how the monitoring information is expected to be delivered. Based on such a model, it is possible not only for the monitoring principal, but also for all the other actors involved to prospect their internal value creation. Therefore, the model depicted in **Figure 2-6** can be considered as a *disclosed* monitoring model (or monitoring agreement) for the underlying value constellation.

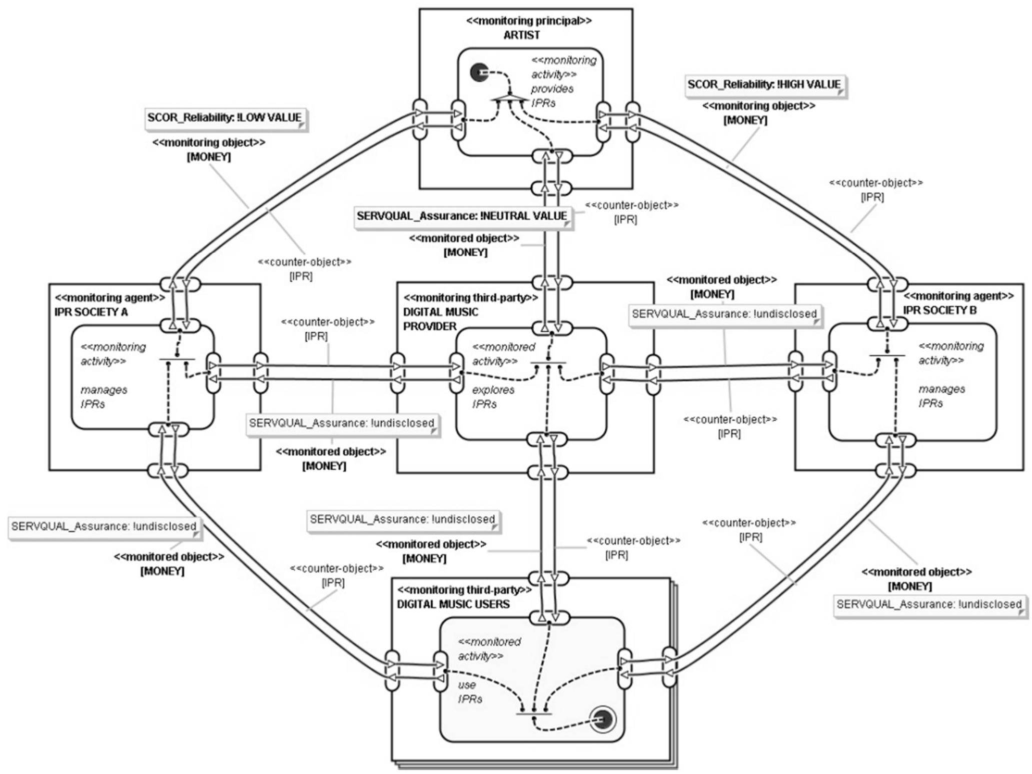

Figure 2-7: IPR monitoring value constellation: value experience model

As the difference between value proposition and value in use is recognized, the discussion now shifts to the need of representing this type of information in a value model. This is a matter of *model utility*. The model depicted in **Figure 2-6** can be used for the purpose of prospecting the value to be created by the actors. However, a different model is depicted in **Figure 2-7**. This model includes an evaluation made by the *monitoring principal* about the value created from engaging in the referred monitoring constellation. It is possible to notice that only direct collaborations among the artist (monitoring principal), digital music provider and IPR societies are highlighted here. The time of analysis considered here is *ex post* monitoring proposition. That is, it is assumed that the model previously depicted in **Figure 2-6** has been deployed, and the artist has assessed the value of the received propositions and translated them into *value in use*. The assessment made by the monitoring principal is represented here by placing the attributes of value in use on top of the monitoring objects and prefixing them with an exclamation mark (e.g. !LOW VALUE).

In sum, the models of value propositions and value in use can be used for different purposes. For instance, while the value proposition model can be used to *estimate* value creation, the value experience model can be used to *measure* it. Moreover, the first model could comprise a *disclosed* monitoring agreement to be shared among the participants of the underlying value constellation, whereas the second model could be used as *private* monitoring information. In the IPR case illustrated here, the perspective taken is the monitoring principal's.

Therefore, the models of *monitoring organization* and *monitoring information* presented here comprise some of the key concepts to address the question of how a value constellation could be monitored. Up to this point, another important theoretical remark must be drawn. From one side, the idea of *monitoring organization* gives to Service Monitoring a status of delegated value activity. From another side, the notion of *monitoring indicator* (especially the concept of value-in-use) returns part of the monitoring competence to the monitoring principal (role assigned to the final consumer of the value constellation). While the model of monitoring organization is Agency-oriented, the models of monitoring information are based on a Service-Dominant Logic.

Here, these theoretical frameworks are used in combination so as to describe a monitoring logic for value constellations. According to this monitoring logic, the monitoring of a value constellation starts with a monitoring need at the consumer's side, demanding monitoring objects. These monitoring objects can be obtained from value monitoring transactions internal to the underlying value constellation. These transactions are themselves Agency relationships. In this context, monitoring agents may also behave opportunistically, thereby triggering new Agency problems. This is the point where the Service-Dominant Logic is applied to distinguish monitoring objects according to the value they generate, at the consumer's side.

In the next section, the discussion continues on how these ontological views can be derived progressively towards the construction of a value viewpoint on Service Monitoring.

2.4 Towards a Value Viewpoint on Service Monitoring

As discussed before, the monitoring of a value constellation demands analysis of factors other than profitability, such as the communication and organization of monitoring information. It is difficult to treat them in isolation even in theory, for as they are all interrelated (Grundmann, 2002; Schwartz and Watson, 2004). This can be noticed from the initial discussion on the ontological questions raised in the previous section. The answers to such questions overlap and even conflict at many points. This can be partially explained by the premise that, at a very first instance, a value constellation is essentially a communication system.

The ontological views elaborated before can be used as a starting point to define a value viewpoint on Service Monitoring. However, some strategic steps are also necessary. These steps can be provided as guidelines to orient the application of the ontological views. Here, these guidelines are provided in terms of the order of scope whereby the monitoring of a value constellation can be articulated. Hence, the general recommendation here is to structure the monitoring of a value constellation from the micro-context of its constituent elements to the macro-context of its general structure. Therefore, this task can start *from* the identification of monitoring value activities (i.e. monitoring services), evolving *through* the identification of monitoring transactions (i.e. monitoring Agency relationships) *toward* the configuration of a monitoring value constellation. These levels of monitoring are introduced in this section and further elaborated in **Chapter 3.**

2.4.1 Monitoring Value Activities

Monitoring value activities correspond to monitoring services offered within a value constellation. Three guidelines apply during the initial configuration of these services.

Guideline 1: *Identify monitored activity*

It is assumed here that the service consumer of a value constellation has the dominant monitoring perspective over it. Hence, this actor is interested in monitoring the behavior of other participants of the constellation. In principle, all the actors involved comprise monitoring targets in potential. However, especial effort should be given to actors whose performed value activities are possible sources of fraudulent behavior. Therefore, *identifying a monitored activity* comprises the first practical guideline of the *Value Activity Monitoring* viewpoint.

Guideline 2: *Identify monitoring agents*

Information about the performance of a certain monitored activity has a cost, which can be prohibitive for the service consumer. Moreover, private verifiable information is normally subject of governance rules and policies. Although it is possible for the service consumer to perform a monitoring activity completely by his own, this task ought to be performed preferably by trusted *monitoring agents* accredited with the necessary business competence to provide monitoring services.

Guideline 3: *Delegate monitoring activity*

According to the availability of monitoring agents, the monitoring activity can be partially delegated from the service consumer of the value constellation to these agents. As the monitoring relationships originated are themselves subjects of Agency problems, delegation here is partial. This means that the role of the monitoring agents is resumed to provide the necessary monitoring objects requested by the service consumer, which operates in this case as a monitoring principal.

2.4.2 Monitoring Value Transactions

Monitoring value transactions correspond to the implied monitoring transactions involving the service consumer and possible monitoring agents, both operating in the same value constellation. Such monitoring transactions are themselves Agency relationships. Hence, two guidelines apply during the enactment of these transactions.

Guideline 4: *Request monitoring object*

While a *monitored object* comprises primary evidence of performance of a certain value activity, a monitoring object comprises secondary evidence of such. In a value constellation, monitoring agents perform monitoring value activities (i.e. monitoring services), which transform monitored objects into monitoring ones. The latter are of special interest of the service consumer, as a monitoring principal.

Guideline 5: *Offer counter-object*

As private verifiable information, monitoring objects have a cost to the service consumer. In a value constellation, such a cost is expressed in terms of *counter-objects* offered in exchange of monitoring objects. This complies with the principle of economic reciprocity (Mankiw, 2006), which is critical for the economic sustainability of a monitoring value transaction.

2.4.3 Monitoring Value Constellations

A *monitoring value constellation* is a value constellation composed of monitoring value transactions. These transactions are formed by triples involving the service consumer of the value constellation (acting as a monitoring principal), competent monitoring agents and corresponding monitoring third-parties. The internal efficiency of this system is assessed through the efficiency of its constituent transactions, which ultimately produce monitoring objects. Therefore, two practical guidelines apply on the distinction of equivalent monitoring objects produced by different value transactions.

Guideline 6: *Estimate value generation*

In *e3value*, the descriptor of a value object already brings information about its objective (economic) value, such as the absolute cost and amount-of-matter. However, as defined here, a *value indicator* comprises information describing the subjective value to be generated by a value object. Examples of value indicators relevant for describing monitoring objects include *assurance*, *reliability* and *safety*. According to a Service-Dominant Logic (Vargo and Akaka, 2009), service providers can only offer value, which can only be finally generated and evaluated at the service consumer's side. Therefore, just as an ordinary value object, a monitoring object also brings a proposition of value, which is offered by the monitoring agent to the service consumer (as a monitoring principal). In this case, the service consumer uses such value propositions as *estimates* of value generation.

Guideline 7: *Measure value generation*

Monitoring objects offered by different monitoring agents may represent equivalent value propositions. The availability of multiple monitoring objects within a same value constellation comprises an indication of monitoring effectiveness of the corresponding monitoring agents. However, monitoring efficiency in this case ought to be defined by the service consumer, as a monitoring principal. This requires from the service consumer to *use* the monitoring objects offered and measure the value generated by them. Therefore, the efficiency of monitoring activities in a value constellation is assessed through the value that the monitoring objects produced by these activities *generate* at the service consumer's side.

In the next section, an attempt is made to put the views and viewpoint presented here under the perspective of the state-of-the-art in Service Monitoring. The aim of this study is to provide a more precise notion of the potential contribution of this research.

2.5 State-of-the-Art in Service Monitoring

Although biased by a value modeling perspective, the ontological views on Service Monitoring described before are consistently aligned with taxonomies from the literature in Service Monitoring in general (Hielscher, Metzger and Kazhamiakin, 2009) and the Enterprise Architecture (Opt'Land et al., 2009). These references have been used in combination so as to provide a basic framework for the analysis of related work in Service Monitoring.

The literature overview analysis is summarized in **Table 2-1**. The related works selected for analysis comprised contributions given in terms of high-impact works published between 2004 and 2011. As Service Monitoring has a wide scope of applications, the target group of analysis included mainly works in the following technology areas: (1) Business Activity Monitoring (BAM); (2) Process Mining; (3) Business Process Management (in general); (4) Business Service Design (for monitoring); and (5) Web services monitoring in general. The selected works have been evaluated according to their coverage of the following requirements: (RQ1) monitoring rationale view, i.e. the "why to monitor"; (RQ2) Business domain viewpoint coverage; (RQ3) business process viewpoint coverage; (RQ4) IT Services viewpoint coverage; (RQ5) monitoring organization view, which relates to the separation of duties among the monitoring constructs; and (6) monitoring information view, i.e. the type of monitoring metrics used. Especially on what regards the fifth requirement (on monitoring organization), the initial survey published in (Silva and Weigand, 2011a) has also considered if the organization was specified from the Business domain to the IT Service systems (e.g. strongly hierarchical organization), or in the opposite way (e.g. ad-hoc or emergent organization). The main relevant conclusions of this literature classification are resumed as follows.

Table 2-1: Classification of Business Process Monitoring Approaches

REFERENCE	RQ-1	RQ-2	RQ-3	RQ-4	RQ-5		RQ-6		
					TOP-DOWN	BOTTOM-UP	KPI	PPM	QoS
Müehlen (2004)	No	No	Part.	No	Yes	Yes	No	No	No
Küng et al.(2005)	No	No	No	No	No	No	Yes	Yes	No
Srinivasan et al. (2005)	Part.	No	Part.	No	Yes	No	Yes	Yes	No
Yu, Jeng (2005)	No	No	No	No	Part.	Part.	Yes	Yes	No
Alles et al. (2006)	Part.	No	No	No	Part.	Part.	No	No	No
Greiner et al. (2006)	Part.	Part.	No	No	No	No	No	No	No
Abe, Jeng (2007)	No	No	No	No	Part.	Part.	Yes	No	No
Beeri et al. (2007)	No	No	No	Part.	No	No	No	Yes	Yes
Kim et al. (2007)	No	No	No	No	Yes	Yes	Yes	No	No
Strnadl (2007)	Part.	No	Part.	No	Yes	Yes	No	No	No
Chen (2007)	No	No	No	No	Part.	No	Yes	No	No
Ferro et al.(2008)	No	No	No	No	No	No	No	Yes	Yes
Kartseva (2008)	Yes	Yes	Yes	No	Yes	No	Part.	Part.	No
Lamparter et al.(2008)	No	No	No	Yes	No	No	No	No	Yes
Paschke, Bichler (2008)	No	No	No	Yes	No	No	No	No	Yes
Pedrinaci et al.(2008)	No	No	No	No	Part.	Part.	Yes	Yes	No
Rimini, Roberti(2008)	No	Part.	No	No	Part.	No	Yes	Yes	No
Tsai et al.(2008)	No	No	Yes	Part.	No	Part.	No	No	Yes
Unger et al.(2008)	No	No	Yes	Yes	No	No	No	No	Yes
Vaculín, Sycara (2009)	No	No	No	Yes	No	No	No	No	Yes
Bai et al.(2009)	No	No	No	Yes	No	No	No	Yes	Yes
Comuzzi et al.(2009)	No	No	Yes	Yes	No	No	No	No	Yes
Fugini, Siadat (2009)	No	No	No	Yes	No	No	No	No	Yes
Kang et al. (2009)	No	No	No	No	No	No	Yes	No	No
Momm et al.(2009)	No	No	No	No	No	No	Yes	Yes	No
Pourshahid et al.(2009)	No	No	No	No	Yes	No	Yes	Yes	No
Spillner et al. (2009)	Part.	Part.	No	Yes	No	No	No	No	Yes
Wang et al.(2009)	No	No	No	Yes	No	No	No	No	Yes
Han et al. (2009)	No	No	No	Yes	No	No	No	No	Yes
Wetzstein et al.(2010)	No	No	Yes	Yes	Part.	Part.	Yes	Yes	Yes
Rodríguez et al. (2010)	Part.	No	Yes	No	Yes	No	Yes	Yes	Yes
Aalst et al.(2011)	No	No	No	Yes	Yes	No	No	Yes	Yes
Robinson and Purao	No	Part.	Yes	No	Part.	Part.	No	Yes	No

First, in Service Monitoring, architectural viewpoints are still structured according to their supporting technologies. In the Business Process viewpoint, the Business Activity Monitoring – BAM (Gartner, 2002) and the recently proposed Process Mining (Aalst, 2011) constitute the state-of-the art. These technologies are supported by their technology predecessor, Complex Event Processing – CEP (Luckham, 2001), which is used to implement Service Monitoring on the IT services layer. Therefore, any attempt to create an aligned and consistent structure for Service Monitoring has to take into consideration the constraints imposed by the viewpoints defined by these technologies, as well as their corresponding internal views.

Second, it has been noticed that many of the ontological questions on Service Monitoring formulated in the previous section are somehow treated by the selected works. From one side, substantial effort has been paid on constructing Service Monitoring views on the business process and IT services viewpoints. Some of these views have been addressed in conflict or redundancy. From another side, not much effort has been paid on building structured Service Monitoring views on the Business domain viewpoint. Thus, the Business domain perspective on Service Monitoring is currently rather sparse. Such an absence may reduce the alignment between what businesses need to monitor and what IT service systems could actually support.

Therefore, Service Monitoring nowadays can be considered as essentially *tactical* (i.e. business process-oriented), but not *strategic* (i.e. Business domain-oriented). Although providing robust technologies to support Service Monitoring, BAM and Process Mining are still attempts to make business sense out of monitoring data, and not conversely. Moreover, these approaches often use a terminology that is not adequate to define business views on Service monitoring. This may reduce on a great extent the actual participation of business analysts in the process of defining Service monitoring requirements for business collaborations. In short, a noticeable absence of structured monitoring views on the Business domain viewpoint has been verified.

However, such an absence cannot be said to be total. The work proposed by Kartseva (2008) has provided relevant contribution in terms of modeling mechanisms for *controlling* business collaborations. This comprises the main rival theory of the research proposed here. Again, the problem treated in that work is the one of how to *control* business collaborations, specifically in the context of value constellations. Therefore, monitoring there is considered merely as an instance of a *controlling mechanism*, but not as a complete subject of discourse, with proper internal views. Nonetheless, the author has provided some demonstration on how to map the representation of that viewpoint on a corresponding business process one. From an architectural perspective, the work of Kartseva represents advances on leveraging Service monitoring (as a controlling pattern) to the Business domain viewpoint. However, from an ontological perspective, the description of the monitoring pattern proposed there lacks many important views relevant for Service monitoring.

In short, many research opportunities can be identified from the classification provided in **Table 2-1**. At the time of its initial publication, this literature review had a special utility of exploring research opportunities in Service monitoring in general. Since then, the absence of frameworks for design of Service monitoring requirements for the Business domain viewpoint has constituted the main motivation of this research.

2.6 Discussion

The main purpose of this chapter has been to provide the basic concepts for understanding the problem of how a value constellation could be monitored. This has been done by exploring the problem with the ontological questions of *who*, *what*, *why* and *how* to monitor in this type of system. Some guidelines to scope the context of the monitoring logic have also been provided. The strategy proposed here consists of starting the monitoring of a value constellation *from* its critical value activities, *through* the articulation of its constituent monitoring value transactions *toward* the organization of a monitoring value constellation, as a self-managed system. A leading example has been used from a business case of Intellectual Property Rights management in the Digital Music sector. The case has provided not only elements of practice to analyze the problem in question, but also scenarios for testing the concepts presented here. The main purpose of using this case has been to justify the practical relevance of the research problem in question.

From a theoretical perspective, special attention must be drawn to *how* the Agency Theory has been used to frame the problem in question. Normally, Agency Theory brings about the scenario where a principal *delegates* one or more of his competences to a specialized agent. While the agent performs the delegated competences, the principal evaluates the agent's performance according to his produced actions. However, monitoring here has been analyzed not only as a pure *delegation* of monitoring activities, but also as cooperation between monitoring parties. Such an extension has been considered as necessary due to the demand of the problem in focus. The problem of monitoring a value constellation gives rises to at least two conceptual venues. One leads to the point of assessing the *value of monitoring* – i.e. the objective accountability of the monitoring. The other one leads to the point of the *monitoring of value* – i.e. the subjective, experiential and individual assessment of the monitoring action. The latter is of critical interest in this research. From this point-of-view, a *service consumer*, operating as a *monitoring principal*, can be perceived as *delegator*, *cooperator* and *evaluator* of monitoring actions in value constellations.

To confirm the relevance of the research problem in discussion, a state-of-the-art in Service monitoring has also been provided. The study has been used to explore research opportunities in the area of Service monitoring in general. More specifically, the study has also confirmed a certain absence of frameworks to design Service monitoring requirements from a business viewpoint. This research is an attempt to fill this absence. As a matter of practice, it opens the possibility of furnishing business analysts with a framework for designing Service monitoring requirements from a business strategy level.

In the next chapter, an ontology is presented as a candidate model for the specification of strategies for monitoring value constellations. The so-called Value Monitoring Ontology (VMO) formalizes the conceptual constructs introduced in this chapter. The modeling purpose of the ontology is to provide the basis of a value viewpoint on Service monitoring – the *Value Activity Monitoring* viewpoint. In order to facilitate the organization and understanding of its conceptual structure, the ontology is presented along with a corresponding application on the IPR case introduced here.

Chapter 3: Value Monitoring Ontology

If you want something done well, do it yourself.

Napoleon Bonaparte (1769 – 1821)

3.1 Introduction

Previously on **Chapter 2**, a theoretical discussion has been provided on the *problem* of how a value constellation could be monitored. The problem has been shown as complex and cross-disciplinary by nature, covering a wide range of economic, organizational, information, legal and communication issues. Due to the difficulty to treat these issues in isolation, the discussion has been leveraged to the ontological level. From that perspective, the problem has been decomposed into related sub-questions, including *who*, *why*, *what* and *how* to monitor in a value constellation. These questions have been posed as alternative *views* for exploring the problem in focus. In order to orient these views, a strategic vision has also been proposed so as to organize the monitoring of a value constellation into monitoring activities, monitoring transactions and monitoring constellations. The idea behind such a strategy is to organize the monitoring of a value constellation by a reconfiguration of its internal roles. Therefore, the notion of a *monitoring value constellation* is proposed here not as another type of value constellation, but as *the extension of an ordinary value constellation, with self-monitoring capabilities*. Together, monitoring views and strategy comprise a prelude of what can be called so far as a value viewpoint in Service monitoring, namely, the *Value Activity Monitoring* viewpoint.

Thus far, the proposed monitoring views and strategy comprise more of a set of theoretical guidelines than a consolidated Business domain viewpoint on Service monitoring. To achieve this purpose, it is necessary to find acceptance from scholars and practitioners working on the corresponding knowledge domain. As introduced in **Chapter 2**, the *Value Activity Monitoring* viewpoint is still biased and *informal*. By "biased", it is meant that the viewpoint represents the proposition of a single designer. By "informal", it can be noticed from the previous discussion that the viewpoint has been provided so far as a theoretical background, admitting a broad range of alternative interpretations. The consolidation of the viewpoint, as proposed here, involves three basic steps. First, it is necessary to *formalize* its constructs as a vocabulary that could be understood by practitioners from the field. Second, the corresponding formalization has to be *evaluated* through real case scenarios so as to be enriched with elements of practice. Last, the resulting formalization ought to be *shared* among practitioners so as to be assessed regarding its practical acceptance and utility. Therefore, what is aimed here is the collective construction of a shared vocabulary to constitute the basis of the so-called *Value Activity Monitoring* viewpoint. Especially in the field of Information Systems, such a type of vocabulary may assume the form of an *ontology*.

In the field of Information Systems, the term *ontology* has become quite popular. There are plenty of alternative definitions for the term, and a discussion on them falls beyond the scope of this document. To keep the discussion as straightforward as possible, the definitions adopted here comprise actually a combination of the ones proposed by Gruber (1995), Guarino (1998) and O'Leary and Studer (2001). From the definition proposed by Gruber, it has been recognized the importance of *formalization* in the process of building an ontology. From another perspective, the definition provided by Guarino poses ontology as an *engineering artifact* – which could also be referred as a *design artifact*, from a Design Science perspective – comprised by the vocabulary describing a domain of knowledge and a corresponding first-order logic theory giving meaning to it. Finally, the definition of O'Leary and Studer highlights the role of *collective intelligence* in the process of consolidating propositions of ontologies into de facto ones. Therefore, the definition of ontology adopted here comprises the proposition of a vocabulary of a certain knowledge domain, constructed as a formally represented design artifact, and *to be* evolved and refined through collective practice and experience.

Ontologies can also be used for different *purposes* in Information Systems. According to Uschold et al. (1998), ontologies can be used as means of *communication*, *interoperability* and *systems engineering*. As a *communication* tool, an ontology can provide uniform representations of activities, processes and strategies to be performed by the Enterprise. As an *interoperability* mechanism, it can be used on the mapping of architectural viewpoints realizing the operations of the Enterprise. As an artifact for *systems engineering*, it can be used, for example, as a formal specification of requirements demanded by or offered by an information system. In this case, a *formal specification* allows reasoning on many possible designs of a system, rather than a detailed description of how the system could be actually implemented. The ontology proposed in this work is aimed to be primarily used as a *formal specification*. As such, it can be used as a shared vocabulary to communicate strategies for monitoring value constellations among practitioners from the field. However, more indirectly, it is also a pre-requisite for mapping a value viewpoint on Service monitoring to its corresponding Business Process viewpoint. This is conformant to the vision of using ontologies on the construction of aligned architectures for Information Systems (Guarino, 1998; Křemen and Kouba, 2012). The vision of aligning Service monitoring viewpoints from an ontological perspective has been proposed in (Silva and Weigand, 2011a), which also comprises one of the outcomes of this research.

An aspect of relevance on the adoption of a candidate ontology refers to the *methodology* employed on its construction. In this work, several alternative methodologies have been analyzed for application. The main works considered here comprised the methodologies proposed by Gómez-Pérez (1996), Uschold et al. (1998), Schreiber et al. (1999), and Sure, Staab and Studer (2009). The last one has been chosen due to its level of integration, flexibility and maturity, considered higher than the other candidates'. The so-referred *Ontology Engineering Methodology* integrates aspects of many predecessor methodologies, such as TOVE (Uschold et al., 1998), and has been applied in many real-world case studies, what characterizes its level of maturity. This methodology encompasses five major steps to be accomplished in the process of engineering an ontology, which comprise: (1) the *feasibility study*, when relevant problems and opportunities are identified to be addressed through the construction of the ontology; (2) the *kickoff* phase, the outcome of which comprises an informal description of the ontology; (3) the *refinement* phase , when the informal description of the ontology is transformed into a respective formal representation; (4) the *evaluation* phase, when the quality of the formal representation is evaluated through the use of one or many evaluation techniques, e.g. standards, user feedback, correctness and consistency checking; and (5) the *application and evolution* phase, when the formal representation is applied on solving problems of a practical order. These five steps can be applied in alternative cycles, according to the availability of evaluating resources. Such alternative cycles make the referred methodology flexible. This is the main reason why this methodology has been chosen to be used in this work.

This chapter is organized according to an alternative application cycle of the referred methodology. In **section 3.2**, the *feasibility study* and *kickoff* phases are documented. A new discussion on the IPR case along with the ontological questions introduced in **Chapter 2** is used to cover these phases. Together, case study documentation and ontological questions provide an Ontology Requirements Specification Document (ORSD). Rather than a fictitious example, the scenarios selected from the IPR case have been kept as close as possible from the current reality of this business. In **section 3.3**, the *refinement* phase is presented through the formalization of the constructs of the ontology as a first-order logics theory. In **section 3.4**, some notes are provided on the *evolution* of the ontology, bringing some of the main aspects of its predecessor semi-formal models. In **section 3.5**, some initial *evaluation* of the ontology is provided in terms of its theoretical *effectiveness*, theoretical *efficiency* and *quality*. Finally, **section 3.6** closes this chapter with some partial conclusions about the results of the Ontology Engineering methodology adopted in this work. In addition to it, a brief discussion is also provided with the aim of identifying possible *application* scenarios of the ontology proposed here. These scenarios correspond to the business cases elaborated in **Chapters 4** and **5.**

3.2 Ontology Requirements

According to the Ontology Engineering methodology adopted here, the first two phases of the process of engineering a candidate ontology comprise the *feasibility study* and *kickoff* phases. During the *feasibility study*, some research problems and opportunities are identified. Preferably, these elements ought to be extracted from real-world *case studies*, which are rich sources of elements of practice (e.g. real-world assumptions and business constraints). During the *kickoff* phase, the aim is to provide an informal description of the problems to be addressed through the use of the candidate ontology. Such a description may assume the form of *structured questions*. Some of these questions have been already addressed in the previous chapter. In this chapter, though, the questions are focused on the knowledge representation issues of the ontology. Together, the description of the feasibility analysis and the kickoff list of conceptual modeling questions comprise a so-called Ontology Requirements Specification Document (ORSD). Part of the ORSD produced for this research has been presented in **Chapter 2**, more in terms of a theoretical background. In this section, the ORSD is complemented by a perspective turnover on the IPR case and further conceptual modeling questions.

3.2.1 Service Monitoring Scenario

The case in Intellectual Property Rights (IPR) introduced in **Chapter 2** provides room for the feasibility analysis of the ontology proposed here. Nonetheless, the narrative story of the case has been slightly changed in this chapter so as to provide a different (but complementary) perspective on the monitoring problems of this case. The value model for the case is depicted in **Figure 3-1**. The *e3value* notation is used here for illustration purposes (as well as throughout the rest of this thesis). The new configuration of the case is described below, according to its internal organization of actors, value activities and value objects.

Actors

Different from the initial description provided in **Chapter 2**, the model depicted in **Figure 3-1** comprises only three types of actor/market segments. The main actors considered here are the *IPR societies*, the *digital music providers* and the *digital music users*. The former two are represented as single actors, whereas the latter one, as a market segment. The artistic segment has been suppressed here so as to reduce the monitoring scenario to the simplest possible configuration. In practice, the actors included in this scenario cooperate only on a business-to-business basis. As a value constellation is driven by the service consumer's perspective, a relative consumption end has been placed on the IPR society's side (represented graphically by the symbol of a consumer's need). Conversely, the market segment of the digital music users is considered as the back-end of the constellation (represented graphically by the symbol of a boundary element). Therefore, the constellation can be interpreted as having the IPR societies being sustained by the other actors through the provisioning of IPRs in exchange of money. Digital music providers play a market mediation role here.

Value Activities

Three generic types of value activities are considered in this scenario: *managing*, *exploring* and *using* IPRs. These activities are assigned to the IPR societies, digital music providers and digital music users, respectively. In theory, the act of producing music and the act of producing the corresponding IPRs occur almost simultaneously. The process of producing a single music track may involve different actors from the artistic segment, e.g. composers, musicians, singers, etc. In practice, it is difficult to identify with precision the point in time when the music is said to be finished and the corresponding IPRs are produced. This explains why IPRs are also referred to as "Neighbouring Rights" (Ricketson and Ginsburg, 2006). Moreover, these rights become subject of legal regulation only after being transferred to an IPR society. Therefore, the model considered here abstracts from the transactions involving artists and IPR societies. By such means, the activity of *managing IPRs* is considered as a business competence of the IPR societies.

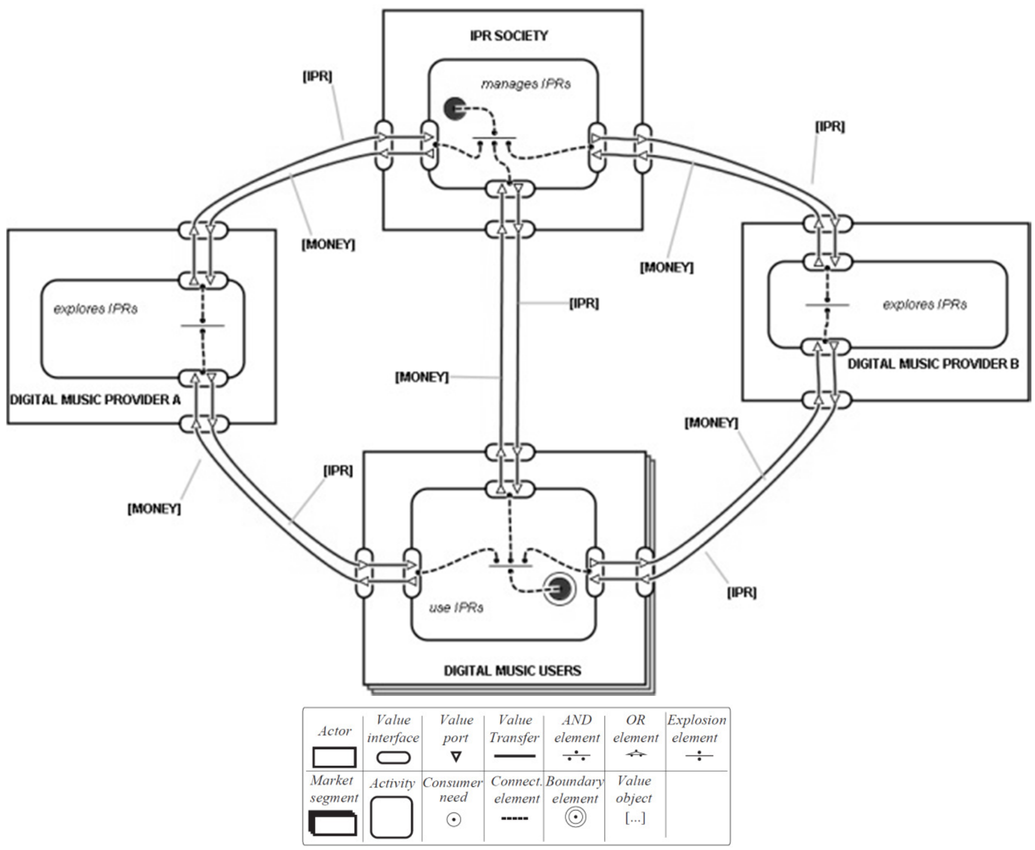

Figure 3-1: IPR business case: core business value constellation model

The activity of *exploring IPRs* may assume different meanings. For instance, IPR societies explore IPRs by collecting and distributing them in this market. It is by means of this value activity that the IPR societies survive in this market. Digital music users also make use of IPRs, for the sake of playing digital music in public and generating individual profit. However, in the example depicted in **Figure 3-1**, the meaning of exploring IPR societies is purely *strategic*. As explained before, IPRs have more economic value than digital music nowadays in this business. As proposed in (Silva and Weigand, 2012), digital music providers could also offer digital music bundled with the corresponding IPRs so as to offer better convenience to the IPR users. As the activity of distributing music is not of high relevance in this scenario, the dominant activity on the digital music provider's side is the one of *exploring*

IPRs. The strategic role of exploring IPRs for the monitoring of the value constellation is explained further in this chapter.

Finally, the value activity of *using IPRs* is placed on the IPR user's side. The term "using IPRs" is aimed to declare that IPRs have a period of validity. This value activity has strategic importance in the constellation, as it closes the accounting cycle of money and IPRs. However, such an activity also constitute a bottleneck in this business, due to its difficulty (if not impossibility) to be monitored on a continuous basis.

Value Objects

Different value objects have been identified by related work as of critical value in this business. For instance, in the work of Gordijn (2002), *digital music* has been considered as an object of high value in this business. Taking a different perspective, the work of Kartseva (2008) considers *evidence documents* as having even more value than digital music (at least on what regards needs of risk mitigation). However, as this market evolves through liberalization, new forms of distribution and reproduction of the digital music are expected to appear. This may cause fluctuations on the value of the economic objects that flow in this business market. Furthermore, experiences on this case reported in (Gordijn, 2002), (Kartseva, 2008) and (Fatemi, Sinderen and Wieringa, 2010) also indicate that emphasis on specific value objects is likely to vary according to the management mechanism in analysis.

For instance, for the design of a monitoring mechanism for this business case, digital music seems to have low value and relevance, due to reasons explained before. Nonetheless, increasing attention has been paid on the role of IPRs in markets of electronic commodities in general. As IPRs "expire", they are still easier to trace than digital music. Moreover, the period of validity of IPRs may indicate the performance of the value activities that use these IPRs. Hence, the objects considered of having critical monitoring relevance for the IPR case comprise *IPRs* and *money*. As these are the only objects flowing in the IPR constellation, they provide a homogeneous representation of the economic flow of the system. That is, neither IPRs nor money can "appear" or "disappear" from the constellation, but only be "transformed" within the system.

Therefore, the IPR case presented above, along with the description of its main actors, value activities and value objects serve as a *feasibility study* for developing the ontology proposed here. This is about a real-world business case, and therefore, all the elements of this case have been carefully selected by combining related documentation about the case and theoretical arguments from the literature. Actually, the feasibility study introduced here will be further elaborated in deeper detail by the use of other real-world case studies presented throughout this thesis.

3.2.2 Competency Questions

The ontological questions elicited in **Chapter 2** comprehend part of the *kickoff* phase of the Ontology Engineering methodology applied in this thesis. In this phase, the questions to be answered through the use of the ontology are raised as an exploratory study about the problem in question. Such an exploration may give rise to several cross-disciplinary questions. For instance, as presented in **Chapter 2**, the problem of monitoring value constellations involves other questions of a cross-disciplinary order. In this chapter, the *kickoff* phase is complemented by other questions of knowledge representation. The competency questions are elaborated as follows.

Who wants to monitor whom?

As exposed throughout this document, the monitoring of a value constellation may demand some *organization*. By organization here it is meant a definition and distribution of the social roles that compose the monitoring system – in this case, a *monitoring value constellation*. Therefore, questions of relevance for the organization of this system include:

(1) What are the *actors* of this system?
(2) What are the *roles* played by these actors?
(3) How are these *actor roles* represented? What are the critical relationships characterizing these roles?
(4) How do these roles relate to one another? Are they mutually related as a hierarchy or as ad-hoc behavioral specifications?
(5) How are these roles related to the constructs of the target implementation system? (i.e. the *e3value* framework)
(6) Who manages these roles? Who assigns which role to whom?

The list presented here is not exhaustive, but it provides sufficient elements for the initial organization of a *monitoring value constellation*. The first five questions can be somewhat represented through ontology constructs. However, the last question points to the need of human intervention in the final solution of the problem. That is, some of the competency questions raised here can be solved by the ontology as an IT artifact, whereas other ones, through human interpretation. Such a trade-off applies throughout all the questions to be answered by the ontology.

Whenever necessary, a distinction will be made between questions to be solved *by* the ontology as an IT artifact and questions to be solved *through* the use of the ontology, by business analysts. That is why the ontology proposed here must not only be provided as a *knowledge* representation and *technology* artifact, but also be complemented with *practice* and *strategy* guidelines.

What to monitor in a value constellation?

As discussed before, there are many monitoring foci in a value constellation. In *e3value*, actors, value activities and value objects constitute perhaps the most probable *monitoring subjects*. It has also been advocated in this thesis that the ultimate monitoring subject in a value constellation might be the *value activity* performed on the service provider's side. However, external actors, value activities and value objects also play an important role in the Service monitoring logic. Hence, a critical question to be answered by the ontology regards how these two scopes are related. This question involves several representation issues, including:

(1) What are the *activities* performed in a *monitoring value constellation*?
(2) What are the *roles* played by these activities?
(3) How are these *activity roles* represented?
(4) How are these activities distributed among the actors?
(5) What are the relationships between these activities and the value objects flowing in a *monitoring value constellation*?

The answers to these questions must be expressed in terms of explicit relationships among actors, value activities and value objects. Moreover, it is expected that such relationships make clearer the notion of a monitoring value constellation, as an organizational system.

Why to monitor a value constellation?

It has also been argued in this thesis that the *rationale* for monitoring a value constellation might be twofold. From a classic point-of-view, a value constellation should be monitored for the sake of *risk mitigation*. From another point-of-view, a value constellation should be monitored also because monitoring can constitute a source of *market exploitation*, i.e. monitoring can generate positive value. In order to be considered in conjunction, these disparate perspectives ought to be reconciled.

What these two perspectives have in common is the notion of a *business need*. In *e3value*, a business need comprises a specific consumer's market demand, which can be *explored* by business actors as a source of profit. Business needs can be satisfied through the provisioning of specific value objects. Normally, a value model expresses only *promises* to deliver these objects, but no *assurances* of such. *Assurance* in this context can be provided through *monitoring information* about the activities performed in the value constellation. Monitoring information can assume the form of specific value objects, i.e. monitoring objects, which constitute performance evidence of the value activities circumscribed in a value constellation. In this sense, monitoring information, as a *risk mitigation* mechanism, can be considered as *part of* a business need.

Nevertheless, monitoring information has also an intrinsic *value*, which can be *explicit* (e.g. its cost) or *implicit* (e.g. its intangible benefit). The *implicit* value of the monitoring information may include, for instance, the *assurance*, *convenience*, *loyalty* and *reliability* that it may represent to the party interested in monitoring the value constellation. Besides, on what regards the *explicit* value of monitoring information, it may become difficult to assess it as part of a business need, at least in a same value model. More precisely, it may be difficult to assess whether the business works *because of* the monitoring or *for* the monitoring. In the latter situation, for example, it may also be the case that the monitoring drains resources out of the core business. Therefore, it is advocated here that monitoring information should be considered as a business need in its own domain (i.e. an opportunity for market exploitation), kept as separate as possible from basic business needs.

An approach to deal with this issue is to split business needs in two: a core business need and a *monitoring need*. These needs should be treated in separation. A *monitoring need* is referred here to as a specific business need of monitoring information. Besides, a monitoring need can also be explored to configure a value constellation specialized in providing monitoring information through monitoring *services*. This type of value constellation is named here as a *monitoring value constellation*. Hence, if the main motivation of monitoring a value constellation is the one of generating value from the monitoring (i.e. treating monitoring as an opportunity for market exploitation), it becomes necessary to define precisely what a monitoring need is. This may trigger other questions, such as:

(1) Who has a monitoring need in a value constellation?
(2) How to prospect it?
(3) How to measure it?
(4) By which means could it be satisfied?
(5) Is it private or public information in a value constellation?

It is worth to highlight that the idea of monitoring value constellations for market exploitation actually extends the idea of monitoring them for the sake of risk mitigation. Both ideas rely on the concept of monitoring information. The extension comprehends the assignment of both explicit and implicit value to monitoring information. Regarding the *implicit* value of monitoring information, this issue demands further inquiries on the *organization* and *information disclosure* in a monitoring value constellation.

How to monitor a value constellation?

As introduced in **Chapter 2**, this question has been narrowed to how a *monitoring value constellation* is organized and how its corresponding monitoring information is disclosed among its participants. The answers to these questions are crucial, for as they may shed new light on the assessment of the *implicit value* of monitoring a value constellation. This issue comprises the ultimate research subject addressed in this thesis.

Regarding the organization of the monitoring of a value constellation, two options have been previously identified. The first one would comprise to delegate the monitoring of individual transactions of a value constellation to other value constellations specialized in providing monitoring services. Such an approach can also be informally referred as “monitoring tourniquet”, for as the logic behind it comprises to enforce value assurance through the construction of a *monitoring value constellation* around the underlying value transaction. Therefore, such an approach would require the use of external resources (i.e. actors, value activities and value objects) for monitoring a certain value transaction. Nonetheless, the second option would comprise to monitor critical value transactions through the internal delegation of monitoring responsibilities. Simply put, the logic behind such an approach comprises to reorganize a value constellation according to monitoring responsibilities. A value constellation like this would much resemble an internal monitoring coalition (or closed monitoring alliance). Both options have been analyzed through the course of this research. However, the latter one is the predominant idea advocated here.

Therefore, still regarding the organization of a *monitoring value constellation*, some questions of relevance to represent this type of knowledge include:

(1) What constructs define the organization of a *monitoring value constellation*?
(2) How are these constructs related? What are the main relationships among them?
(3) What is the rationale behind the monitoring organization?
(4) Can such a monitoring organization be replicated in value constellations from different businesses?
(5) Is the organization rigid or flexible? How much adaptation does it demand so as to be useful in practice?

Regarding the information disclosure in a *monitoring value constellation*, this issue may be controversial, at least at a first glance. The rationale behind such a system is the one of an ordinary value constellation that could monitor itself, through the use of its internal participants (i.e. with no insertion of external resources whatsoever). Roughly put, the idea behind such a notion is the one of "if you fail, we all fail". Nevertheless, for the sake of individual competitiveness and strategic advantage, some information ought to be kept private to the domain of the parties interested in monitoring the behavior of the entire constellation. This may give rise to other questions to be considered in the construction of the ontology, including:

(1) What are the constructs characterizing the notion of monitoring information in value constellations?
(2) How are these constructs related to one another?
(3) How much monitoring information is disclosed and how much is kept concealed to each actor?
(4) How do these concepts define the notion of *value monitoring*?

Definitely, the "how" part of monitoring value constellations is the most relevant topic covered by this research. The notion of value monitoring as addressed here is posed as a combination of organizational phenomena and best practices for Information Management specific to the requirements for a Service monitoring logic. Further clarification of this notion is provided through the development of the case study along this chapter.

Ontology Requirements Specification Document (ORSD)

According to the methodology adopted in this research, the competency questions raised in this section along with the documentation of the referred case study comprise the Ontology Requirements Specification Document (ORSD). In practice, though, the ORSD of this research encompasses further elements of practice scattered throughout this thesis, mainly in terms of elements of practice extracted from other case studies. Altogether, these resources provide the main requirements of knowledge representation for the construction of the ontology proposed here. Nonetheless, the scope of these questions falls far beyond of what could be captured by an only ontology model. These problems demand not only elements of *knowledge representation*, but also elements of *practice*, *strategy* and *technology*.

In the next section, these elements are provided through the proposition of the so-called Value Monitoring Ontology (VMO). The ontology is proposed as a means to support the communication of strategies for monitoring value constellations. It is therefore aimed to support the construction of a Business domain viewpoint on Service monitoring, which is referred here to as the *Value Activity Monitoring* viewpoint.

3.3 Ontology Representation

In order to be understood by a certain community of knowledge domain experts, an ontology must have its representation formalized, preferably by using a widely-accepted representation language. The Web Ontology Language (OWL) has become the *de facto* standard language for knowledge representation among practitioners from the Semantic Web and Ontology Engineering communities. OWL-DL is a decidable fragment of OWL and comes from a set of frame-based knowledge representation formalisms named Description Logics (Baader et al., 2003). Moreover, OWL can be used in two forms: in its machine-interpretable version (Motik, Patel-Schneider and Parsia, 2009), which allows automated reasoning and knowledge sharing on the Web, and in its more human-readable version – the OWL semantics and abstract syntax – which allows the expression of first-order logics axioms that compose an ontology.

The language used in this work is the OWL2, which constitutes the currently newest version of OWL. OWL2 evolves on its predecessor in terms of providing additional syntactic sugar (e.g. property disjointness and equivalence), which can be used to reduce ambiguity in the specification of the ontology axioms. This contributes to minimize problems of automated reasoning. Both languages are currently well-supported by the availability of tools for specification, syntax and consistency checking. In this chapter, the proposed ontology is described in OWL *abstract syntax*. The full OWL2 specification of VMO is provided as an **Appendix** in this document.

The main constructs of OWL comprise *classes*, *properties* and *individuals*. *Classes* are used to categorize individuals that share common characteristics. *Properties* link individuals to one another. OWL also has two types of properties: *object properties* and *data type properties*. An *object property* link an individual belonging to a certain class to an individual belonging to another class, whereas a *data type property* link individuals of a certain class to native OWL data types. Both classes and properties can be organized into *hierarchies*. Class hierarchies can be used as a starting point for the definition of more complex constructs, such as complex behavioral classes. Properties can also be specialized in many ways, such as with the use of cardinality constraints, and universal and existential quantification.

The representation of the Value Monitoring Ontology (VMO) is organized along three sub-sections. First, a basic *class hierarchy* is introduced. Second, an overview of the *property hierarchy* is provided. Last, a formal description of the ontology is presented by relating classes and properties through first-order logics *axioms.*

3.3.1 Class Hierarchy

As mentioned before, the notion of a monitoring value constellation consists of the enrichment of an ordinary value constellation with monitoring capabilities. It is also assumed that the specification of the underlying core business value constellation is given according to the *e3value* framework ontology – described in detail in (Gordijn, 2002). Thus, the modeling purpose here is not to redefine the notion of a value constellation as addressed by the *e3value* framework, but to extend its original constructs with the specification of monitoring constructs.

In order to achieve this effect, the definition of the monitoring constructs has been kept as loosely-coupled as possible from the definition of the *e3value* constructs. These two systems of constructs are connected through the notion of role-playing. Therefore, as depicted in **Figure 3-2**, the Value Monitoring Ontology (VMO) comprehends a class hierarchy composed of *e3value* constructs and *value monitoring constructs*. The classes here are organized through basic inheritance relationships (is-a). Classes market in light-grey represent *primitive classes*, whereas the ones market in dark-grey represent the *defined classes*. *Primitive classes* are defined by only necessary conditions. This type of condition can be read as “if an individual is a member of a certain class, then it is necessary for it to fulfill the conditions imposed by the description of this class”. *Defined classes* are described by necessary and sufficient conditions. This type of condition can be read as “if an individual fulfills the conditions describing a defined class, then it is sufficient to state that it is also a member of this class”. The description of both primitive and defined classes is provided in terms of axioms. An axiomatic description of ontology classes gives shape to the identity and behavior of the individuals that are members of these classes. The axiomatic description of the classes depicted here is provided further in this chapter.

Moreover, classes belonging to the same hierarchical level are considered here as mutually disjoint. Disjoint classes have no individuals in common.

Figure 3-2: Value Monitoring Ontology: asserted class hierarchy

A brief introduction to the VMO class hierarchy is described as follows. All the classes of the ontology derive from the OWL root class *Thing*, which has been suppressed in **Figure 3-2**. The class hierarchy splits in two main sub-hierarchies: one for the basic *e3value classes* and another one for the *value monitoring constructs*. The *e3value* classes included in this hierarchy include: *Actor*, *ValueObject*, *ValueOffering*, *MarketSegment*, *ValueInterface*, *ValueActivity*, *ValueTransaction*, *ValueExchange* and *ValuePort*. The *e3value* classes not considered here are considered only as supporting constructs (e.g. composite actor). All the *e3value* classes are posed here as *primitive*.

The most basic constructs of VMO comprise the classes that define the monitoring roles to be played by the *e3value* constructs. These comprise the *ActorRole*, *ActivityRole* and *ObjectRole* classes. The roles played by the *actors* are defined by the *MonitoringPrincipal*, *MonitoringThirdParty* and *MonitoringAgent* classes. The roles played by the value activities comprise the *MonitoringActivity* and *MonitoredActivity* classes. Accordingly, the roles played by the value objects comprehend the *CounterObject*, *MonitoringObject* and *MonitoredObject* classes. These classes are all *defined*. They are used to extend the actor, value activity and value object classes with monitoring behavior.

From the definition of these basic classes, other more complex constructs are derived, including the *MonitoringNeed*, *MonitoringPolicy* and *MonitoringIndicator* classes. Other supporting classes include the *Indicator*, *IndicatorRole* and *ValuePartition* classes. The IndicatorRole class has two subclasses: *ValuePropositionIndicator* and *ValueInUseIndicator*. The ValuePartition is "covered" by the classes *LowValue*, *HighValue* and *NeutralValue*. These classes are used to provide qualitative characterization of the concept of value.

Hence, the class hierarchy presented here comprises the basic VMO constructs. It is worth remarking that VMO does not include data type properties. This is due to the purpose of this ontology – to serve more as a formal specification than an implementation artifact.

3.3.2 Object Property Hierarchy

In OWL, properties can also be organized as hierarchies. Properties in OWL are used to define the behavior of classes. *Object properties*, more specifically, can be used to define one another mutually. These properties here are classified according to their respective *domains*, *ranges*, *super-properties*, *inverse properties* and *disjoint properties*. Property disjointness is one of the new constructs provided by OWL2. The summary of the object properties of VMO is provided in **Table 3-1**.

In OWL, object properties may have a *domain* and a *range* specified. Object properties link individuals from the domain class to the individuals from the range class. It is worth remarking that in OWL domains and ranges are not considered as constraints to be verified. They are used as reasoning axioms. These axioms are used to infer the types of the individuals that instantiate the property.

Table 3-1: Value Monitoring Ontology: Classification of Object Properties

Property	Domain	Range	Super Property	Inverse Property	Disjoint Properties
produces	ActivityRole	Object Role	CommunicationProperty	*isProducedBy*	*uses, consumes*
uses	ActivityRole	Object Role	CommunicationProperty	*isUsedBy*	*produces, consumes*
consumes	ActivityRole	Object Role	CommunicationProperty	*isConsumedBy*	*produces, uses*
achieves	MonitoringObject	MonitoringNeed	InformationProperty	*isAchievedThrough*	(OWA)
estimates	MonitoringPrincipal	MonitoringNeed	InformationProperty	*isEstimatedBy*	*measures*
measures	MonitoringPrincipal	MonitoringNeed	InformationProperty	*isMeasuredBy*	*estimates*
precedes	ValuePropositionIndicator	ValueInUseIndicator	InformationProperty	*isPrecededBy*	(OWA)
hasMonitoringGoal	MonitoringPrincipal	MonitoringNeed	InformationProperty	*isMonitoringGoalOf*	(OWA)
hasIndicatorRole	Indicator	IndicatorRole	InformationProperty	*isIndicatorRoleOf*	(OWA)
hasInformationExpression	ValueObject	Indicator	InformationProperty	*isInformationExpressionOf*	*hasInformationRealization*
hasInformationRealization	Indicator	ValuePartition	InformationProperty	*isInformationRealizationOf*	*hasInformationExpression*
hasReciprocity	MonitoringObject and MonitoredObject	CounterObject	InformationProperty	*isReciprocityOf*	(OWA)
isEstimationOf	ValuePropositionIndicator	MonitoringNeed	InformationProperty	*isEstimatedThrough*	*isMeasurementOf*
isMeasurementOf	ValueInUseIndicator	MonitoringNeed	InformationProperty	*isMeasuredThrough*	*isEstimationOf*
hasAuthority	ActorRole	ObjectRole	OrganizationProperty	*isAuthorityOf*	*hasCompetence, hasResponsibility*
hasCompetence	ActorRole	ObjectRole	OrganizationProperty	*isCompetenceOf*	*hasAuthority, hasResponsibility*
hasOwnership	ActorRole	ObjectRole	OrganizationProperty	*isOwnershipOf*	*hasPossession*
hasPossession	ActorRole	ObjectRole	OrganizationProperty	*isPossessionOf*	*hasOwnership*
hasResponsibility	Actor	ValueExchange	OrganizationProperty	*isResponsibilityOf*	*hasAuthority, hasCompetence*
hasActivityParticipant	MonitoringPolicy	ActivityRole	OrganizationProperty	*isActivityParticipantOf*	(OWA)
hasActorParticipant	MonitoringPolicy	ActorRole	OrganizationProperty	*isActorParticipantOf*	(OWA)
hasObjectParticipant	MonitoringPolicy	ObjectRole	OrganizationProperty	*isObjectParticipantOf*	(OWA)
hasActivityRole	ValueActivity	ActivityRole	OrganizationProperty	*isActivityRoleOf*	(OWA)
hasActorRole	Actor	ActorRole	OrganizationProperty	*isActorRoleOf*	(OWA)
hasObjectRole	ValueObject	ObjectRole	OrganizationProperty	*isObjectRoleOf*	(OWA)

The object properties in VMO are internally classified according to three super-properties: *CommunicationProperty*, *InformationProperty* and *OrganizationProperty*. These classes are purely representative, and do not admit domains or ranges. They are used to orient the human analyst on understanding the cross-disciplinary aspects included in the ontology. Thus, the *CommunicationProperty* comprises the super-property categorizing properties extracted from the literature in Communication and Language Action Perspective (Andersson et al., 2006; Dietz, 2006). Analogously, the *InformationProperty* comprehends sub-properties related to Service monitoring in general. Still, the *OrganizationProperty* comprises a mix of sub-properties extracted from the literature in Organizational Science and the Role-Based Access Control (RBAC) model.

For the sake of completeness, the object properties in VMO also admit corresponding inverse properties. Moreover, in order to reduce ambiguity from possible overlaps among shared domains and ranges, the properties have also been defined according to corresponding disjoint properties. However, disjointness has not been used thoroughly. Some object properties have been left with no mutual disjointness. For these cases, the interpretation is left for *Open World Assumption* (OWA). Such an assumption comprises to leave the interpretation on the property as free as possible from constraints. Disjointness in this case is left for open inference, through either human interpretation or automated reasoning.

There are two ways of creating descriptions for individuals in OWL. One way consists of defining *classes through properties*. Another way consists of defining *properties through classes* (i.e. via definition of domains and ranges). Although it is possible to use both approaches on the construction of an ontology, such a practice may lead to inconsistencies when automated reasoning is used. Hence, the domains and ranges described in **Table 3-1** have the purpose to facilitate the understanding of the internal structure of the ontology by human analysts. Nonetheless, the formal specification of the ontology (vide **Appendix**) does not include domains and ranges restrictions on the classes. Instead, the definition of the classes relies only on *necessary* and *necessary and sufficient conditions* (i.e. the definition of classes through properties). In the following sub-section, classes and properties are put into perspective through the description of the axioms that compose the theory expressed through the VMO model.

3.3.3 Axioms

In OWL2, axioms can be used to restrict the meaning of the theory expressed in an ontology model. OWL2 already provides some basic axioms that define the relationships among its basic modeling constructs, e.g. *class subsumption* and *property disjointness*. Other axioms can be specified by the ontology engineer so as to restrict the meaning of the added classes and properties. Axioms assume the form of logical statements, posing restrictions on the properties of a class. For example, the statement $3StarsHotel \sqsubseteq Accommodation \sqcap \exists\, provides.AirConditioning$ describes the class of three-star hotels, which are accommodations that provide an air conditioning service. The inclusion axiom '$\sqsubseteq$' means that any three-star hotel provides some air conditioning service, but not any accommodation that provides air conditioning is necessarily a three-star hotel. This could be expressed by using the equality axiom '$\equiv$' instead. Similarly, relationships of class subsumption can be expressed by a statement such as $3StarsHotel \sqsubseteq Accommodation$, defining that any three stars hotel is also a type of accommodation.

Moreover, properties can be constrained by quantification (i.e. existential and universal) or by cardinality (i.e. at least, at most and exactly). *Existential restrictions* describe classes of individuals that participate in *at least* one relationship along a specified property to individuals that are members of a specified class. For example, the class of individuals that have at least one (some) *provides* relationship towards members of the class *Air Conditioning*. The word 'some' is used to denote existential restrictions[1]. Differently, *universal restrictions* describe classes of individuals that for a given property *only* have relationships along this property to individuals that are members of a specific class. For example, the class of individuals that only have *provides* relationships with members of the class *Free Parking*. The word 'only' is used to denote universal restrictions[2].

Finally, a more complex class description may involve the concatenation of multiple axiomatic declarations, through the use of *union* and *intersection* role constructors. In the example, the constructor '$\sqcap$' has been used to concatenate, as a logical 'and', the hierarchical condition of the class *3StarsHotel* with the property describing it.

The axiomatic description of VMO is provided here in two parts. The first part comprises a recap on the main modeling constructs of the *e3value* framework. The second part elaborates on the value monitoring constructs defining the notion of a monitoring value constellation.

The *e3value* Constructs

The *e3value* constructs considered here comprehend some of the basic constructs extracted from the original *e3value* ontology (Gordijn, 2002). The original model has been described in the Unified Modeling Language (UML). Here, the description of the model has been slightly changed so as to provide a uniform axiomatic description. The modeling constructs are described below.

Actor

An *actor* in *e3value* comprehends an independent entity which can assume socio-economic responsibilities. Enterprises and organizations in general are good examples of actors. Although it may be possible to include individual human resources as

[1] Existential restrictions may be denoted by the existential quantifier ($\exists$). They are also known as 'someValuesFrom' in OWL speak.

[2] Universal restrictions may be denoted by the universal quantifier ($\forall$). They are also known as 'allValuesFrom' in OWL speak.

actors in a value model, it is more common to refer to them as part of collective organizations. Socio-economic responsibilities in this context are normally referred to as *core business competences* or *value activities*. Some examples include value activities of production, distribution, manufacturing, collection, consumption and management activities in general.

Hence, according to the axiom described below, an actor is defined as an *e3value* construct, operating in some market segment, performing exactly one type of value activity, and having at least one value interface for the exchange of value objects. However, in a *monitoring value constellation*, actors have different *monitoring roles*. Possible monitoring roles of actors include the ones of a *monitoring agent*, *monitoring principal* and *monitoring third-party*. In order to restrict the roles of an actor to the ones relevant for a monitoring context, a closure axiom must be defined. Therefore, in a *monitoring value constellation*, an actor can play *only* the before mentioned roles. The definition of these roles is provided further, in the sub-section of the value monitoring constructs. Last, an actor has the responsibility on his own value exchanges. In *e3value*, value exchanges constitute the means whereby the economic objects are communicated among the actors. The relationship of responsibility declared here much resembles the concept of a coordination act, from the Language Action Perspective (Austin, 1962; Searle, 1969).

$$
\begin{aligned}
Actor \sqsubseteq\ & e3valueConstruct \sqcap \\
& \exists\, in.MarketSegment \sqcap \\
& = 1\ performs.ValueActivity \sqcap \\
& \geq 1\ has.ValueInterface \sqcap \\
& \exists\, hasActorRole.MonitoringAgent \sqcap \\
& \exists\, hasActorRole.MonitoringPrincipal \sqcap \\
& \exists\, hasActorRole.MonitoringThirdParty \sqcap \\
& \qquad \forall\, hasActorRole.(MonitoringAgent \sqcup MonitoringPrincipal \sqcup \\
& \qquad MonitoringThirdParty) \sqcap \\
& \exists\, hasResponsibility.ValueExchange
\end{aligned}
$$

Market Segment

A *market segment* consists of a set of actors that perform the same type of value activity. Market segment can also communicate through at least one value interface. The description of this concept has been kept as the original.

$$
\begin{aligned}
MarketSegment \sqsubseteq\ & e3valueConstruct \sqcap \\
& \exists\, consistsOf.Actor \sqcap \\
& \geq 1\ has.ValueInterface
\end{aligned}
$$

Value Activity

A *value activity* consists of the main business competence performed by a certain actor. Value activities also have at least one value interface. What is relevant for the monitoring context here is that value activities can also play monitoring roles. These roles are given according to Agency relationships. Hence, a value activity can assume the role of a *Monitoring Activity* or a *Monitored Activity*. Similar to actors, a closure axiom is defined so as to restrict the roles that can be played by value activities in monitoring value constellations. Behavioral specification of the roles of monitoring activities is provided further in this section. The basic class axioms are given below.

$$
\begin{aligned}
ValueActivity \sqsubseteq\ & e3valueConstruct \sqcap \\
& = 1\ isPerformedBy.Actor \sqcap \\
& \geq 1\ has.ValueInterface \sqcap \\
& \exists\ hasActivityRole.MonitoringActivity \sqcap \\
& \exists\ hasActivityRole.MonitoredActivity \sqcap \\
& \quad \forall\ hasActivityRole.(MonitoringActivity \sqcup \\
& \quad MonitoredActivity)
\end{aligned}
$$

Value Object

Together with actors and value activities, *value objects* comprise one of the most important concepts of a value constellation. A value object consists of an object of economic value, which can be traded among the participants of a value constellation. Value objects are offered and requested through *value ports*, a concept explained further. In *e3value*, the notion of a value object already denotes some *information* about the object itself (e.g. the price of the object). However, a distinction starts to be drawn here with the purpose of separating possible types of information that can be assigned to value objects. Amount-of-matter, price and time of delivery are examples of what has been named elsewhere as *first-order values* (Weigand et al., 2007). These values are essential for the economic sustainability of a value constellation. However, as discussed before on the value of monitoring, there are other values that are important to assess the success of the monitoring itself. These values have also been referred as *second-order values* (Weigand et al., 2007). Therefore, this second layer of information comprises what is called here as the *information expression* of a value object.

Similar to actors and value activities, value objects also play different roles in a monitoring value constellation. The roles considered here comprises the ones of a *counter-object*, *monitoring object* and *monitored object*. A closure axiom is also applied here to restrict the scope of possible roles played by the objects of a monitoring value constellation.

$$
\begin{aligned}
ValueObject \sqsubseteq\ & e3valueConstruct \sqcap \\
& \exists\ isOffered\_Requested\_By\ .ValuePort \sqcap \\
& \forall\ hasInformationExpression.Indicator \sqcap \\
& \exists\ hasObjectRole.MonitoringObject \sqcap \\
& \exists\ hasObjectRole.MonitoredObject \sqcap \\
& \exists\ hasObjectRole.CounterObject \sqcap \\
& \quad \forall\ hasObjectRole.(MonitoringObject \sqcup MonitoredObject \sqcup \\
& \quad CounterObject)
\end{aligned}
$$

Value Exchange

A *value exchange* is the abstract communication channel that connects actors in a value constellation. Communication here is purely economic. Thus, a value exchange also connects two value ports: one from the actor providing the value object and another one from the actor receiving it. A value exchange therefore connects exactly one output value port from one actor's domain to a corresponding input value port from another actor's domain. Value exchanges can also compose value transactions. As mentioned above, value exchanges are also shared responsibility between the actors involved in a value transaction.

$$\begin{aligned} ValueExchange \sqsubseteq\ & e3valueConstruct \sqcap \\ & = 1\ hasIn.ValuePort \sqcap \\ & = 1\ hasOut.ValuePort \sqcap \\ & \geq 1\ in.ValueTransaction \sqcap \\ & \exists\ isResponsibilityOf.Actor \end{aligned}$$

Value Offering

A *value offering* denotes what an actor offers to or requests from the environment circumscribed by a value constellation, through in-going and out-going offerings, respectively. It closely relates to the concept of a value interface (see below). A *value interface* models an offering of an actor to his/her environment, and the offering such an actor requests in return from his/her environment. An offering is a set of equally directed value ports exchanging value objects, and implies that all ports in that offering should exchange value objects or none at all. A value offering consists of one or more equally directed value ports. A value port is in exactly one value interface.

$$\begin{aligned} ValueOffering \sqsubseteq\ & e3valueConstruct \sqcap \\ & = 1\ in.ValueInterface \sqcap \\ & \geq 1\ consistsOf.ValuePort \end{aligned}$$

Value Interface

A *value interface* is an abstract construct supporting the economic communication in a value constellation. It groups one in-going and one out-going value offering. It can also be assigned to at most one actor, or market segment or value activity. In practice, value interfaces work as logical containers of value ports. For the sake of profitability analysis, it helps to organize value objects into pairs of economic reciprocity.

$$\begin{aligned} ValueInterface \sqsubseteq\ & e3valueConstruct \sqcap \\ & \leq 2\ consistsOf.ValueOffering \sqcap \\ & \leq 1\ assignedTo.Actor \sqcap \\ & \leq 1\ assignedTo.MarketSegment \sqcap \\ & \leq 1\ assignedTo.ValueActivity \sqcap \\ & \quad \forall\ assignedTo.(ValueActor \sqcup Value\ Activity \sqcup \\ & \quad MarketSegment) \end{aligned}$$

Value Port

A *value port* gives direction to value exchanges. While value exchanges comprise the channels whereby the objects are communicated, value ports provide the orientation of who is giving and taking what in the exchange. Value ports are also important concepts for accountability and control. In profitability sheets, value ports control the number of objects exchanged among the actors. A value port *in-connects* and *out-connects* value exchanges, *offers* or *requests* exactly one type of value object and is *in* exactly one offering. Hence, the most important information here regards the type of value object communicated through a value port. The specific amount of the value objects transferred has secondary relevance.

The concept of a value port is also useful to define how the rights of ownership and possession of the value objects are managed in a value constellation. From a Language Action Perspective, value ports denote implicit coordination acts of *requesting* and *offering*. Moreover, value ports also abstract from the internal structure of the business processes implementing the economic exchanges.

$$\begin{aligned} ValuePort \sqsubseteq\ & e3valueConstruct \sqcap \exists\ inConnects.ValueExchange \sqcap \\ & \exists\ outConnects.ValueExchange \sqcap \\ & = 1\ offers\_requests.ValueObject \sqcap \\ & = 1\ in.ValueOffering \end{aligned}$$

Value Transaction

From the global perspective of an entire value constellation, value exchanges may be perceived as randomly organized coordination acts of an economic order. However, from a local perspective, the same system can also be perceived from pairs of actors exchanging value objects. Each of these units of exchange comprises an agreement in potential, or a prelude for business contracts. The set of value exchanges performed between a certain pair of actors operating in a value constellation comprises the so-called *value transaction.*

$$\begin{aligned} ValueTransaction \sqsubseteq\ & e3valueConstruct \sqcap \\ & \geq 1\ consistsOf.ValueExchange \end{aligned}$$

Monitoring a value constellation is quite an open question. There are many possible starting points. The direction adopted here, however, comprises to structure the Service monitoring logic from the level of value transactions. Truly, some value transactions are more critical than others in a value constellation. Not only can value transactions be considered as monitoring contexts in their own domain, but also, as starting points to organize the monitoring of a value constellation.

The Value Monitoring Constructs

As previously mentioned in this chapter, the notion of a *monitoring value constellation* comprises the extension of an ordinary value constellation with monitoring capabilities. The extension proposed here aims to preserve the definitions of the two systems as loosely-coupled as possible. This can be achieved through the definition of monitoring roles to be played by the elements of a value constellation. The main elements to be characterized by monitoring roles comprise the classes of *actors*, *value activities* and *value objects*. Based on these roles, more complex monitoring concepts can be derived. These include the notions of *monitoring need*, *monitoring policy* and *monitoring indicator*. Together, they can be used to describe the model of a *monitoring value constellation*.

The axiomatic description of these elements is provided below. Each of the concepts is described in two steps. First, a brief statement about the properties of the concept is provided. Second, the properties are formalized into logical axioms. These axioms define the social behavior of the monitoring constructs, through the use of the *communication*, *information* and *organization* properties mentioned above. As the most elementary concepts are composed into more complex ones, an attempt is made decompose the overall description gradually. Whenever found appropriate, the concepts will be illustrated through the value model of the IPR case.

Monitoring Principal

As explained in **Chapter 2**, the Agency Theory comprises the main organizational theory serving as a background for the notion of a *monitoring value constellation*. It has also been proposed that the monitoring organization of a value constellation can start from the micro-context of its constituent transactions. Now considering the satisfaction of the consumer's need as the main goal of the constellation, this can be split into core business needs (e.g. an Intellectual Property Right – IPR), and *monitoring needs* (e.g. monitoring information about the appropriate use of the IPRs). As the party interested in monitoring the entire constellation, the final consumer has the option to engage in one or more value transactions whereby his monitoring needs could be achieved. Although value transactions with external actors could be considered for this purpose, the approach considered here involves the final consumer using his previously committed transactions to monitor the constellation. In either case, the final consumer has the focal monitoring perspective here, and could assume the role of a *monitoring principal.* The axiomatization of this role is provided below.

$$
\begin{aligned}
&MonitoringPrincipal \equiv ActorRole \sqcap \\
&\qquad \forall\, hasMonitoringGoal.MonitoringNeed \sqcap \\
&\qquad \exists\, estimates.MonitoringNeed \sqcap \\
&\qquad \forall\, measures.MonitoringNeed \sqcap \\
&\qquad \exists\, hasCompetence.MonitoringActivity \sqcap \\
&\qquad \forall\, hasPossession.CounterObject \sqcap \\
&\qquad \forall\, hasOwnership.MonitoringObject \sqcap \\
&\qquad \forall\, hasAuthority.ValueInUseIndicator \sqcap \\
&\qquad \exists\, isActorParticipantOf.MonitoringPolicy
\end{aligned}
$$

Hence, an *actor* (enterprise or organization) performing a *monitoring principal* role is the one who:

(1) *Has the monitoring goal of only filling a monitoring need* – as proposed before, core business needs and monitoring needs should be treated in separation. In *e3value*, the concept of a business need denotes a certain actor/market's demand that can be filled by a specific type of value object. Thus, a monitoring principal *has a monitoring goal* of filling a monitoring need. The description of a monitoring need is made more explicit further.

(2) *Estimates some monitoring need* – estimation here refers to *prospection*. The point here is that monitoring needs represent only part of what could be prospected in a value constellation.

(3) *Measures only monitoring need* – there are many possible sources of measurement in a value constellation. However, a monitoring need is the ultimate measurement subject of a monitoring principal.

(4) *Has competence of some monitoring activity* – according to the Enterprise Ontology (Dietz, 2006), enterprise actors engage on production acts through competence, and on coordination acts, through responsibility. This view is adapted and used here. In *e3value*, the notions of production and coordination acts are not explicitly stated. To make this aspect clearer, it has been stated before that all the actors in ordinary value constellations engage on value exchanges through the relationship of *responsibility*. Here, it is declared that monitoring actors engage on monitoring roles through *competence*. Hence, a monitoring principal has the *competence* to perform a monitoring activity. Agency relationships are also applied here to characterize value activities.

(5) *Has possession of only counter-objects* – in *e3value*, the concept of a value exchange denotes coordination. However, a value exchange is not decomposed into coordination acts of offering, requesting, accepting or confirming, for as a value model is not a process model. However, in the context of monitoring, it is essential to govern how the monitoring information flows among the actors of a value constellation. Thus, a monitoring principal is the one who *has possession* of counter-objects. The semantics of possession here also comes from Agency Theory. That is, what is given is ownership, and what is taken is possession.

(6) *Has ownership of only monitoring objects* – all the monitoring objects flow to the monitoring principal because he owns these objects.

(7) *Has authority on only value-in-use indicators* – as detailed further, indicators comprehend information about value objects. Not any ordinary information is considered here, but only the ones which refer to *value*. A monitoring principal has *authority* on value-in-use indicators, which comprise specific type of indicators. Authority here is referred to as a variant of possession. That is, authority implies possession on a certain type of information.

(8) *Is participant of some monitoring policy* – as detailed further, a monitoring policy is a networked form of organization. It frames actors, value activities and value objects as a closed monitoring alliance. A monitoring principal has fundamental participation in this alliance.

As denoted by the symbol of concept equality, the monitoring principal role is a defined (behavioral) class. All individuals exhibiting the properties listed above can be classified as fillers of this role.

Monitoring Agent

Monitoring, as a value activity, can also be delegated. A *monitoring agent* is the one who performs a monitoring activity that could be done by the monitoring principal. A monitoring value constellation can be organized in pairs of monitoring agents and principals. That is, monitoring in general can also be subject of Agency (Shapiro, 2005). In order to monitor a value constellation, an actor performing the role of a monitoring principal may engage on one or many Agency relationships of monitoring. Such relationships do not necessarily need to include external actors. Thus, a social phenomenon of particular interest comprises to transform the existing value transactions of a value constellation into monitoring (agency) transactions. The behavior of the monitoring agent is described as follows.

$$\begin{aligned} MonitoringAgent \equiv\ & ActorRole \sqcap \\ & \forall\, hasCompetence.MonitoringActivity \sqcap \\ & \forall\, hasPossession.MonitoringObject \sqcap \\ & \forall\, hasOwnership.MonitoredObject \sqcap \\ & \exists\, hasAuthority.ValuePropositionIndicator \sqcap \\ & \exists\, isActorParticipantOf.MonitoringPolicy \end{aligned}$$

Therefore, an *actor* performing a *monitoring agent* role is the one who:

(1) *Has competence to perform only monitoring activities* – once the monitoring principal delegates the monitoring activity to a monitoring agent, this one acquires the competence of performing it.
(2) *Has possession of only monitoring objects* – monitoring agents only manage monitoring objects on behalf of the monitoring principals. This is a form of possession.
(3) *Has ownership of only monitored objects* – as explained further, a monitored object is a raw version of a monitoring object. In order to provide monitoring objects to a monitoring principal, a monitoring agent has to get the resources for it, which includes monitored objects. These come from relationships with monitoring third-parties. From these relationships, a monitoring agent acquires possession on monitored objects.
(4) *Has authority of only value proposition indicators* – monitoring objects are also subject of valuation. From a Service-Dominant Logic perspective (Vargo and Akaka, 2009), service providers can only offer value propositions. However, value can only be measured on the consumer's side, through experience and use. Therefore, any information qualifying monitoring objects provided by a monitoring agent represent only value proposition of such.
(5) *Is participant of some monitoring policy* – a monitoring agent is also part of a monitoring policy.

A monitoring agent is also a defined (behavioral) class. The conditions above are necessary and sufficient to describe this actor role.

Monitoring Third-Party

The importance of third-parties is recognized in extended versions of Agency Theory (Arthurs et al., 2008). In order to fill his obligations toward a principal, an agent may engage in direct collaboration with third-parties from whom some necessary resources may be obtained. In this case, implied relationships between principals and third-parties are only indirect. Third-parties are also considered important here in the context of monitoring value constellations. The axiomatization of the role is provided below.

$$
\begin{aligned}
MonitoringThirdParty \equiv {} & ActorRole \sqcap \\
& \forall\, hasCompetence.MonitoredActivity \sqcap \\
& \forall\, hasOwnership.CounterObject \sqcap \\
& \forall\, hasPossession.MonitoredObject \sqcap \\
& \exists\, hasAuthority.ValuePropositionIndicator \sqcap \\
& \exists\, isActorParticipantOf.MonitoringPolicy
\end{aligned}
$$

Thus, an *actor* performing a *monitoring third-party* role is the one who:

(1) *Has competence to perform only monitored activities* – the monitoring third-party is the target of the monitoring mechanism, according to the predominant point-of-view of the monitoring principal. A monitoring third-party, therefore, can be monitored by the monitoring principal, through the mediation of at least one monitoring agent.
(2) *Has ownership of only counter-objects* – the counter-objects flow from the monitoring principal, through the monitoring agents, to reach the monitoring third-parties.
(3) *Has possession of only monitored objects* – as the monitoring third-party engages in collaboration with monitoring agents, it becomes a mere possessor of the monitored objects it delivers.
(4) *Has authority on some value proposition indicator* – the monitored objects delivered by a monitoring third-party are offered to the monitoring agents as propositions. Although they represent primary evidence of value activity performance, there is no guarantee that such objects are actually authentic.
(5) *Is participant of some monitoring policy* – the monitoring third-party is the third actor participant of a monitoring policy. Together with monitoring agents and principals, they form a triangle where many problems of monitoring may arise. The main problems involve information asymmetry and opportunistic behavior (Bolton and Dewatripont, 2004).

A *monitoring third-party* is a defined (behavioral) class. The conditions above are necessary and sufficient to describe this actor role.

In order to illustrate the actor roles described above, a scenario from the IPR case is depicted in **Figure 3-3**. The initial monitoring organization comprises: (1) an *IPR* *society* playing the role of a monitoring principal; (2) two *digital music providers* playing the role of monitoring agents; and (3) a market segment of *digital music users* playing the role of a monitoring party. So far, the original value objects are kept intact. The *e3value* notation is extended with UML-like stereotypes discriminating the actor roles. As the description of the monitoring roles is decomposed, the model of the monitoring value constellation of the IPR case will be gradually composed.

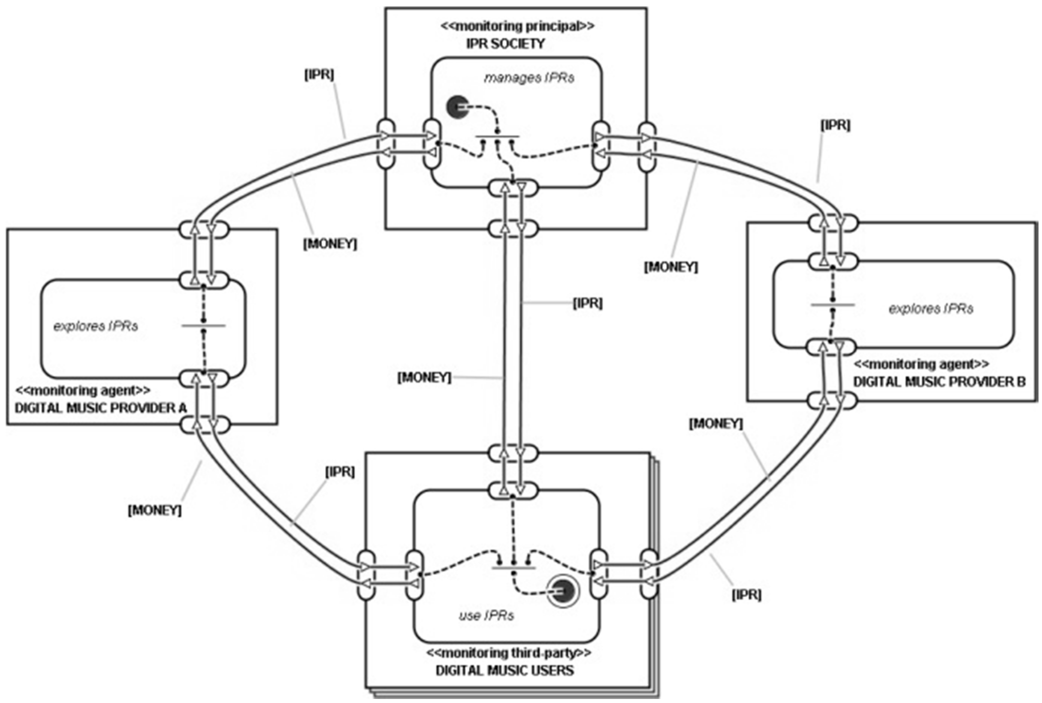

Figure 3-3: IPR monitoring value constellation: snapshot on actor roles

Monitored Activity

Once the roles of the main actors involved have been defined, the next step comprises to define the roles of their respective value activities of competence. Here, the specification of the roles played by value activities is also covered by Agency Theory. Therefore, two types of value activities are recognized: monitored activity and monitoring activity. A *monitored activity* constitutes the back-end value activity of the value constellation. It is the activity from which the core business objects are produced. It comprises also the main suspect source of opportunistic behavior. The role of this activity is formally described as follows:

$$
\begin{aligned}
MonitoredActivity \equiv\ & ActivityRole \sqcap \\
& \forall\, isCompetenceOf.MonitoringThirdParty \sqcap \\
& \forall\, produces.MonitoredObject \sqcap \\
& \exists\, uses.CounterObject \sqcap \\
& \exists\, consumes.CounterObject \sqcap \\
& \exists\, isActivityParticipantOf.MonitoringPolicy
\end{aligned}
$$

Therefore, a *value activity* performing a *monitored activity* role is the one which:

(1) *Is competence of only a monitoring third-party* – a monitored activity is on the extreme of the triple involving principal, agent and third-party. This is an implied relationship. Third-parties do not perform monitoring, but are only subjects of it. The same applies to their corresponding value activities.
(2) *Produces only monitored objects* – not only is this activity a source of opportunistic behavior, but also its produced objects.
(3) *Uses some counter-objects* – the objects primarily produced by the monitoring principal flow toward this activity. That is why it is the back-end value activity of the constellation. Counter-objects here have an aim to preserve economic reciprocity even in the monitoring context. That is, monitored objects have also a relative price.
(4) *Consumes some counter-objects* – some counter-objects are used by this activity, but some end up on being consumed by it.
(5) *Is activity participant of some monitoring policy* – monitored activities integrate the structure of a monitoring policy.

At this point, it is worth to remark the use of production acts specific to a value constellation. These comprise the acts of *producing*, *using* and *consuming* value objects in value constellations. Production acts represent some of the basic constructs of a communication act, according to classic literature in Language Action Perspective (Austin, 1962; Searle 1969; Allwood, 1976). In the field of Information Systems, Dietz (2006) has also applied the same notion so as to represent private activities performed by the actors that compose the modern Enterprise. The Business Reference Ontology (Andersson et al., 2006) identifies some of the main types of activities that are also identified in value constellations. These types of activity have been adapted here so as to characterize the main *value activities* that comprise a monitoring value constellation. These types of activities represent the extremes of a value constellation, being assigned to the *service producer* and to the *service consumer*, respectively. All the other intermediate activities performed by actors supporting the economic communication of these two extremes comprise the value activities that somewhat *use* or *transform* the value objects circulating in a value constellation. Examples of using and transforming value activities include activities of *management*, *processing* and *semi-manufacturing*.

Hence, the value activities of *consumption*, *production* and *use* are sufficient to describe also a monitoring value constellation as a closed monitoring system, from which performance evidence can easily be sensed among the participants of the system. A *monitored activity*, therefore, can either consume or produce monitored objects.

Monitoring Activity

While the monitored activity is on the service provider's side of the value constellation, the monitoring activity is originally on the service consumer's side.

However, as mentioned before, this activity can also be delegated to specialized monitoring agents. The formalization of this role is given below.

$$
\begin{aligned}
& MonitoringActivity \equiv ActivityRole \sqcap \\
& \qquad \exists\, isCompetenceOf.MonitoringPrincipal \sqcap \\
& \qquad \exists\, isCompetenceOf.MonitoringAgent \\
& \qquad\qquad \forall\, isCompetenceOf.(MonitoringAgent \sqcup \\
& \qquad\qquad MonitoringPrincipal) \sqcap \\
& \qquad \exists\, produces.CounterObject \sqcap \\
& \qquad \exists\, uses.MonitoredObject \sqcap \\
& \qquad \forall\, consumes.MonitoringObject \sqcap \\
& \qquad \exists\, isActivityParticipantOf.MonitoringPolicy
\end{aligned}
$$

Hence, a *value activity* performing a *monitoring activity* role is the one which:

(1) *Is competence of only a monitoring principal or a monitoring agent* – primarily, this activity is competence of the monitoring principal. However, it can be delegated to monitoring agents. For the monitoring principal, this delegation reduces the scope of monitoring an entire constellation (and its individual transactions) to the scope of transactions with the monitoring agents.

(2) *Produces some counter-objects* – among many other types of supporting objects, counter-objects are the main ones produced by this activity.

(3) *Uses some monitored objects* – a monitoring activity transforms monitored objects (primary performance evidence) into monitoring objects (secondary performance evidence). For example, the money paid by an IPR consumer (e.g. a restaurant) to an IPR user (e.g. a digital music provider) comprises primary performance evidence for the IPR case value constellation. However, the money reported from the IPR user to the IPR society does not constitute primary evidence anymore. This is a processed version of the evidence, which comprises actually a monitoring object.

(4) *Consumes only monitoring objects* – many types of objects may flow from and to a monitoring value activity, but only monitoring objects are of special interest of consumption. For example, IPR societies (as monitoring principals) receive reports of the money paid by digital music consumers (as monitoring third-parties), but their ultimate interest is on the (reliable) performance reports provided by the digital music providers (as monitoring agents).

(5) *Is activity participant of some monitoring policy* – together with the monitored activity and their respective competent actors, this activity type is also participant of a monitoring policy.

It is worth noting how the monitoring roles described so far are constructed in terms of mutual relationships of Communication Action. The descriptions of the monitoring actors and monitoring activities provided thus far are illustrated below in **Figure 3-4**. Here, the value activities of *managing* and *exploring* IPRs play the role of *monitoring activities*, being assigned to the *IPR societies* and to the *digital music providers*, respectively. The value activity of *using* IPRs plays the role of a monitored activity, being assigned to the *digital music users*.

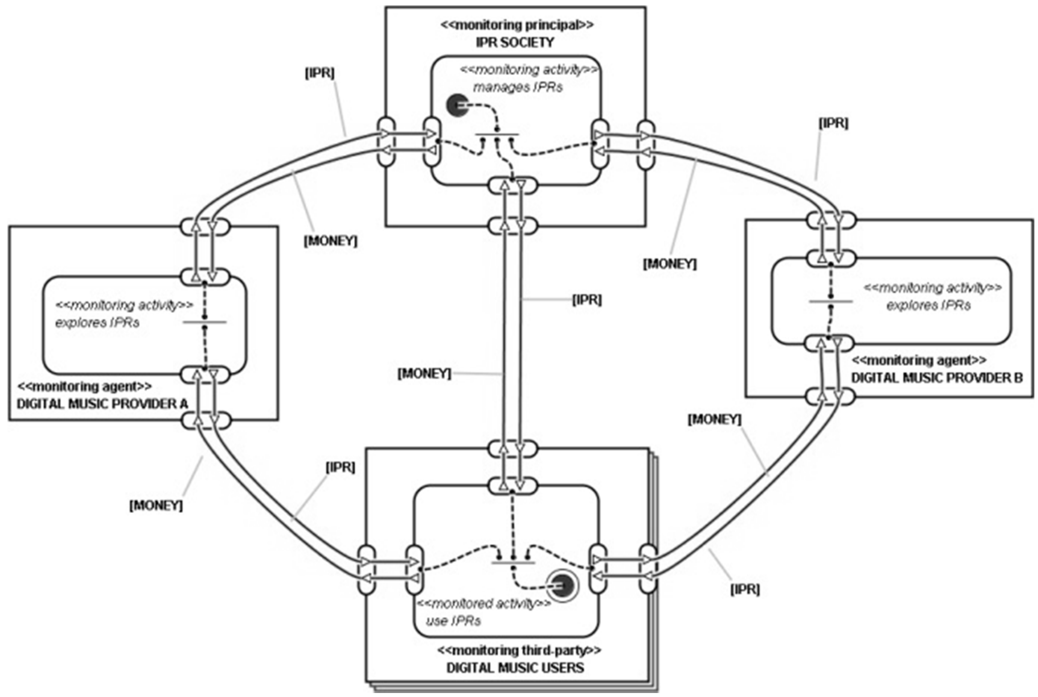

Figure 3-4: IPR monitoring value constellation: snapshot on actor and value activity roles

In order to complete the basic organization of a monitoring value constellation, as depicted above, it is necessary to define the roles of the objects that flow in this system.

Monitored Object

The *monitored object* comprises the observable behavior of a monitored activity. It comprises actually the most tangible source of monitoring information in a monitoring value constellation. The description of this object role is given below.

$$\begin{aligned}
&MonitoredObject \equiv ObjectRole \sqcap \\
&\quad \forall\, isProducedBy.MonitoredActivity \sqcap \\
&\quad \exists\, isUsedBy.MonitoringActivity \sqcap \\
&\quad \exists\, isOwnershipOf.MonitoringAgent \sqcap \\
&\quad \exists\, isOwnershipOf.MonitoringPrincipal \sqcap \\
&\qquad \forall\, isOwnershipOf.(MonitoringAgent \sqcup \\
&\qquad MonitoringPrincipal) \sqcap \\
&\quad \forall\, isPossessionOf.MonitoringThirdParty \sqcap \\
&\quad \forall\, hasReciprocity.CounterObject \sqcap \\
&\quad \exists\, isObjectParticipantOf.MonitoringPolicy
\end{aligned}$$

Hence, a *value object* performing a *monitored object* role is the one which:

(1) *Is produced by only a monitored activity* – as discussed before, the back-end value activity of production is the main target of the monitoring here. This activity may act as a monitored activity. As its internal behavior is unknown, its external behavior is defined through the monitored object.
(2) *Is used by some monitoring activity* – delegated monitoring activities may use the monitored objects to produce the monitoring objects of interest of the monitoring principal.
(3) *Is ownership of some monitoring agent* – monitored objects only flow through the domain of monitoring agents. These in turn have direct access to the monitored information, through direct relationships with the monitoring third-parties.
(4) *Is ownership of some monitoring principal* – private verifiable information, such as the monitored objects, has a cost. Monitoring principals acquire some ownership rights to get this information externally, through the action of the monitoring agents.
(5) *Is ownership of only a monitoring agent or a monitoring principal* – this closure axiom represents that these actor roles are the only ones to whom it is granted ownership of the monitored objects.
(6) *Is possession of only a monitoring third-party* – this axiom reinforces the role of monitoring third-parties as managers of the monitored objects.
(7) *Has reciprocity with some counter-object* – this condition states that some reciprocity is needed for acquiring monitored objects.
(8) *Is object participant of some monitoring policy* – value objects roles also compose the structure of the monitoring policy, described further in this section.

Monitored object is also a defined (behavioral class). It must be noticed that the characterization of a monitoring value constellation is the one of a social behavior phenomenon.

Monitoring Object

A *monitoring object* is a result of transformation of monitored objects. It corresponds to the notion of secondary performance evidence. This type of object is of ultimate interest of the monitoring principal of a value constellation. In order to reach this end, this object has to fill some social relationships, such as the ones formalized below.

$$
\begin{aligned}
&MonitoringObject \equiv ObjectRole \sqcap \\
&\qquad \exists\, isProducedBy.MonitoringActivity \sqcap \\
&\qquad \forall\, isConsumedBy.MonitoringActivity \sqcap \\
&\qquad \forall\, isOwnershipOf.MonitoringPrincipal \sqcap \\
&\qquad \forall\, isPossessionOf.MonitoringAgent \sqcap \\
&\qquad \forall\, hasReciprocity.CounterObject \sqcap \\
&\qquad \exists\, achieves.MonitoringNeed \sqcap \\
&\qquad \exists\, isObjectParticipantOf.MonitoringPolicy
\end{aligned}
$$

Thus, a *value object* performing a *monitoring object* role is the one which:

(1) *Is produced by some monitoring activity* – a monitoring activity uses monitored objects (primary performance evidence) and transforms them into monitoring ones (secondary performance evidence).
(2) *Is consumed by only a monitoring activity* – although these objects may flow through alternative paths in a value constellation, they can only be consumed at the monitoring principal's side.
(3) *Is ownership of only a monitoring principal* – as the monitoring principal engages in monitoring relationships with monitoring agents, he acquires ownership on the monitoring objects produced by them.
(4) *Is possession of only a monitoring agent* – this relationship reinforces again the supporting role of the monitoring agents as possessors of monitoring objects.
(5) *Has reciprocity with only a counter-object* – monitoring objects also have a cost, which is covered by reciprocal exchanges.
(6) *Achieves some monitoring need* – this relationship is crucial. As discussed before, monitoring here is treated as a business need in its own. As ordinary business needs require provisioning of specific value objects, the same applies to monitoring needs. A monitoring object is used to achieve a monitoring need.
(7) *Is object participant of some monitoring policy* – *idem* to previous explanation for monitored objects.

Monitoring object is also a defined (behavioral) class. The conditions stated above are necessary and sufficient to describe them.

Counter-Object

The *counter-object* comprises the glue of economic reciprocity in a monitoring value constellation. As the monitoring relationships described here are also subject to Agency, monitoring and monitored objects ought to be provided at a cost. This cost not necessarily need to be absolute (e.g. monetary), but rather relative, i.e. defined in terms of something offered in return. An attempt to clarify the role of this object is provided through the formalization below.

$$
\begin{aligned}
&CounterObject \equiv ObjectRole \sqcap \\
&\quad \exists\, isProducedBy.MonitoringActivity \sqcap \\
&\quad \exists\, isUsedBy.MonitoringActivity \sqcap \\
&\quad \forall\, isConsumedBy.MonitoredActivity \\
&\quad \exists\, isOwnershipOf.MonitoringAgent \sqcap \\
&\quad \exists\, isOwnershipOf.MonitoringThirdParty \sqcap \\
&\qquad \forall\, isOwnershipOf.(MonitoringAgent \sqcup \\
&\qquad MonitoringThirdParty) \sqcap \\
&\quad \exists\, isReciprocityOf.MonitoringObject \sqcap \\
&\quad \exists\, isReciprocityOf.MonitoredObject \sqcap \\
&\qquad \forall\, isReciprocityOf.(MonitoringObject \sqcup MonitoredObject) \sqcap \\
&\quad \forall\, isPossessionOf.MonitoringPrincipal \sqcap \\
&\quad \exists\, isObjectParticipantOf.MonitoringPolicy
\end{aligned}
$$

Therefore, a *value object* performing a *counter-object* role is the one which:

(1) *Is produced by some monitoring activity* – the monitoring principal has the major monitoring perspective over the value constellation. This is done through his internal monitoring activity (i.e. the consumer's value activity). This activity is served by external monitoring objects provided by monitoring agents. In order to acquire these objects, the monitoring principal offers counter-objects in return, produced by their respective monitoring activities.
(2) *Is used by some monitoring activity* – counter-objects may also be used by the monitoring activities performed by the monitoring agents. They flow through these actors toward the final service providers of the constellation.
(3) *Is consumed by only a monitored activity* – after being used by the monitoring activities of the agents, these objects finally reach monitored activities within the domain of the monitoring third-parties (service provider's side).
(4) *Is ownership of some monitoring agent* – these objects are offered by the monitoring principal to monitoring agents in exchange of *monitoring objects.*
(5) *Is ownership of some monitoring third-party* – these objects are also provided by the monitoring agents to the monitoring third-parties, in exchange of *monitored objects*.
(6) *Is ownership of only a monitoring agent or a monitoring third-party* – this closure axiom defines the owners of the monitoring information in a monitoring value constellation.
(7) *Is reciprocity of some monitoring object* – this relationship reinforces that monitoring objects are provided in exchange of a relative price.
(8) *Is reciprocity of some monitored object* – monitored objects are also offered in exchange of a relative price.
(9) *Is reciprocity of only a monitoring object or a monitored object* – this closure axiom restricts the kind of objects flowing in a monitoring value constellation. Other objects may flow in an ordinary constellation, but only counter-objects and respective monitoring and monitored objects are considered for the cost-effectiveness analysis of the monitoring.
(10) *Is possession of only a monitoring principal* – counter-objects are used by the monitoring principal to control the monitoring of the value constellation
(11) *Is object participant of a monitoring policy* – this object role closes the structure of a monitoring policy, together with the actor, value activity and object roles described above.

The monitoring roles presented so far are necessary and sufficient to describe the basic organization of a monitoring value constellation. The distinction between *monitored* and *monitoring objects* can also be referred to as a difference between monitoring evidence and monitoring knowledge (Pardo, 2005). Both objects have a value, which can be relative to a reciprocal price. According to Mankiw (2006), *"the value of something is what you give up to get it"*. Here, the explicit value of monitoring is represented by the notion of counter-objects. These are offered in exchange of the other types of value objects.

In order to describe how these monitoring roles work together, the specification of the so-called monitoring policy is provided next.

Monitoring Policy

A *monitoring policy* comprises the most basic form of social organization in a monitoring value constellation. From the roles described so far, it should be possible to identify who provides what to whom in a monitoring value constellation. However, a monitoring policy defines some cardinality restrictions on those relationships. Its formalization is provided below.

$$
\begin{aligned}
&MonitoringPolicy \equiv ValueMonitoringConstruct \sqcap \\
&\quad = 1\, hasActorParticipant.MonitoringPrincipal \sqcap \\
&\quad \leq 1\, hasActorParticipant.MonitoringThirdParty \sqcap \\
&\quad \geq 2\, hasActorParticipant.MonitoringAgent \sqcap \\
&\qquad \forall\, hasActorParticipant.(MonitoringPrincipal \sqcup \\
&\qquad MonitoringAgent \sqcup MonitoringThirdParty) \sqcap \\
&\quad \leq 1\, hasActivityParticipant.MonitoredActivity \sqcap \\
&\quad \geq 2\, hasActivityParticipant.MonitoringActivity \sqcap \\
&\qquad \forall\, hasActivityParticipant.(MonitoringActivity \sqcup \\
&\qquad MonitoredActivity) \sqcap \\
&\quad \leq 1\, hasObjectParticipant.MonitoredObject \sqcap \\
&\quad \geq 2\, hasObjectParticipant.MonitoringObject \sqcap \\
&\quad \exists\, hasObjectParticipant.CounterObject \sqcap \\
&\qquad \forall\, hasObjectParticipant.(MonitoringObject \sqcup \\
&\qquad MonitoredObject \sqcup CounterObject)
\end{aligned}
$$

Therefore, an instance of a monitoring policy can be considered as an abstract event which:

(1) *Has exactly one monitoring principal* – many monitoring principals could exist in a value constellation. However, such a scenario would be very complex. For simplification, the focal monitoring perspective is fixed on a single monitoring principal. This role should be assigned to the service consumer of the value constellation.

(2) *Has at most one monitoring third-party* – the monitoring here is end-to-end. That is, it is assumed that the monitoring principal has a well-defined target actor to be monitored. This actor plays the role of a monitoring third-party. This creates a virtual monitoring transaction (or *monitoring chokepoint*) between a monitoring principal and a monitoring third-party.

(3) *Has at least two monitoring agents* – this refers to the principle of the two witnesses, widely used in the field of Contract Law (Grundmann, 2002; Pardo, 2005; Cormier, 2010). The principle of two witnesses allows for the relative construction of a monitoring truth among the participants of the monitoring Agency triangle. They can be used for mutual confrontation in evidence checking.

(4) *Has only monitoring principals, monitoring agents and monitoring third-parties as participant actor roles* – this closure axiom restricts the types of actors recognized in this social organization. As management collaborations can also be subject of Agency, operations supporting the monitoring (e.g. compliance checking, enhancement and regulation) could also be organized according to these roles.
(5) *Has at most one monitored activity* – the target of the monitoring is punctual, focused on a single value activity suspect of fraudulent behavior.
(6) *Has at least two monitoring activities* – there are at least two activities serving as indirect reports of performance of the suspect value activity. This is conformant with the principle of the two witnesses.
(7) *Has only monitoring and monitored activities as participant activity roles* – this closure axiom restricts the types of activities recognized in this social organization.
(8) *Has at most one monitored object* – there is only one type of monitored object that serves as primary evidence of the behavior of the monitored activity.
(9) *Has at least two monitoring objects* – from an only primary performance evidence (given by a monitored object), at least two versions about this performance are derived. These are produced by the monitoring activities performed by the monitoring agents. Another version can be produced (optionally) by the monitoring principal himself.
(10) *Has some counter-objects* – the number of counter-objects is not restricted here. Monitoring and monitored objects constitute the basic frame of value objects here. Counter-objects can be used to reinforce the structure of the monitoring value transactions with some economic reciprocity, if necessary.
(11) *Has only monitoring, monitored and counter-objects as participant object roles* – this closure axiom restricts the type of objects flowing in this social organization.

An example of a monitoring policy for the IPR case is depicted in **Figure 3-5**. Here, the monitoring roles for actors, value activities and value objects are illustrated. Special attention must be paid to the value objects in this constellation. The identity of these objects is preserved, while their respective roles change. The behavior of the value objects is used to define the behavior of the value activities. These in turn define the behavior of the monitoring parties. In addition to basic concepts in Communication Action Perspective, paradigms of Information Organization and Management have also been used. These include the Role-Based Access Control (RBAC) model, guidelines for the design of Policy-Driven Management Systems and elements of business strategy.

RBAC engineering practices include firstly characterizing policy permissions and, further, assigning them to build stereotyped roles to be played by actors model (Sandhu, Ferraiolo and Kuhn, 2000; Coyne and Davis, 2007). Permissions are logical containers relating operation types to object types. They can provide access to operations and disclosure of objects. The semantics of the *monitoring policy*, described above, is based on this model. The monitoring roles of value objects define the semantics of the value activities, through the communication acts of *consumption*, *production* and *use*. Additional relationships of ownership and possession reinforce the meaning of the social communication. The relationships between monitoring value activities and objects are used to build to behavior of the monitoring parties. Together, these relationships define the overall model of a monitoring policy, which specifies who provides what monitoring information to whom in a value constellation.

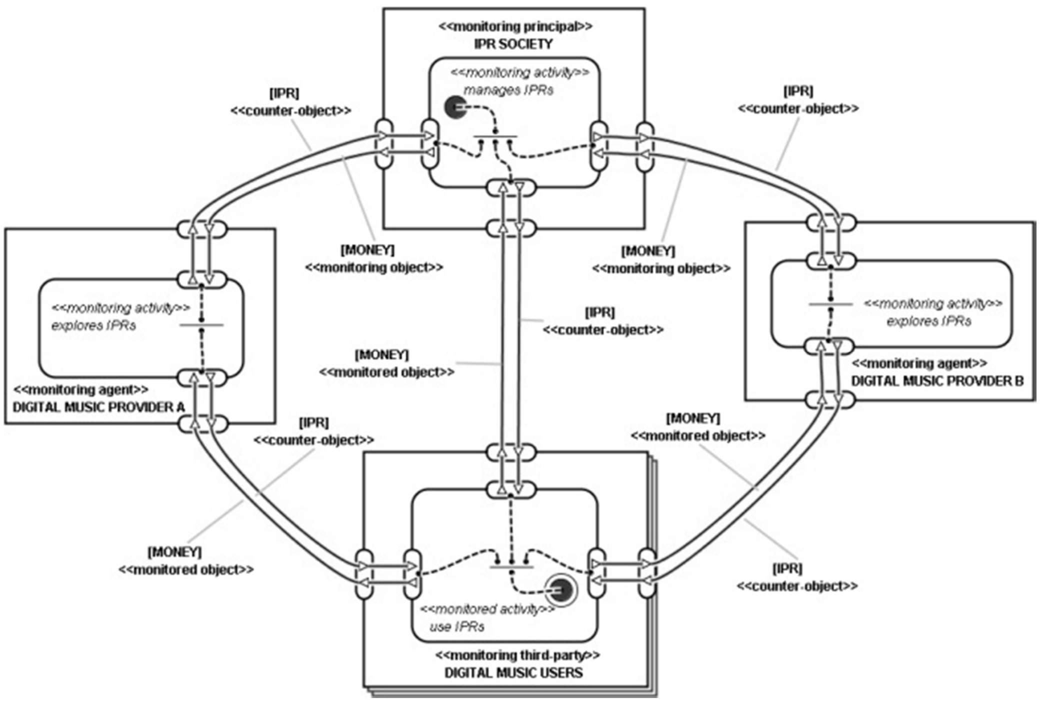

Figure 3-5: IPR monitoring value constellation: a monitoring policy example

As a management system, a monitoring value constellation is also amenable of internal regulation. A monitoring policy constitutes a basic social unit of monitoring regulation in a value constellation. According to Sloman (1994), it is a good engineering practice to separate as much as possible the logic of management and managed systems. From an external point-of-view, a monitoring value constellation is an ordinary value constellation enriched with self-monitoring capabilities. However, from an internal point-of-view, the allocation of the roles is kept as separate as possible.

The identification of monitoring policies in value constellations may require some elements of strategy. Real-world business cases, such as the IPR case illustrated above, provide rich scenarios to define and explore business strategies (Jarzabkowski and Spee, 2009). A strategy of relevance here comprises to reduce, as much as possible, the wide monitoring space that a value constellation may have. For example, in the IPR example, the complexity of the market segment of *digital music users* is collapsed as a single market segment. This reduces the monitoring of the value constellation to a single monitoring policy. However, more complex value constellations may comprehend multiple overlapping monitoring policies. The identification and replication of monitoring policies in value constellations may demand significant human expertise in the Business domain in analysis. Replication, as a business strategy, is normally achieved through practice that comes from real-world cases, scenarios and situations (Winter and Szulanski, 2001).

Indicator

The concept of *value object*, as proposed by the *e3value* framework, already denotes some self-describing information about an economic object of trade. For instance, the price and amount of a value object are sufficient to describe it from a profitability analysis point-of-view. However, the notion of a monitoring value constellation presented here brings about another level of information describing value objects. This information does not represent the explicit or tangible value of a value object, but instead, its implicit, intangible value. This level of information has been referred by Weigand et al. (2007) as *second-order values*. Price and amount-of-matter are examples of what could be called *first-order values*, which are essential values for the economic sustainability of a value constellation. Yet according to the authors, second-order values can only be analyzed in conjunction with first-order values.

It is worth to remark that second-order values are different from the so-called non-functional properties of services, as proposed by (O'Sullivan, Edmond and Hofstede, 2005) and also from the *particular* entities of the DOLCE ontology (e.g. time, location, amount of matter and abstract quality), as proposed by Gangemi et al. (2002). The referred models much resemble first-order values, which are subject of a rather standardized classification and parameterization. Second-order values, though, are more subject of individual and non-transferrable assessment. For instance, *time* and *amount-of-matter* (i.e. quantity) represent first-order values. These values can be objectively classified and assessed (Hobbs and Pan, 2006; Gruber and Olsen, 1994). Parties involved in a value transaction must agree in *advance* on attributes like these so as to exchange value objects. However, attributes such as *assurance*, *empathy* and *reliability* cannot be objectively assessed in advance. Besides, the assessment of these attributes requires individual experience. They comprise examples of second-order values, which are of special interest here.

Therefore, the notion of *indicator*, as proposed here, comprises a layer of information that extends the meaning of value objects. An attempt to formalize this concept is provided below.

$$
\begin{aligned}
Indicator \equiv\ & ValueMonitoringConstruct\ \sqcap \\
& \forall\ isInformationExpression.ValueObject \sqcap \\
& \forall\ hasInformationRealization.ValuePartition \sqcap \\
& \exists\ hasIndicatorRole.ValueInUseIndicator\ \sqcap \\
& \exists\ hasIndicatorRole.ValuePropositionIndicator\ \sqcap \\
& \qquad \forall\ hasIndicatorRole.(ValueInUseIndicator \\
& \qquad\qquad \sqcup\ ValuePropositionIndicator)
\end{aligned}
$$

Thus, an instance of an indicator (or value indicator), is an abstract unit of information which:

(1) *Is information expression of only a value object* – all the original *e3value* constructs already denote some self-describing information. This relationship means that value objects are the only sources to be annotated with additional information about value. Information expression is also an Ontology Design Pattern (Gangemi and Presutti, 2009), which can be used to treat information sources and information descriptors in separation. For example, *assurance* can be considered as an information expression of the value object *money*. By information expression it is meant here that a value transaction may involve information that goes beyond purely economic indicators. This is an attempt to decompose the notion of a value object according to its explicit and implicit components of value.
(2) *Has information realization of only a value partition* – the ontology proposed here has no data type properties. As described further in this chapter, a value partition comprises abstract levels of value characterizing indicators.
(3) *Has indicator role of some value-in-use indicator* – indicators here play two roles: *value-in-use indicator* and *value proposition* indicator. As explained further, the definition of these roles is given according to who has the authority on each type of information. As already mentioned before, according to the Service-Dominant Logic (Vargo and Akaka, 2009), any business object brings a value proposition and a value experience. Service providers offer value propositions on top of value objects, but the value in use of such objects can only be assessed internally, but the service consumer. This also applies for monitoring objects. For instance, information (or evidence) about the *assurance* or *reliability* of a money report can be offered as a monitoring object. However, even the monitoring object itself is subject of internal evaluation done by the monitoring principal. Such evaluation is only possible through *experience* or *use* of the value object.
(4) *Has indicator role of some value proposition indicator* – this comprises the provider's viewpoint on the monitoring indicator.
(5) *Has indicator role of only a value-in-use indicator or a value proposition indicator* – this closure axiom represents that these are the only components of a value object, at least according to supporting literature in Economics (Barzel, 1982; Kohn, 2004).

Value Proposition Indicator

A *value proposition indicator* is referred to as a promise, made by the service provider to the service consumer, to create value. Here, a *value proposition indicator* comprehends information about this promise. This information is assumed here to be explicitly disclosed in the model of a monitoring value constellation. The concept is formalized below.

$$
\begin{aligned}
&ValuePropositionIndicator \equiv IndicatorRole \ \sqcap \\
&\qquad \exists\ isIndicatorRoleOf.Indicator \sqcap \\
&\qquad \exists\ isEstimationOf.MonitoringNeed \sqcap \\
&\qquad \exists\ isAuthorityOf.MonitoringAgent \ \sqcap \\
&\qquad \exists\ isAuthorityOf.MonitoringThirdParty \sqcap \\
&\qquad\qquad \forall\ isAuthorityOf.(MonitoringAgent \ \sqcup \\
&\qquad\qquad MonitoringThirdParty) \sqcap \\
&\qquad \forall\ precedes.ValueInUseIndicator
\end{aligned}
$$

Hence, an instance of a *value proposition indicator* comprises the most basic form of monitoring information in a value constellation, which:

(1) *Is estimation of some monitoring need* – as mentioned before, monitored objects are used to *achieve* monitoring needs. However, these objects are also amenable to valuation. On supporting the notion of value monitoring, value proposition indicators can be used to estimate monitoring needs regarding the *implicit value* that the monitoring objects may return.
(2) *Is authority of some monitoring agent* – authority here is meant by possession of monitoring information. Monitoring agents have authority on the disclosure of information about their offered monitoring objects.
(3) *Is authority of some monitoring third-party* – these parties also have authority to somewhat restrict the information disclosed about the monitored objects they produce.
(4) *Is authority of only a monitoring agent or a monitoring third-party* – this closure axiom represents that these are the only parties considered as the possessors of the monitoring information.
(5) *Precedes value-in-use indicator* – precedence here denotes a time relationship between the indicators (and not a relationship of priority). Even for monitoring objects, a proposition of value creation is offered first. Such a proposition is public. Only after experience, the monitoring object can be assessed regarding its value-in-use.

In order to illustrate the concept of a value proposition indicator, an example from the IPR case is provided in **Figure 3-6**. The value proposition indicator considered here is the one of *assurance*. This indicator is provided by the SERVQUAL scale, proposed by Parasuraman, Berry and Zeithaml (1991). The SERVQUAL scale provides indicators for measuring and managing service quality from a business perspective. Assurance is considered here as relevant for describing the value of monitoring information. Other relevant SERVQUAL indicators include *responsiveness*, *empathy*, *reliability* and *tangibles*. The indicators are illustrated with comments added on top of the value objects. The model includes information about the organization and information disclosure of the monitoring value constellation. It can be noticed that the values assumed by the proposition indicators are prefixed with the symbol '?'. The meaning of this is that "assurance" comprises only a promise of the value to be created on the monitoring principal's side, through the monitoring objects offered. Moreover, the propositions of both monitoring agents are equivalent. Henceforth, it becomes necessary to define information that somewhat *distinguishes* monitoring objects with equivalent value propositions.

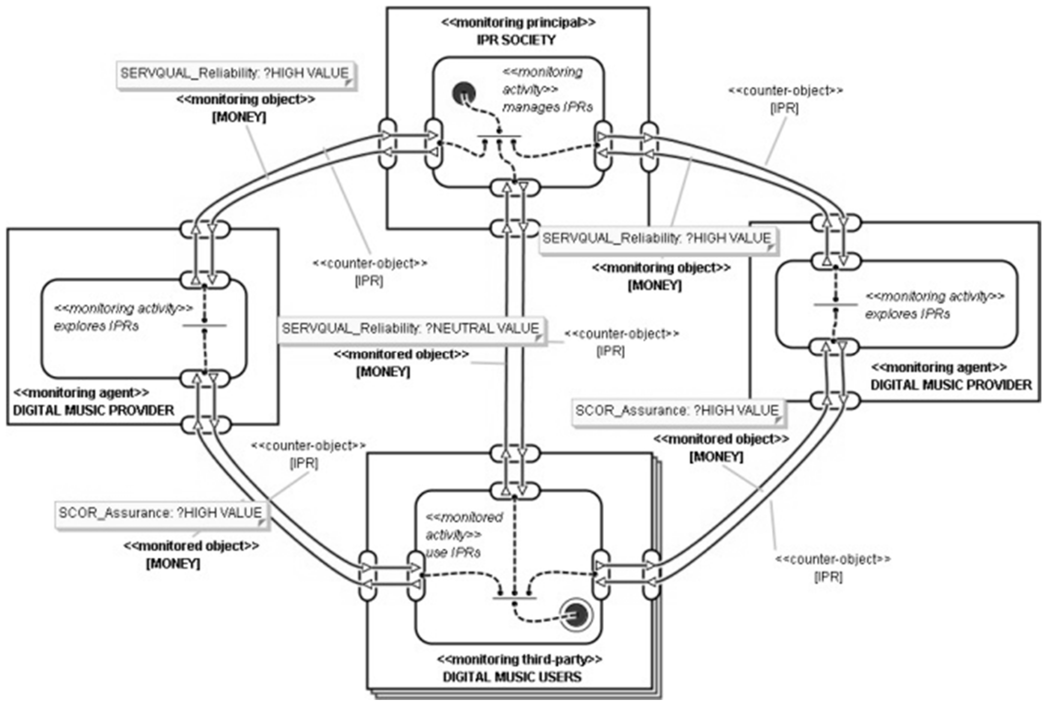

Figure 3-6: Value proposition model for the IPR monitoring value constellation

Value-in-Use Indicator

A *value-in-use indicator* corresponds to the notion of *value experience*, a fundamental principle of Service-Dominant Logic (Vargo and Akaka, 2009). It is an adaptation of the original concept for monitoring value constellations. The *value-in-use indicator* comprises monitoring information about the actual value experienced after the value propositions are delivered. The scope of this information is of a private concern of the monitoring principal. The axiomatization of the main relationships describing this concept is provided below.

$$
\begin{aligned}
ValueInUseIndicator \equiv\ & IndicatorRole\ \sqcap \\
& \exists\ isIndicatorRoleOf.Indicator\ \sqcap \\
& \forall\ isAuthorityOf.MonitoringPrincipal\ \sqcap \\
& \forall\ isMeasurementOf.MonitoringNeed\ \sqcap \\
& \forall\ isPrecededBy.ValuePropositionIndicator
\end{aligned}
$$

Therefore, an instance of a *value-in-use indicator* comprises another abstract unit of monitoring information, which:

(1) *Is authority of only a monitoring principal* – while value propositions are of authority of monitoring agents and third-parties, value-in-use indicators are of private concern of the monitoring principal. A model containing this information may represent competitive advantage to the monitoring principal.
(2) *Is measurement of only a monitoring need* – while value propositions are used to estimate monitoring needs, value-in-use indicators comprise the actual measurement of the value experience provided through monitoring objects.
(3) *Is preceded by a value proposition indicator* – this inverse property is stated for the sake of model completeness.

To illustrate this concept, a model for the IPR case is provided in **Figure 3-7**. The value experience here refers to the previous promise of assurance. Here, it is assumed that the value proposition has been delivered, and the monitoring principal as the final consumer of the monitoring information has experienced the value generated by the monitoring object. This is represented graphically by prefixing the value indicators with the '!' symbol. It is worth to remind that this model contains monitoring information that is private to the monitoring principal. In the example given, the value-in-use indicator is used to make a distinction between the two equivalent value propositions of monitoring objects. It is also worth to remark that, while the value proposition model depicted in **Figure 3-6** has a *preemptive* modeling purpose, the model depicted below has a *reactive* modeling purpose. That is, the monitoring principal can use this model to take decisions upon the underlying value transactions.

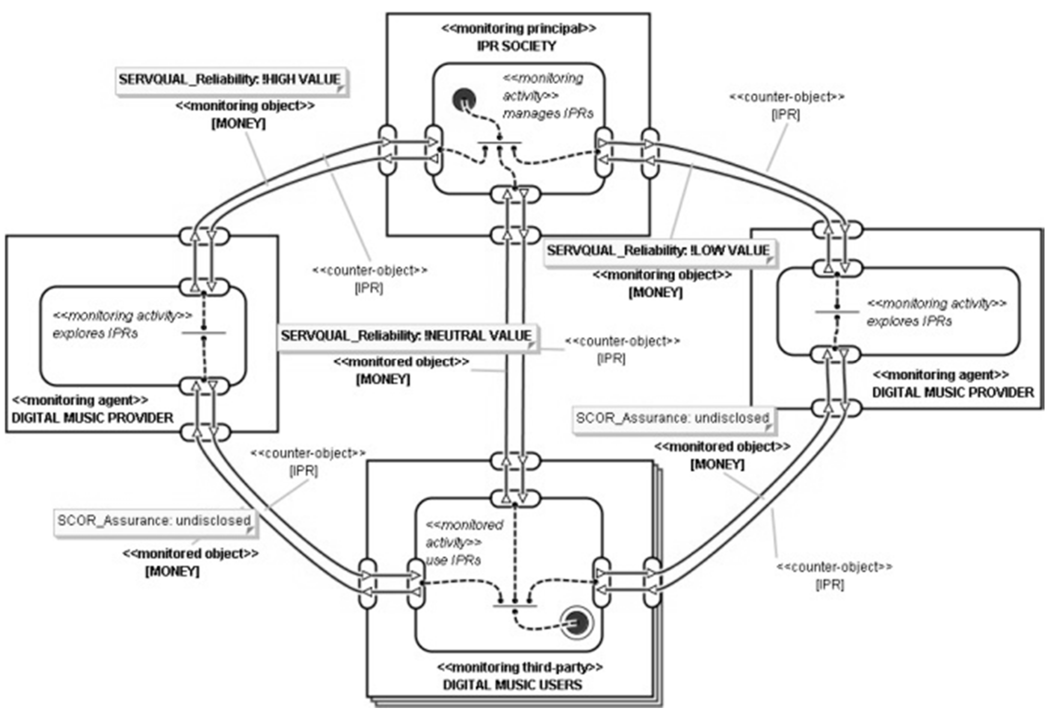

Figure 3-7: Value-in-use model for the IPR monitoring value constellation

Value Partition

As mentioned before, the ontology proposed here do not have data type properties. In order to express the notion of information realization, the ontology design pattern of *value partition* is used. This pattern is not part of OWL, but has been used to describe abstract formal ontologies that do not have data types (Horridge, 2011). Despite of its name, the pattern is not related to value modeling, but is used to create subclasses that *cover* a class. The formalization of the pattern is given below.

$$
\begin{aligned}
&ValuePartition \equiv ValueMonitoringConstruct \sqcap \\
&\qquad (HighValue \sqcup LowValue \sqcup NeutralValue) \sqcap \\
&\qquad \forall\, isInformationRealizationOf.Indicator
\end{aligned}
$$

(1) *Is covered partition of the high value, low value and neutral value abstract classes* – in order to describe the value assigned to indicators, an abstract class is created and “sliced” in partitions of things (OWL individuals) that are of high value *or* low value *or* neutral value.
(2) *Is information realization of only an indicator* – the value partition class realizes the notion of a value indicator. In the example depicted above, value partitions are used to describe the *assurance* indicator. Value partitions here are used only as supporting constructs. The specification of the ontology provided in the **Appendix** can be easily extended with a data type structure.

Monitoring Need

Based on the concepts provided thus far, it is possible to formalize the notion of a *monitoring need*. A monitoring value constellation, as described here, is driven by the purpose of filling the monitoring needs of a certain consumer. The concept is formalized as follows.

$$
\begin{aligned}
&MonitoringNeed \equiv ValueMonitoringConstruct \sqcap \\
&\qquad \forall\, isMonitoringGoalOf.MonitoringPrincipal \sqcap \\
&\qquad \exists\, isEstimatedThrough.ValuePropositionIndicator \sqcap \\
&\qquad \exists\, isEstimatedBy.MonitoringPrincipal \sqcap \\
&\qquad \forall\, isAchievedThrough.MonitoringObject \sqcap \\
&\qquad \forall\, isMeasuredBy.MonitoringPrincipal \sqcap \\
&\qquad \forall\, isMeasuredThrough.ValueInUseIndicator
\end{aligned}
$$

Hence, a monitoring need represents the most relevant information of a monitoring value constellation, which:

(1) *Is monitoring goal of only a monitoring principal* – each actor in a monitoring value constellation has his own goals. However, as proposed here, this system is also Service-Dominant. Therefore, a monitoring need is the ultimate goal of the monitoring principal (as a final consumer of monitoring information).
(2) *Is estimated through some value proposition indicator* – just as ordinary business needs are estimated through first-order values (e.g. amount of matter

and time), value monitoring needs are estimated through value proposition indicators, which are considered here as second-order values.

(3) *Is estimated by some monitoring principal* – monitoring needs are estimated by the monitoring principal himself, who is the only one able to make estimations in terms of internal value to be generated.

(4) *Is achieved by only a monitoring object* – as ordinary business objects are said to fill core business needs, monitoring objects help to achieve monitoring needs.

(5) *Is measured by only a monitoring principal* – measurement here refers to the assessment of the value experience. This is absolutely internal and private to the monitoring principal.

(6) *Is measured through only a value-in-use indicator* – this is the core property of the notion of value monitoring. The value of some object is said to be monitored only after its *experience* (or *use*). As each value experience is assumed to be unique, value monitoring can also be considered as unique and non-transferrable. As monitoring objects are offered as value propositions, their intrinsic value is also subject of internal evaluation. Such an evaluation (measurement) can support the principal's decision-making.

In the example illustrated above in **Figure 3-7**, a monitoring need is represented graphically as starting stimulus in the value model. According to the example, it is possible to notice that the notion of a monitoring need does not demand a new structure for monitoring a value constellation. It ought to be interpreted that, for instance, the *IPR society* has a *need* of monitoring objects. Such a role is filled by the value object of *money*. The measurement provided by the indicator of *assurance* (after use) represents the final evaluation of the IPR society regarding the value generated by the monitoring object.

In summary, the constructs presented above comprise the value monitoring constructs of the Value Monitoring Ontology (VMO). The specification described above provides only a starting point to tackle the problem of monitoring value constellations. As the problem in question is of a multi-disciplinary order, an attempt has been made in terms of blending communication, economic, information and organizational aspects to produce an integrated *Value Activity Monitoring* viewpoint. The main rationale for blending disparate theories towards producing a new one is that such an endeavour represents an opportunity for phenomenological problem exploitation (such as monitoring value constellations), as well as its potential for innovation (Oswick, Fleming and Hanlon, 2011). Last, the OWL abstract syntax specification provided above corresponds to the results of the ontology *refining* phase, according to the Ontology Engineering methodology adopted here. The full specification of the ontology in OWL2 is provided in the **Appendix** of this document.

3.4 Ontology Evolution

According to Sure, Staab and Studer (2009), the *evolution* of ontologies is primarily an organizational process. An important part of this process comprises the gathering of *changes* to the ontology. Changes here refer mainly to the constructs included in or excluded from the ontology along the course of its development. In practical research, the *evolution* and *evaluation* phases are often accomplished in *cycles* within the ontology development process. In this case, the evolution of the ontology can be documented along the course of its evaluation through practical application scenarios. These scenarios can be provided by case studies. This is the particular case of VMO, which has been evaluated through application in real-world business cases. Each case corresponds to a different version of the ontology proposed here. In this section, these versions are described according to three indicators of evolution: (1) the *dominant concept* of the version; (2) the *organizational strategy*; and (3) the respective *case* used a practical evaluation scenario.

The *first version* of the ontology proposed here, so-called Enterprise Monitoring Ontology (EMO) has been published in (Silva and Weigand, 2011b). Since this version, it has been aimed to treat the problem of monitoring value constellations from a cross-disciplinary perspective. In order to achieve this purpose, concepts have been borrowed from fundamental literature in Agency Theory (Eisenhardt, 1989), Contract Theory (Bolton and Dewatripont, 2006), Contract Law (Lando and Beale, 2000), Enterprise Engineering (Dietz, 2006) and the Role-Based Access Control (RBAC) model (Sandhu, Ferraiolo and Kuhn, 2000). Special emphasis has been given on treating the monitoring of a value constellation as a *regulated social organization*. Therefore, the main construct of this version is the concept of a *monitoring policy*. The *strategy* behind a monitoring policy was the one of identifying critical value transactions and supporting them with external value constellations specialized in providing monitoring services. Therefore, the resulting organization would comprise an *open* (monitoring) *value constellation*, due to its inclusion of external actors. A case from the market of Renewable Energy has been used to evaluate this version. The case was focused on high-value transactions in a value constellation from the Renewable Energy sector being supported by an external constellation of Smart Metering providers, specialized in monitoring services. The inclusion of external monitoring actors in this case brought some problems of information disclosure to discussion. The ontology has been applied to organize the monitoring of this constellation. The resulting organization has been evaluated as sound, thereby validating the concept of a monitoring policy.

The *second version* of the ontology has been published in (Silva and Weigand, 2012). In this version, more attention has been paid to reinforce the concept of a *monitoring need*. Thus, an initial attempt has been made to associate this concept to the notion of a *business need*, according to the *e3value* framework. From this perspective, it has been proposed that, in a value constellation, monitoring could also be treated as a separate business need. Based on that, it has been also proposed to classify business needs (as defined by the *e3value*) into core business needs and management needs. A core business need would be filled by ordinary business objects, whereas management needs, by proof-of-performance objects. A *monitoring need* has been defined as a specific type of management need. Such a need can be as complex as it may, demanding not only monitoring organization, but also *monitoring coordination*. Henceforth, the ontology has been enriched with conceptual elements borrowed from studies in Language Action Perspective (LAP), including the works of Austin (1962), Searle (1969) and Allwood (1976). The concepts of *apprehension*, *coordination*, *display* and *production acts* have been adapted and included in the ontology so as to describe the monitoring coordination of a value constellation. The strategy of *open* (monitoring) *value constellations* and the concept of a *monitoring policy* have been preserved. Finally, the resulting ontology model has been evaluated through the IPR case. The problem on hand comprised that, in this business, it is difficult to detect fraudulent behavior based only on explicit coordination acts. To cope with this issue, the concepts of *apprehension* and *display acts* have been used as an alternative (implicit) form of monitoring behavior in a value constellation. Although the approach has been evaluated as sound by the research community in Enterprise Engineering, it has been argued how these acts could be visualized in a final value model, although preserving some monitoring privacy.

The *third version* of the model is the Value Monitoring Ontology (VMO) reported in this document. In this version, the concept of a *monitoring indicator* is reinforced. A monitoring indicator has been referred to as information describing the value component of an economic object. Value here can be *explicit* (i.e. a value proposition indicator) or *implicit* (i.e. a value-in-use indicator). This distinction is grounded on a Service-Dominant Logic (Vargo and Akaka, 2009; Grönroos and Ravald, 2011). While a *value proposition indicator* can be used to *estimate* value creation, a *value-in-use indicator* can be used to *measure* actual value creation, what can only be done at the consumer's side, *individually*. Besides, while value proposition indicators could to be disclosed as public monitoring information in a value constellation, value-in-use indicators ought to be kept private to the consumer. Based on such a distinction, the logic proposed here comprises that *a suspicious value activity can be monitored not only through the value objects it produces, but also (and mainly) through the actual value generated by these objects*. In terms of Business Strategy, the concept of a *monitoring policy* has been changed so as to describe closed (monitoring) value constellations. The logic here is that a value constellation can be monitored through reconfiguration of its internal roles. Last, the resulting model has been evaluated through a new case in Customs Control and the Renewable Energy case. The evaluation results of these cases are provided in **chapters 4** and **5**, respectively.

The summary of evolution of VMO is shown in **Table 3-2**. It is worth to note how the dominant concept and organizational strategy has changed along the versions of the ontology. Each version of the ontology has focused on a different dominant concept. This has been important to test the maturity of each concept, individually. The current version of the ontology, therefore, can be used to treat the monitoring of a value constellation from three balanced perspectives: (1) *as a complex business need*; (2) *as a social organization phenomenon*; and (3) *as subject of use and experience*. As a social organization, a monitoring value constellation has been reduced from an open to a closed system. That is, the idea of a monitoring value constellation, as currently proposed, comprises only a reconfiguration of an ordinary value constellation according to monitoring roles. No external actors are included. This reduction is aimed to analyze a monitoring value constellation as a sustainable system.

Table 3-2: Value Monitoring Ontology: Summary of Evolution

	Dominant Concept	**Organizational Strategy**	**Business Case Evaluation**
EMO (1st Version)	Monitoring Policy (Monitoring as a regulated social organization)	Monitoring as an Open Value Constellation	Renewable Energy (Smart Metering Market)
EMO (2nd Version)	Monitoring Need (Monitoring as a complex business goal)	Monitoring as an Open Value Constellation	IPR Case (Digital Music Industry)
VMO (Current version)	Monitoring Indicator (Monitoring as value proposition and value experience)	Monitoring as a Closed Value Constellation	Renewable Energy Case + Customs Control Case

3.5 Ontology Evaluation

As presented in **Chapter 2**, the model proposed here is evaluated according to different ontology evaluation types. In this section, preliminary results are reported on both *standard-based* and *technology-based ontology evaluation*. The former is presented through a discussion on the *theoretical effectiveness* and *efficiency* of the ontology. The latter supports the claim of *quality* of the ontology.

3.5.1 Theoretical Effectiveness

VMO is aimed to be used on solving a problem of a practical order. However, it is relevant to assess how *effective* this candidate ontology is in theory. This can be done through a method named *standard-based ontology evaluation* (Brank, Grobelnik and Mladenic, 2005). According to this method, a theory considered as the "standard" can be used to evaluate the ontology regarding its conceptual soundness. Here, this standard comprehends a theoretical proposition from Agency Theory (Eisenhardt, 1989, p. 59; Shapiro, 2005, p. 280), which closely relates to the problem of monitoring a value constellation. In simple terms, the proposition states that, in Agency relationships, *monitoring information is a purchasable commodity*, and as such, is also provided through Agency relationships (i.e. the collaborations articulated to monitor Agency relationships are themselves Agency relationships). These monitoring relationships should be as cost-effective as possible. As the monitoring of a value constellation can also be perceived as pairs of Agency relationships, a question of relevance here is *how effective (in theory) VMO is on solving the problem of monitoring a value constellation.*

This question is addressed in VMO by formalizing the monitoring of a value constellation as a *business need* and as *organizational phenomenon*. The arguments in favor of the adoption of each of these perspectives are given as follows.

By formalizing the monitoring of a value constellation as a *business need*, the economic value of monitoring objects can be assessed through profitability analysis, which is a mechanism already provided by the *e3value* framework. By that means, it is possible to assess the profitability of a monitoring value constellation as a business in its own. Truly, if a monitoring object helps to achieve the monitoring needs of a given consumer through positive value creation, then such an object is cost-effective. Consequently, the value constellation providing such a value object is also considered as cost-effective. Therefore, as a constructor of monitoring value constellations, VMO is also cost-effective from a theoretical point-of-view.

As an *organizational phenomenon*, a monitoring value constellation has been defined in VMO as an ordinary value constellation enriched with self-monitoring capabilities. These capabilities are defined in terms of monitoring roles, which can be assigned to the actors, value activities and value objects that already compose an ordinary value constellation. By these means, a value constellation can be monitored *per se*, through reconfiguration of its internal organizational structure. In other words, the monitoring of a value constellation does not necessarily need to be delegated to other value constellations specialized in providing monitoring services. In this case, the cost of monitoring may be prohibitive, thereby reducing the profitability of the underlying core business constellation. Taking this problem in consideration, the VMO concept of a *monitoring value constellation*, as an organizational phenomenon, is also cost-effective in theory.

3.5.2 Theoretical Efficiency

From the *external perspective* of business markets, a monitoring value constellation can be perceived as a cost-effective management system. However, from the *internal perspective* of a consumer's monitoring need, a monitoring value constellation can offer different levels of efficiency. This brings to the evaluation of VMO as a theoretically efficient model. Thus, another question of relevance here consists of *how efficient (in theory) VMO is on solving the problem of monitoring a value constellation.*

Yet according to a standard-based ontology evaluation, the parameters of theoretical efficiency considered here comprise some of the fundamental principles of the Service-Dominant Logic (Vargo and Akaka, 2009, p. 35). The fundamental principles (FPs) considered as relevant to the problem of monitoring a value constellation are stated below:

- **FP7:** *The enterprise cannot deliver value, but only offer value propositions, i.e. the firm can offer its applied resources and collaboratively (interactively) create value following acceptance, but cannot create/deliver value alone.*
- **FP10:** *Value is always uniquely and phenomenological determined by the beneficiary, i.e. value is idiosyncratic, experiential, contextual, and meaning laden.*

According to VMO, a *monitoring need* can be achieved through *monitoring objects*, which are provided by *monitoring agents*. However, just as any ordinary value object, a monitoring object represents only a promise to create value, but not assurance of such. As monitoring collaborations are themselves Agency relationships, this may constitute a problem of recursive monitoring. That is, even if considered as cost-effective, a monitoring value constellation can be composed of many unreliable monitoring relationships, each of them triggering new monitoring problems.

This issue is addressed in VMO by the formalization of the concepts of *a value proposition indicator* and *value-in-use indicator*. These concepts correspond to the fundamental premises in Service-Dominant Logic cited above. Based on these concepts, the organization of a monitoring value constellation is refined by two extra models. One model comprises *explicit* monitoring information, to be disclosed among the participants of the value constellation. This model contains only propositions of the value of monitoring objects and can be used to *estimate* the value to be produced by these objects. The other model comprises only *implicit* monitoring information, private to the consumer's side. This model contains the actual *measurements* of the value generated by the monitoring objects *after* use or experience. Therefore, these models comprise an attempt to make a monitoring value constellation as efficient as possible.

3.5.3 Ontology Quality

There is some literature agreement on that ontology *correctness* and *consistency* are critical quality properties of candidate ontologies (Brank, Grobelnik and Mladenic, 2005; Noy, Guha and Musen, 2005; Vrandesic 2010). These properties can be checked through *technology-based ontology evaluation*. In this work, the Web Ontology Language 2 (OWL2) has been used to represent VMO in a machine-readable form.

OWL2 is supported by a plethora of tools for ontology development. These tools normally provide several functionalities for ontology development, including ontology annotation, alignment, merging, visualization, and other facilities. Most importantly, these tools already generate syntactically correct OWL specifications. In this work, the Protégé 4.1 Ontology Development tool has been used. A complete OWL2 specification of VMO is provided as an **Appendix** to this document. In this chapter, VMO has been described in OWL abstract syntax, as it is addressed to a multi-disciplinary community of practitioners and scholars. Nonetheless, graphical visualization has been suppressed in this chapter. The ontology specification provided in the **Appendix** of this document can be imported in any ontology development tool. Hence multiple graphical views can be generated for the ontology model.

Protégé 4.1 also provides support for automated consistency checking of OWL2 ontologies. Consistency checking is a service normally provided by Description Logic (DL) reasoners, used in conjunction with ontology development tools. In this work, the Fact++ reasoner has been used during the automated consistency checking of VMO. Fact++ is one of the reasoners embedded in Protégé 4.1. During the consistency checking, the ontology reasoner can be used to verify if the concepts of the ontology admit valid instances. The specification of VMO has been checked as consistent.

3.6 Discussion

In this chapter, a candidate ontology has been proposed to address the problem of monitoring value constellations. The so-called Value Monitoring Ontology (VMO) is an attempt to tackle the referred problem from a cross-disciplinary perspective. Thus, it is a blend of principles in Communication Action, Economics, Information Management and Organizational Sciences considered as relevant for monitoring a value constellation. As a design artifact, VMO can be classified as: (1) a *problem-solving design artifact*; (2) a *decision-support system*; (3) a *task ontology*; and (4) as *value viewpoint in Service monitoring*.

As a *problem-decision design artifact*, VMO has been proposed as a means to solve a problem considered of high relevance for business needs. The evidence of such is the use of real-world cases studies since its initial construction phases. As a *decision-support system*, VMO has its value in the sense of including monitoring as part of the configuration of a value constellation. That is, VMO represents a point-of-view whereby the sustainability of a value constellation depends not only on the profitability of its initial configuration, but also on how such a configuration is monitored, according to the value it returns to a final consumer. In order to achieve such a purpose, decisions such as who should monitor whom and how should be taken upfront. As a *task ontology*, and according to the ontology classification provided by Guarino (1998), VMO describes the mechanism of monitoring a value constellation as an *organizational phenomenon*. Thus, monitoring here is considered as business need in its own, which drives the configuration of a value constellation organized according to monitoring roles. The resulting system has been named as *monitoring value constellation* – an ordinary value constellation enriched with self-monitoring capabilities. As the constructor of a value viewpoint in Service monitoring, VMO comprises an attempt to leverage Service monitoring to a question of Business Strategy. The rationale considered here is that the monitoring of the internal business processes of an Enterprise should be driven by monitoring information considered as critical from an economical viewpoint. VMO therefore works as a constructor for what is called here as a *Value Activity Monitoring* viewpoint.

The *Value Activity Monitoring* viewpoint brings about a subtle conceptual boundary between Service monitoring and what could be called *Value Monitoring*. The former supports managerial decision based on the analysis of *displayed* performance behavior in business collaborations. The latter, as proposed in this work, is aimed to support managerial decision based on the analysis of what is actually *apprehended* or *experienced* from the performance offered. This conceptual distinction has been demonstrated in the scope of a monitoring value constellation. In this context, it has been argued that the monitoring of value requires not only *delegation*, but also (and mainly) *cooperation* among business parties. Although monitoring information can be offered as proposition to create value, the measurement of such can only be done through individual use and experience. This perspective has been advocated from a Service-Dominant logic.

Moreover, it has been reported that VMO has been built by following the Ontology Engineering methodology proposed by Sure, Staab and Studer (2009). This methodology organizes the Ontology Engineering process in five phases: (1) *feasibility analysis*; (2) *ontology requirements specification* (or kickoff phase); (3) *ontology refinement* (through formal specification); (4) *ontology evaluation*; and (5) *ontology evolution*. This methodology is flexible to a certain extent, admitting alternative cycles throughout its phases. In the particular case of this research, the former two phases have been inspired by elements of practice provided by real-world case study in Intellectual Property Rights (IPR). The third phase has been conducted through the use of the Web Ontology Language 2 (OWL2). The ontology description has been provided in two forms. In this chapter, its description is provided in OWL abstract syntax, so as to facilitate human understanding. In the **Appendix** of this document, a more complete version of it is provided in OWL functional syntax, so as to allow for automated formal verification. Finally, the last two phases of the methodology have been accomplished in cycles between theory and case study application. Some preliminary evaluation has been provided in this chapter, regarding the theoretical effectiveness, theoretical efficiency and quality of the ontology.

In the next chapter, further evaluation is provided through reports of experience from two other cases studies. In **Chapter 4**, a case in Customs Control is provided. In **Chapter 5**, a case in Renewable Energy and Smart Metering complements the main findings of this research. These cases bring about scenarios that challenge the way Service monitoring is performed nowadays in business collaborations. It is demonstrated therefore how VMO can be used to cope with some of these challenges.

Chapter 4: A Case in Customs Control

Simplicity is prerequisite for reliability.

Edsger W. Dijkstra,
In: *How do we tell truths that might hurt?* (1975)

4.1 Introduction

This chapter reports on the application of VMO on a business case from the Customs Control sector. According to the Ontology Engineering methodology adopted in this research, this case application accomplishes part of the ontology evaluation phase. As previously mentioned, different Ontology evaluation techniques have been used in this work, with a special emphasis on *application-focused ontology evaluation*. This type of evaluation can be done through case studies, which can provide necessary elements of practical relevance. The context of the case reported here is briefly introduced as follows.

The description of this case has been provided as a research courtesy by participants of the Extended Single Window (ESW) project[3]. The ESW project is an organizational consortium comprising knowledge institutions (TNO, Delft University of Technology, University of Tilburg and the Fontys and NHTV Universities of Applied Science), the Dutch main ports and their community systems (Rotterdam Port Authority, Port of Amsterdam, Schiphol, Portbase and Cargonaut), logistics hinterland regions (NV Regio Venlo), interest groups and industry associations as well as international operators. The main goal of this project is to create a faster, safer and more reliable international flow of goods by increasing the efficiency of import, export and customs procedures. The Dutch Customs is interested in the innovation of these procedures. The focus of the project is to strengthen the role of the Netherlands as the logistics gateway for Europe and to contribute to added value in Supply Chain Management (SCM).

A supply chain can be defined as "a network of facilities and distribution options that performs the functions of procurement of materials; transformation of these materials into intermediate and finished products; and distribution of these finished products to customers" (Handfield, Nichols and Ernest, 1999). A supply chain can be part of a value constellation. The value constellation delimited in this case is the one of International Trade, including value transactions among companies and market segments from the commerce of fruit juice raw materials and derived fruit composites. The dominant monitoring perspective in this case is the one of a Customs Control

[3] DINALOG: Extended Single Window – Information Gateway to Europe, http://www.dinalog.nl/institute/projects/research-development-projects/extended-single-window-information-gateway-to-europe/271

Authority, which has the granted competence of monitoring suspicious value activities performed in this market. These value activities are monitored through the excise taxes on the goods they produce. In theory, the Customs Control Authority has direct monitoring transactions with all the actors and market segments involved in this business. However, the amount of indirect transactions among the participants of this constellation makes the cost of direct (full) monitoring prohibitive. Therefore, one of the main challenges in this case comprises to monitor the underlying value constellation through the monitoring chokepoint of a single value transaction. In the ESW project, such a strategy is the inverse of the Single Window business perspective[4].

Briefly stated, the *monitoring problem* brought to light by this case is essentially *organizational*. Hence, this chapter brings about a discussion on how VMO can be used to produce alternative monitoring organizations for this type of business network. Special emphasis is given to the cost-effectiveness and cost-efficiency analysis of the strategy produced. It is demonstrated analytically how the relative cost of monitoring in this business network can be reduced significantly through reuse and reorganization of its organizational structure.

This chapter is organized as follows. In **section 4.2**, a value model is provided describing the main actors, value activities and value objects that compose the core business value constellation of this case. In **section 4.3**, the core business value constellation model is transformed into a *monitoring value constellation* model. The transformation process is described by adding layers of monitoring information on top of the core business value constellation model. The resulting monitoring value constellation contains the description of an internal monitoring need, alternative monitoring policies and some critical monitoring indicators. In **section 4.4**, a discussion is provided on the potential cost-effectiveness and cost-efficiency of the monitoring value constellation model produced. Additionally, some best practices and limitations encountered are also reported. Last, **Section 4.5** closes this chapter with a summary of the main results of the case study evaluation.

4.2 Core Business Value Constellation

The case reported here is a sub-extract of a network of seven interrelated business-to-government cases in Audit and Customs Control, originally published in (Bukhsh and Weigand, 2011). As part of the contribution of this work, it has been proposed to separate the *Extended Single Window* case from the other ones, yet preserving as much as possible the integrity of its internal economic and organizational constraints. The resulting separation has been shaped as a value constellation model, which is described in this section according to its encompassed *actors*, *value activities* and *value objects*. Due to agreements of private information non-disclosure, the identities of the companies involved in this case remain anonymous. Therefore, the model includes only the main

[4] UN/CEFACT: The Single Window Concept. Technical Report ECE/TRADE/324, International Trade ProceduresWorkingGroup (ITPWG/TBG15) of UN/CEFACT available for download at http://unpan1.un.org/intradoc/groups/public/documents/UNECE/UNPAN019892.pdf

market segments of the Customs Control Business domain, what characterizes it as a purely strategic model.

4.2.1 Actors, Value Activities and Value Objects

The value constellation model designed for the Customs Control case is depicted in **Figure 4-1**. This corresponds to what is called here as an ordinary value constellation model (or *core business value constellation model*). Hence, this model describes only the core competences of the underlying Business domain in analysis. Thus far, it contains no explicit description of monitoring information (not as defined in this work). The descriptors of the value objects in this model are kept in the singular form, indicating that the focus of analysis here is the strategic relevance of these objects (and not their quantitative occurrences). The model is described below, according to its participant actors, respective value activities and exchanged value objects.

Raw Materials Industry

As shown in the picture below, this value constellation contains a conventional supply chain of production, semi-manufacturing and retailing activities. The root of the chain is the *Raw Materials Industry*, which in reality represents a business actor from the *primary* industry of the fruit commerce sector (e.g. fruit farmers of large production scale). This actor is competent to provide a *raw material* to the Manufacturing Industry in exchange of *money*. This value transaction is optionally supported by Shipping Companies, from which it receives a *shipping service* in exchange of *money*. This actor has yet a direct value transaction with the Customs Control Authority, to which it pays an *excise tax* on the goods produced in exchange of a *legitimation document*, which constitutes evidence of performance. Furthermore, while the value transaction between this actor and the Customs Control Authority is mandatory, the other ones are optional. This is specified through the circuit of logical connectors within the value activity of *producing raw material*. This activity is the main production point of the constellation (depicted as a boundary element).

Manufacturing Industry

In reality, this actor represents a business actor from the *secondary* industry of the fruit commerce sector (e.g. producers of fruit juice and composites). As depicted in the picture above, this actor plays a central strategic position in this constellation. It therefore operates as a communication chokepoint among the other actors of the constellation. This actor is competent to produce a *finished good* to the retail industry in exchange of *money*. This value transaction can also be optionally supported by Shipping Companies, from which it receives a *shipping service* in exchange of *money*. Last, this actor has a direct value transaction with the Customs Control Authority, to which it has to pay an *excise tax* in exchange of a *legitimation document*. In order to perform the value activity of *producing finished goods*, this actor has mandatory value transactions with the Customs Control Authority, Raw Material Industry and Shipping Companies. The objects acquired from these transactions are used to produce the finished good. This is represented through the logical connector ‘AND’, placed inside the underlying value activity.

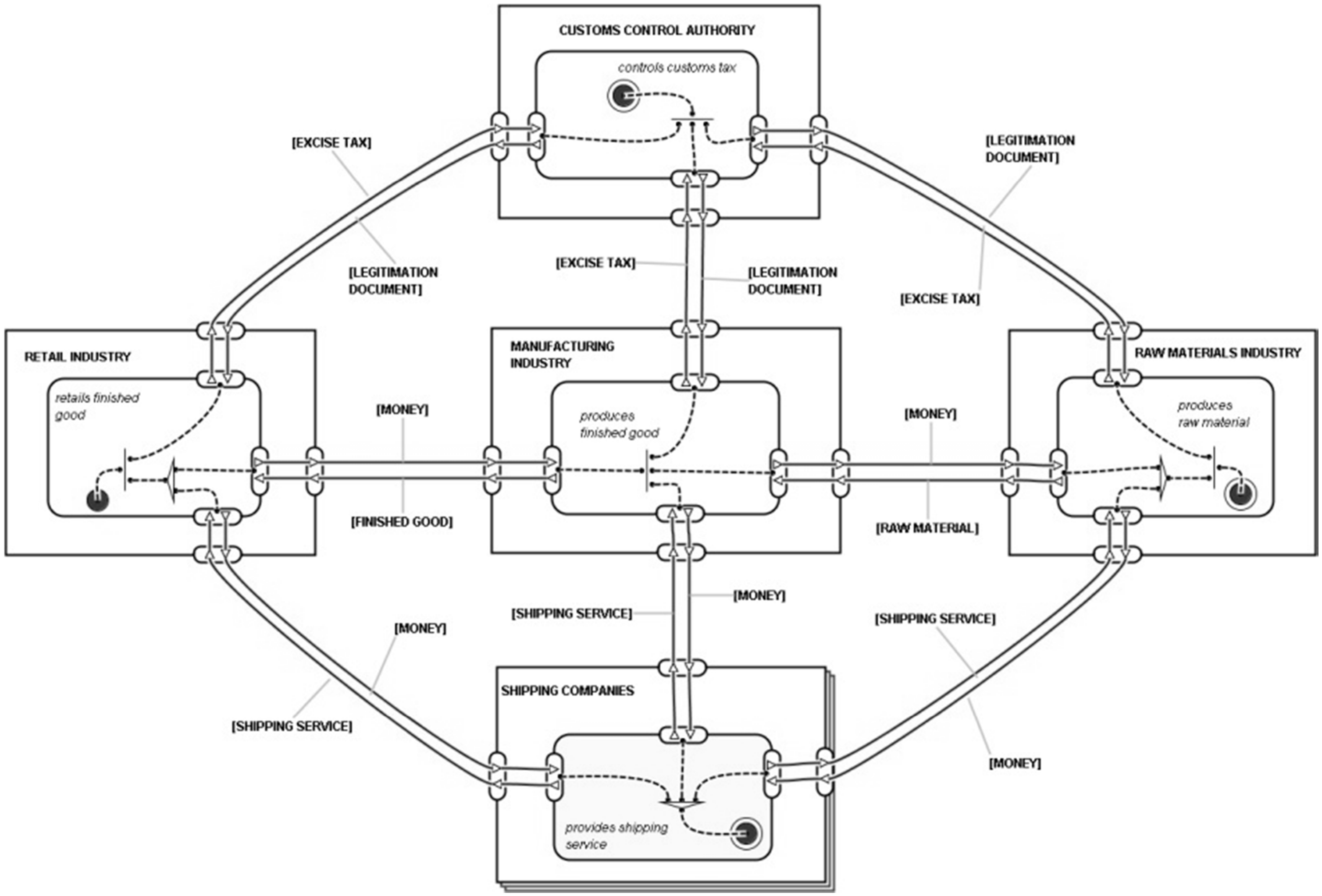

Figure 4-1: Customs Control case: core business value constellation model

Retail Industry

This actor represents a business actor from the *tertiary* industry fruit commerce sector (e.g. retailers of bottled refreshments). According to the picture depicted above, this actor has the consumption perspective of the value constellation. Although the case is essentially a business-to-government instance, a relative consumption point is placed here to indicate that there is core business need in this value constellation. This actor has the competence of retailing a *finished good*, the target market of which is out scope of this constellation. The actor pays *money* to the Manufacturing Industry in exchange of a *finished good*. This value transaction can also be optionally supported by Shipping Companies, from which it may get a *transport service* in exchange of *money*. Last, this actor has a direct value transaction with the Customs Control Authority, to which it has to pay an excise tax in exchange of a legitimation document. The internal logical circuit within the value activity of *retailing finished goods* indicates that the value transaction with the Customs Control Authority is mandatory, whereas the ones with the other actors are optional.

Shipping Companies

This market segment has an essentially supporting role in this business. Shipping companies here provide an optional *shipping service* in exchange of *money* to all the actors of the manufacturing value chain. However, in terms of business strategy, it fills an important position in the value constellation for as it closes a cycle of money flow among the five business-to-business transactions. The value activity of *providing shipping services* comprises another production point of the constellation (represented by a boundary element).

Customs Control Authority

This actor represents a government organization, granted with the competence of controlling the excise taxes applicable to the International Trade manufacturing market. This actor has direct value transactions with all the other actors of the constellation. These transactions are mandatory, as denoted by the 'AND' logical connector within the value activity of *controlling customs tax*. Taking the perspective of the Retail Industry as the consumption point of the value constellation, the activity of controlling tax represents a relative production point. That is, it produces objects that are necessary to fill the Retail Industry's business need. This is represented through the boundary element placed within this value activity.

4.2.2 Monitoring Problem

In order to provide a better definition of the specific monitoring problem of this business case, it is worth to return to the ontological questions to be answered through the use of VMO.

Who wants to monitor whom?

According to the value model depicted in **Figure 4-1**, the consumer's business need comes from the Retail Industry. From a business-to-business perspective, the model specifies that, in order to perform the value activity of *retailing finished goods*, the Retail Industry engages in cooperation with the Manufacturing Industry actor, the market segment of Shipping Companies and the Customs Control Authority, from which the necessary value objects are obtained. However, although the Retail Industry may have its own monitoring needs, the monitoring problem of this case is taken from the perspective of another actor. Hence, the monitoring need comes from the Customs Control Authority, which is willing to monitor this value constellation.

From this perspective, it is considered that the *Customs Control Authority* wants to monitor the *Manufacturing Industry* and the *Shipping Companies*. The rationale of such a choice is also strategic. The *Manufacturing Industry* is chosen because it operates as a monitoring chokepoint in this constellation (i.e. all the value object types flow through this actor). Therefore, monitoring this actor may reveal indirect information about the performance of the entire constellation. From a different perspective, it may also be worth to monitor the behavior of the Shipping Companies. This market segment operates as a glue for the manufacturing supply chain within the value constellation. Hence, although difficult to obtain, the monitoring information provided by this actor can be useful for the sake of evidence triangulation.

What to monitor?

The value activities of *producing finished goods* and *providing shipping services* are the monitoring subjects in this case. These activities comprise the core competences of the Manufacturing Industry and the Shipping Companies, respectively.

Why to monitor?

As advocated along this thesis, there are at least two reasons for monitoring a value constellation: *risk mitigation* and *market exploitation*. For the sake of *risk mitigation*, the value activities of *producing finished goods* and *providing shipping services* should be monitored because the value activity of *controlling customs taxes* depends on the performance of these activities. Hence, these comprise the end-to-end monitoring paths of the value constellation in analysis. For the sake of market exploitation, this is not a case of such, at least not from a business-to-business perspective. However, from a business-to-government perspective, it can be stated that the sustainability of the value activity of *controlling customs taxes* depends on the excise taxes it collects.

How to monitor?

All the value activities in a value constellation are considered as private to the domain of their respective actors. However, the performance of these activities can be sensed through the value objects they produce. For instance, the value activity of producing finished goods can be characterized by its outflow of *money*, *excise taxes* and *finished* *goods*. The delivery of these objects may serve as monitoring evidence *per se*. However, in order to serve as reliable evidence of performance, the delivery of these value objects must be somehow confirmed by other actors in the value constellation. Thus, the point now shifts to who can provide monitoring evidence to whom. This is a problem of monitoring organization and governance.

Although necessary, monitoring organization may not be sufficient to fill the monitoring needs of the party interested in monitoring a value constellation. Monitoring delegation has to be complemented by monitoring experience and use. For example, in the Customs Control case, the monitoring needs of the Customs Control Authority may be achieved through the *excise taxes* produced by the other actors. However, the value returned by these objects constitutes additional monitoring information. Such a value can only be measured internally, by the Customs Control Authority.

4.2.3 Problem Assumptions

There are three important monitoring assumptions to be considered in this case, which are described as follows.

Single Window Assumption

This assumption is based on data reusability by all government authorities for all types of goods movements and can be defined as "a facility that allows parties involved in trade and transport to lodge standardized information and documents from a single entry point to fulfill all import, export, and transit-related regulatory requirements. If information is electronic, then individual data elements should only be submitted once"[5]. For how the case is depicted in **Figure 4-1**, this works as a simplifying assumption. In practical terms, this assumption means here that the Customs Control Authority can monitor the entire value constellation from the point of a single value transaction whereby all the critical monitoring information flows. Such a transaction would operate as a monitoring chokepoint of the constellation. For instance, in the case depicted above, it can be noticed that the value transaction between the Customs Control Authority and the Manufacturing Industry can be perceived as a monitoring chokepoint. The excise taxes declared by the Manufacturing Industry comprehend a transformation of all the other objects of the constellation, and therefore constitute indirect monitoring evidence about these objects.

Closed Monitoring Assumption

This assumption comes from the notion of a monitoring value constellation, as defined by VMO. Based on that, a monitoring value constellation can be perceived as a closed system of monitoring actors and objects, without inflow or outflow of monitoring evidence. The monitoring logic here is that the failure of one single actor could be indirectly sensed by the all the other actors.

[5]European Union: Single Authorisation for Simplified Procedures (SEA) (2006), http://ec.europa.eu/taxation_customs/resources/documents/customs/procedural_aspects/general/centralised_clearance/1284_rev1-en-sea_guidelines.pdf

Cross-Monitoring Assumption

It is also assumed that there are multiple monitoring perspectives within this value constellation. For instance, the perspective taken here is the one of the Customs Control Authority. However, the Retail Industry and all the other actors have their own private monitoring perspective. Hence this assumption can be used to simplify the overall monitoring of the value constellation, for it means that all the actors monitor one another.

Based on the case elements and assumptions given above, the discussion now shifts to how VMO can be applied to this case. This is done by the application of the VMO concepts of *monitoring need, monitoring policy* and *monitoring indicators*.

4.3 Monitoring Value Constellation

This section describes the process of transforming the core business value constellation of the Customs Control case into a monitoring value constellation. This is done by: (1) identifying a monitoring need; (2) designing monitoring policies to achieve this need; and (3) defining monitoring indicators relevant for the measurement of the monitoring need. These steps are described as follows.

4.3.1 Monitoring Need

As mentioned before, the Customs Control Authority has the monitoring perspective of this case. This actor performs the value activity of *controlling customs taxes* of the value constellation. However, the value to be created by this activity is somewhat dependent on the performance of other critical activities. The value activities of *producing finished goods* and *providing shipping services* have been identified as the most suspicious activities. The value objects produced by these activities are not sufficient as reliable evidence of performance. Therefore, a monitoring need is originated at the Customs Control Authority's side. A recap on VMO brings the following relationships:

$$
\begin{aligned}
&MonitoringNeed \equiv ValueMonitoringConstruct \ \sqcap \\
&\qquad \forall\ \boldsymbol{isMonitoringGoalOf.MonitoringPrincipal} \ \sqcap \\
&\qquad \exists\ isEstimatedThrough.ValuePropositionIndicator \sqcap \\
&\qquad \exists\ isEstimatedBy.MonitoringPrincipal \sqcap \\
&\qquad \forall\ \boldsymbol{isAchievedThrough.MonitoringObject} \sqcap \\
&\qquad \forall\ isMeasuredBy.MonitoringPrincipal \sqcap \\
&\qquad \forall\ isMeasuredThrough.ValueInUseIndicator
\end{aligned}
$$

Thus, the Customs Control Authority here is considered as the monitoring principal of the value constellation. The monitoring goal of this actor is to fill its internal (value) monitoring need. This monitoring need is achieved through a monitoring object. The problem now is to identify one or more monitoring policies whereby this monitoring object could be obtained.

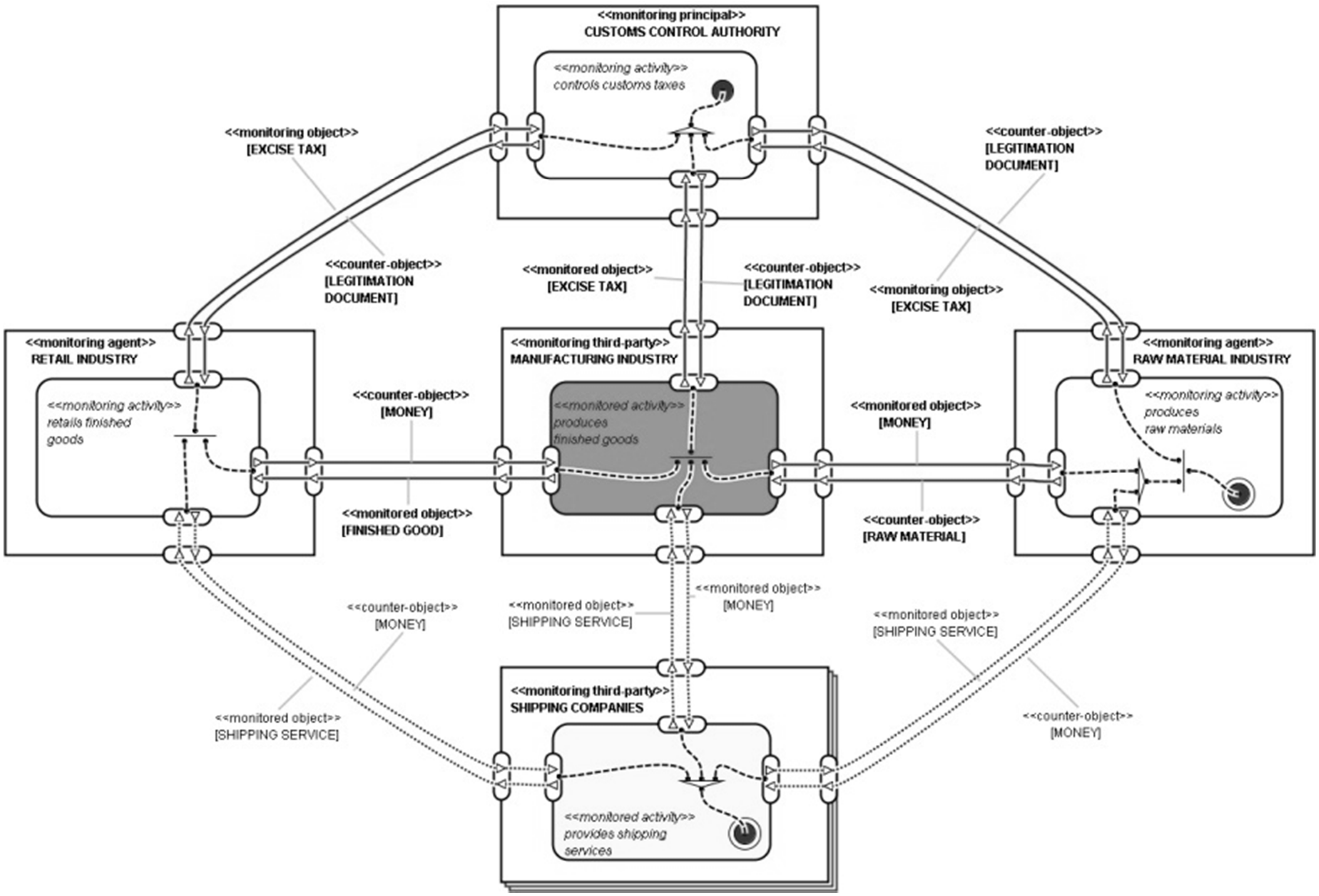

Figure 4-2: Customs Control monitoring policy: Manufacturing Industry with focal monitored activity

4.3.2 Monitoring Policies

Two monitoring policies have been identified for this case, which are depicted in **Figures 4-2** and **4-3**. The policies respect the monitoring problem assumptions of the case. As depicted in the pictures, all the monitoring roles are annotated with UML-like stereotypes. The monitoring policies are identified in the pictures by highlighting their corresponding value creation paths in solid lines. The target suspicious value activity is highlighted in grey. The explanation of both policies is provided below the pictures.

Monitoring Policy 1: Monitoring Manufacturing Industry's Activity

The first monitoring policy is the one designed for monitoring the Manufacturing Industry, illustrated above in **Figure 4-2**. The starting point for configuring this monitoring policy is the monitoring need of the Customs Control Authority, which acts as a *monitoring principal* in this value constellation. From this point and on, it is possible to identify the other major monitoring roles in the constellation. It is also worth to recap on the behavioral specification of the monitoring actor roles. Emphasis is given on the relationships of *competence*, *possession* and *ownership* between the actor roles and respective value activities and value objects:

$$
\begin{aligned}
&MonitoringPrincipal \equiv ActorRole \sqcap \\
&\quad \forall\, hasMonitoringGoal.MonitoringNeed \sqcap \\
&\quad \exists\, estimates.MonitoringNeed \sqcap \\
&\quad \forall\, measures.MonitoringNeed \sqcap \\
&\quad \exists\, \boldsymbol{hasCompetence.MonitoringActivity} \sqcap \\
&\quad \forall\, \boldsymbol{hasPossession.CounterObject} \sqcap \\
&\quad \forall\, \boldsymbol{hasOwnership.MonitoringObject} \sqcap \\
&\quad \forall\, hasAuthority.ValueInUseIndicator \sqcap \\
&\quad \exists\, isActorParticipantOf.MonitoringPolicy \\
&MonitoringAgent \equiv ActorRole \sqcap \\
&\quad \forall\, \boldsymbol{hasCompetence.MonitoringActivity} \sqcap \\
&\quad \forall\, \boldsymbol{hasPossession.MonitoringObject} \sqcap \\
&\quad \forall\, \boldsymbol{hasOwnership.MonitoredObject} \sqcap \\
&\quad \exists\, hasAuthority.ValuePropositionIndicator \sqcap \\
&\quad \exists\, isActorParticipantOf.MonitoringPolicy \\
&MonitoringThirdParty \equiv ActorRole \sqcap \\
&\quad \forall\, \boldsymbol{hasCompetence.MonitoredActivity} \sqcap \\
&\quad \forall\, \boldsymbol{hasOwnership.CounterObject} \sqcap \\
&\quad \forall\, \boldsymbol{hasPossession.MonitoredObject} \sqcap \\
&\quad \exists\, hasAuthority.ValuePropositionIndicator \sqcap \\
&\quad \exists\, isActorParticipantOf.MonitoringPolicy
\end{aligned}
$$

The monitoring policy is explained as follows. The Customs Control Authority acts as the monitoring principal of the constellation. This actor wants to monitor the value activity of *producing finished goods*, performed by the Manufacturing Industry (acting as a monitoring third-party). This can be done directly, by the Customs Control Authority itself, or indirectly, through Retail Industry and Raw Material

Industry, which can act as *monitoring agents*. If monitored directly, the value activity of the Manufacturing Industry is monitored through the *excise taxes* is produces to the Customs Authority. If monitored indirectly, this value activity is monitored through the value objects of *finished good* and *money* it produces to the other actors operating as monitoring agents. Thus, while *excise taxes* represent primary evidence of performance produced by the *monitored activity* of *producing finished goods*, the corresponding *finished good* and *money* comprise *secondary* evidence of such. The monitoring logic is that, as monitoring objects, the excise taxes provided by the monitoring agents represent indirect "traces" of the original monitored objects (i.e. money and finished good). All the other value objects offered in reciprocity are framed as counter-objects. This includes *legitimation document* and *money*. Value objects given are of *possession* of the giving actor, whereas value objects received are of *ownership* of the receiving actor. The relationship of *competence* is visible through the assignment of the monitoring activities to the corresponding monitoring actors.

In other words, the policy model can also be interpreted as follows. The Customs Control Authority wants to monitor the internal activity of the Manufacturing Industry. This could be done directly by this actor, but this would not constitute sufficient monitoring evidence. Therefore, additional evidence is needed, what can be acquired through the excise taxes provided by the other actors operating as monitoring agents. Although the value objects provided by these actors may comprise only secondary monitoring evidence, they can be used for monitoring triangulation. The 'OR' logical connector inside the monitoring principal activity denotes the possible value transactions whereby the monitoring objects can be provided. The resulting monitoring policy comprises only a reconfiguration of existing resources. Therefore, no extra actors, value activities or value objects are used.

Monitoring Policy 2: Monitoring Shipping Companies' Activity

Another monitoring policy has been designed, but for monitoring the Shipping Companies. The model of this policy is depicted in **Figure 4-3**. The monitoring policy has its value paths highlighted in solid lines. The model is explained as follows.

In this scenario, the Customs Control Authority wants to monitor the value activity of *providing shipping services*, performed by the Shipping Companies. As depicted in the model, there is no direct value transaction between this market segment and the Customs Control Authority. In practice, however, direct monitoring channels exist between these two actors. However, they have been suppressed here for as the monitoring of such is also expensive in practice. Moreover, an attempt has been made here in terms of simplifying the model for reuse of value transactions as monitoring channels. The resulting policy comprises Retail Industry and Raw Materials Industry acting as monitoring agents. The Shipping Service is used as a monitored object. The excise taxes provided by the monitoring agents play the role of monitoring objects. The monitoring logic is that these taxes represent indirect evidence of performance of the Shipping Companies. This monitoring policy complements the previous one on covering the monitoring value constellation.

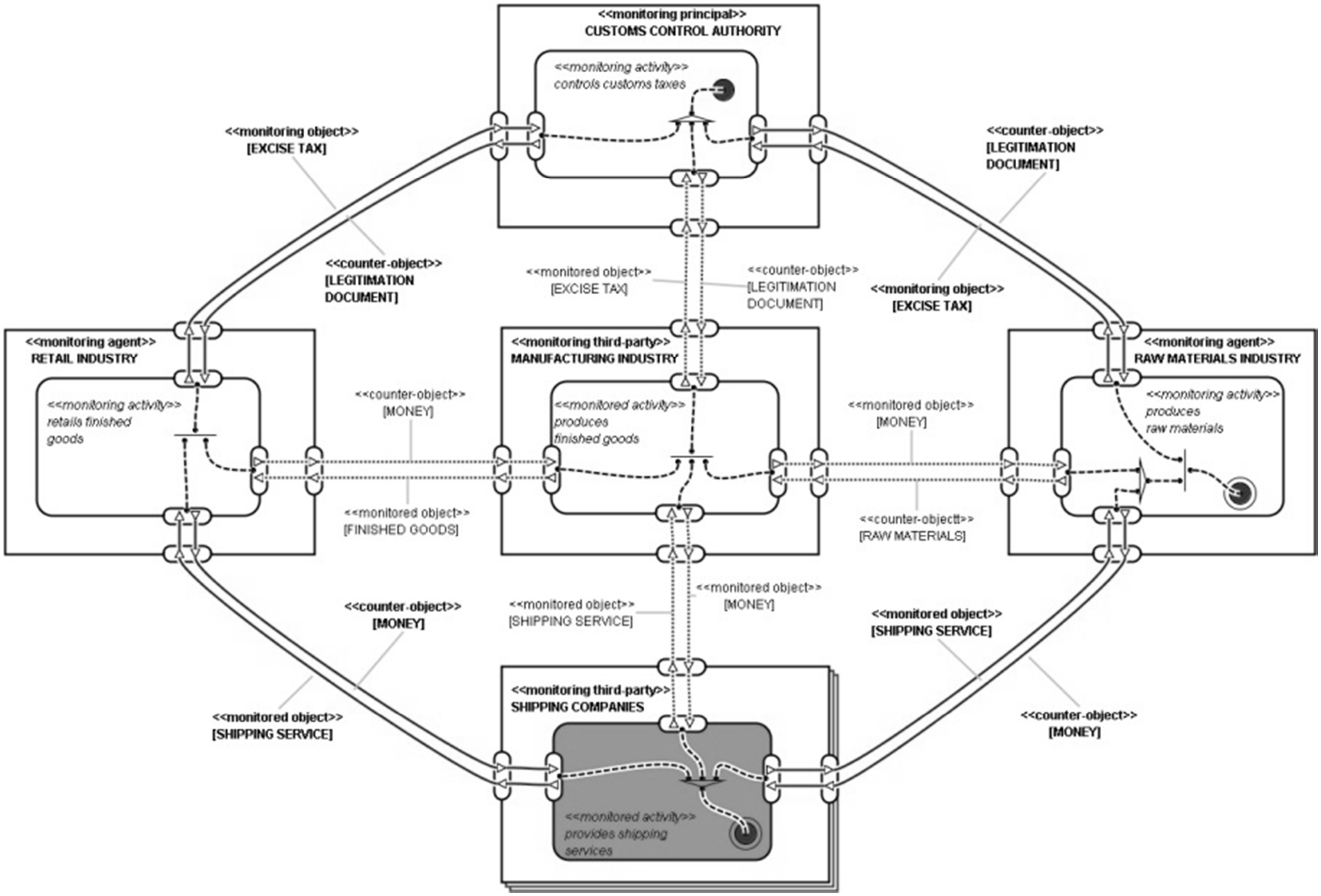

Figure 4-3: Customs Control monitoring policy: Shipping Companies with focal monitored activity

For the sake of compliance, the policy models above can be checked through the abstract specification of a monitoring policy:

$$
\begin{aligned}
&\boldsymbol{MonitoringPolicy} \equiv ValueMonitoringConstruct\ \sqcap \\
&\qquad = 1\ hasActorParticipant.MonitoringPrincipal \sqcap \\
&\qquad \leq 1\ hasActorParticipant.MonitoringThirdParty \sqcap \\
&\qquad \geq 2\ hasActorParticipant.MonitoringAgent \sqcap \\
&\qquad\qquad \forall\ hasActorParticipant.(MonitoringPrincipal\ \sqcup \\
&\qquad\qquad MonitoringAgent\ \sqcup MonitoringThirdParty) \sqcap \\
&\qquad \leq 1\ hasActivityParticipant.MonitoredActivity \sqcap \\
&\qquad \geq 2\ hasActivityParticipant.MonitoringActivity \sqcap \\
&\qquad\qquad \forall\ hasActivityParticipant.(MonitoringActivity\ \sqcup \\
&\qquad\qquad MonitoredActivity) \sqcap \\
&\qquad \leq 1\ hasObjectParticipant.MonitoredObject \sqcap \\
&\qquad \geq 2\ hasObjectParticipant.MonitoringObject \sqcap \\
&\qquad \exists\ hasObjectParticipant.CounterObject\ \sqcap \\
&\qquad\qquad \forall\ hasObjectParticipant.(MonitoringObject\ \sqcup \\
&\qquad\qquad MonitoredObject\ \sqcup CounterObject)
\end{aligned}
$$

It is worth to notice how the monitoring policies previously described comply with the cardinality constraints specified above. Each policy contains exactly one monitoring principal, at most one monitoring third-part and at least two monitoring agents. All the closure axioms are respected so as to indicate the only monitoring roles in a monitoring value constellation.

The monitoring policy models described above constitute proposals of strategies for monitoring the value constellation of the Customs Control case considered here. Together, they specify the basic organization of a monitoring value constellation for this case. However, in order to fulfill the specification of the monitoring goal considered, additional monitoring information is needed. Such monitoring information comprehends the prospection and measurement of the value generated by the monitoring objects. This is demonstrated on the models described next.

4.3.3 Monitoring Indicators

As stated before, monitoring indicators in VMO are used to denote information about the subjective value to be generated by a value object. This also applies to monitoring objects. Hence, monitoring indicators are used here to refine the definition of monitoring objects. This concept also brings implications for the definition of monitoring needs in monitoring value constellations. The point here is that a monitoring problem of a value constellation is not solved solely through the provisioning of monitoring objects. The ultimate goal is on the assessment of the value generated by these objects. Thus, according to VMO indicators can be used to measure monitoring efficiency in a value constellation.

Two models have been produced to describe the internal monitoring efficiency of the Customs Control value constellation. One model contains the public value propositions of the constellation, whereas the other model contains only the private measurements of value creation taken from the perspective of the monitoring principal.

Value Proposition Model

This model is depicted below in **Figure 4-4**. For the interpretation of the model, it is worth to return to the formal definition of a value proposition indicator, which is given below.

$$
\begin{aligned}
&ValuePropositionIndicator \equiv IndicatorRole \ \sqcap \\
&\qquad \exists\, isIndicatorRoleOf.Indicator \sqcap \\
&\qquad \exists\, isEstimationOf.MonitoringNeed \sqcap \\
&\qquad \exists\, isAuthorityOf.MonitoringAgent \ \sqcap \\
&\qquad \exists\, isAuthorityOf.MonitoringThirdParty \sqcap \\
&\qquad\qquad \forall\, isAuthorityOf.(MonitoringAgent \ \sqcup \\
&\qquad\qquad MonitoringThirdParty) \sqcap \\
&\qquad \forall\, precedes.ValueInUseIndicator
\end{aligned}
$$

Hence, a value proposition indicator is of authority of some monitoring agent and also of some monitoring third-party (and only these two parties, according to the closure axiom). This information represents the estimation of some monitoring need and precedes the derivation of a value-in-use indicator.

For the Customs Control case, a value indicator considered as of relevance corresponds to the *assurance* indicator, from the SERVQUAL scale (Parasuraman, Berry and Zeithaml, 1991). According to SERVQUAL, assurance is defined as “the knowledge and courtesy of employees and their ability to convey trust and confidence”. Especially for this business case, assurance is considered as an indicator of high value for all the participants of the manufacturing supply chain. Therefore, all the propositions among the participants of this suplly chain are proposed as of *high value*. The actors receiving such propositions can use this information to prospect their own value creation. However, the point is that these propositions are public, and the Customs Control Authority (acting as a monitoring principal) can use this information to prospect its internal monitoring goals of value creation. Moreover, all the excise taxes are proposed as of *neutral value* to the Customs Control Authority. The meaning of such is that the subjective value of these objects is not a relevant subject of proposition, but only of internal measurement for the monitoring principal. Based on this model, it is possible for the monitoring principal to prospect his internal value creation. Now the point shifts to the scenario where it is assumed that the value propositions had been delivered and the corresponding value experiences have been measured.

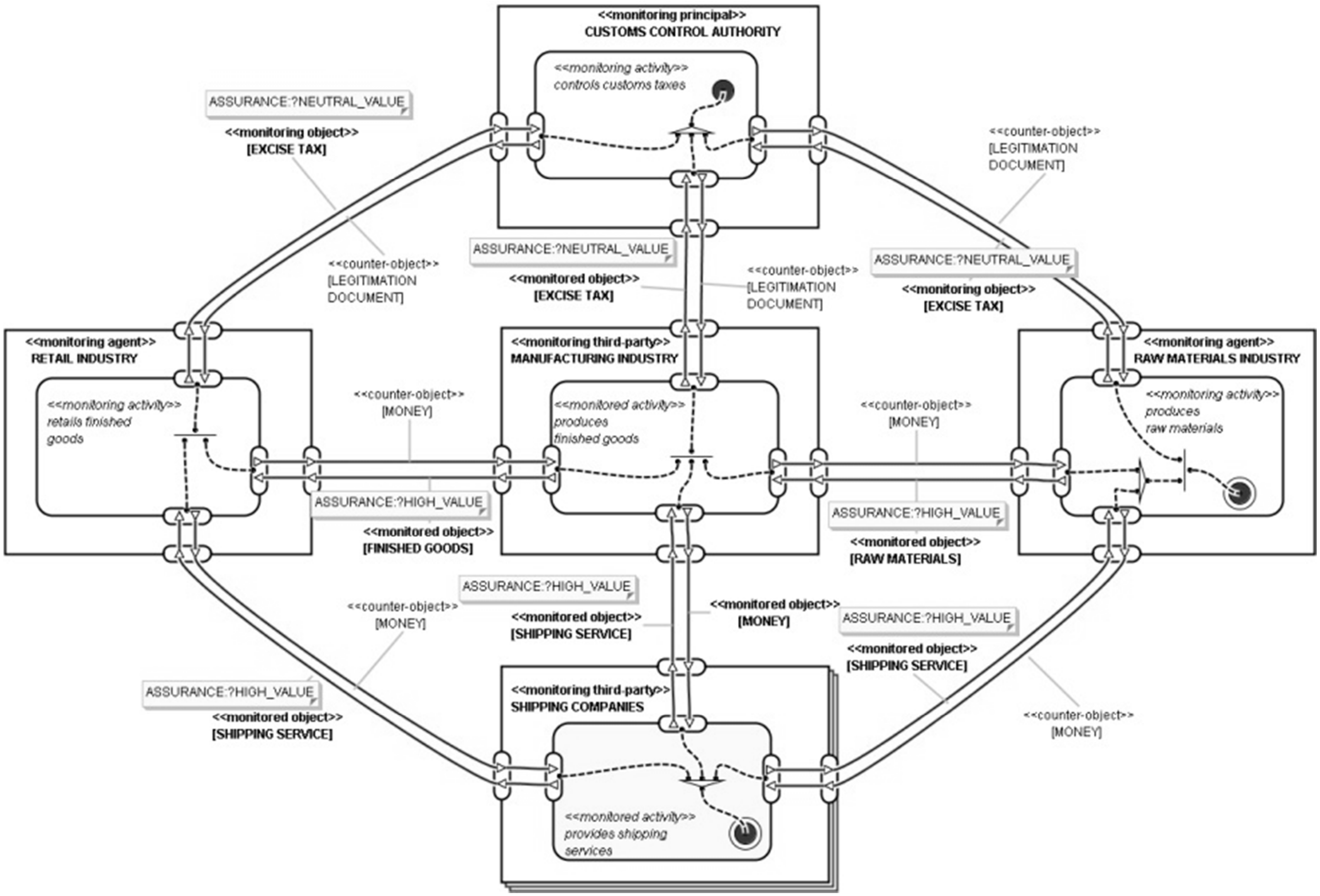

Figure 4-4: Customs Control monitoring value constellation: value proposition model

Value Experience Model

The value experience model represents the perspective of the monitoring principal in a point in time after value propositions had been delivered. The demonstration of a value experience model for the Customs Control Authority is depicted in **Figure 4-5**. It is worth to return to the definition of a value-in-use indicator given below.

$$\begin{aligned}&ValueInUseIndicator \equiv IndicatorRole \sqcap\\&\quad \exists\, isIndicatorRoleOf.Indicator \sqcap\\&\quad \forall\, isAuthorityOf.MonitoringPrincipal \sqcap\\&\quad \forall\, isMeasurementOf.MonitoringNeed \sqcap\\&\quad \forall\, isPrecededBy.ValuePropositionIndicator\end{aligned}$$

Therefore, a *value-in-use indicator* (i.e. value experience) comprehends information that is of authority of only a monitoring principal. It also comprises the actual measurement of a monitoring need and is preceded (in time) by a value proposition indicator.

The model depicted below illustrates some value-in-use indicators measured by the Customs Control Authority. This includes only the value transactions that involve direct participation of this actor. Information about the other value transactions are assumed to be undisclosed, for as they represent private value measurements. In this scenario, it is considered that the value propositions of value assurance have been experienced by the Customs Control Authority. Two of them have been measured as of high-value, whereas another one, as of low-value. If considered that the two monitoring agents have offered equivalent value propositions for the same type of monitoring objects, then the distinction between them can be made on the subjective value generated by these objects. In this particular business case, assurance represents a value of relevance to distinguish monitoring objects. Truly, the declaration of excise taxes reveals critical evidence about the performance of the taxed activities and actors. However, the assurance (as a value indicator) that comes from the provisioning of these monitoring objects may strengthen long-term collaboration between monitoring principals and agents to the point of reducing future monitoring needs. The main relationships used in the indicator models depicted above are highlighted below, returning to the definition of a monitoring goal.

$$\begin{aligned}&MonitoringNeed \equiv ValueMonitoringConstruct \sqcap\\&\quad \forall\, isMonitoringGoalOf.MonitoringPrincipal \sqcap\\&\quad \exists\, \boldsymbol{isEstimatedThrough.ValuePropositionIndicator} \sqcap\\&\quad \exists\, \boldsymbol{isEstimatedBy.MonitoringPrincipal} \sqcap\\&\quad \forall\, isAchievedThrough.MonitoringObject \sqcap\\&\quad \forall\, \boldsymbol{isMeasuredBy.MonitoringPrincipal} \sqcap\\&\quad \forall\, \boldsymbol{isMeasuredThrough.ValueInUseIndicator}\end{aligned}$$

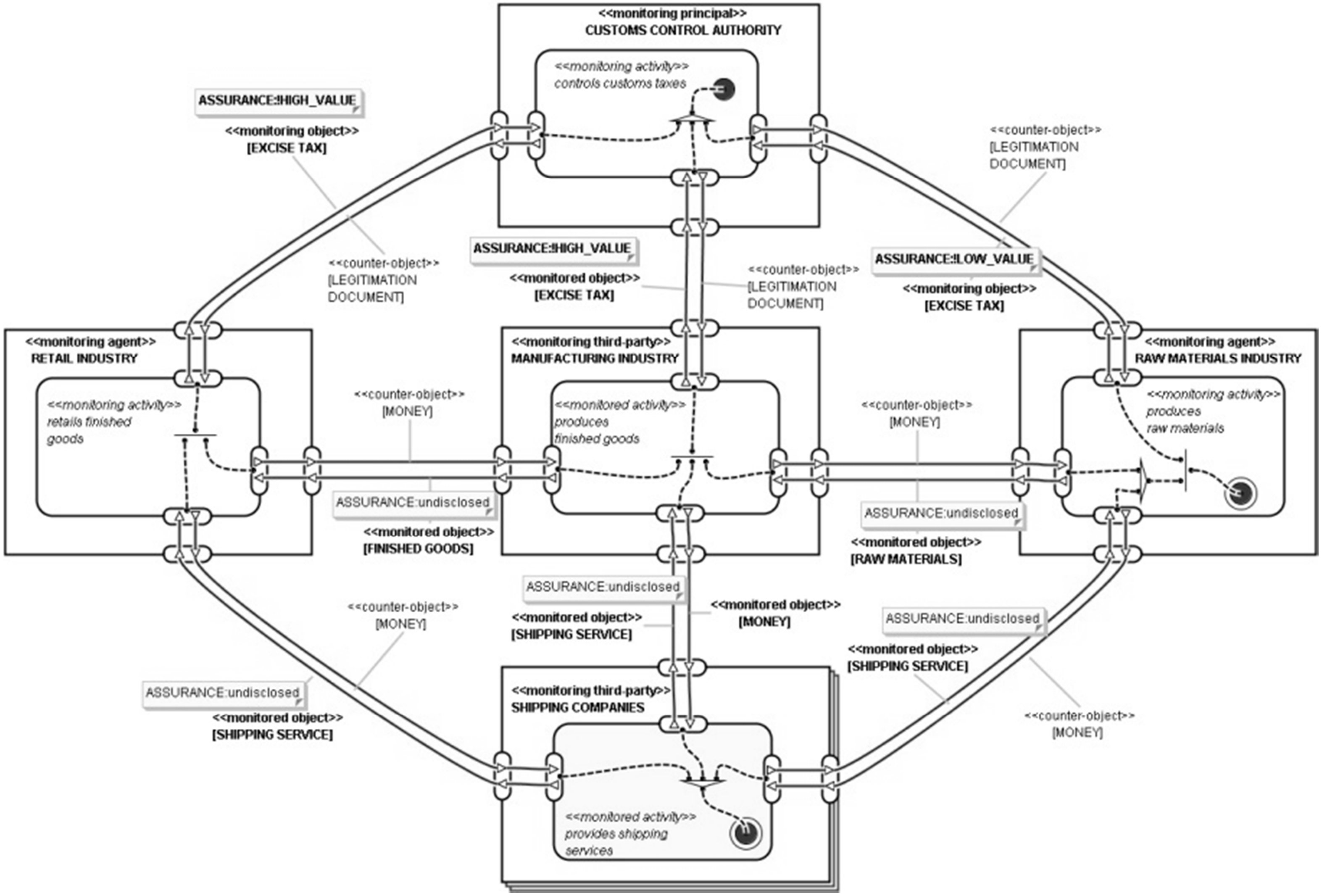

Figure 4-5: Customs Control monitoring value constellation: value experience model

4.4 Application-Based Ontology Evaluation

In this section, a discussion is provided on evaluating the application of VMO on the Customs Control case. The evaluation is focused on the *practical effectiveness*, *practical efficiency*, *best practices* and *limitations* encountered on the application of VMO on this business case.

4.4.1 Practical Effectiveness

According to the research design framework proposed to evaluate VMO (vide **Chapter 2**), the case studies used in this work have the purpose of evaluating this candidate ontology regarding its practical effectiveness and efficiency. Practical effectiveness here is related to a demonstration of *cost-effectiveness* of the monitoring value constellations framed by VMO. Two arguments are use here to advocate VMO as a cost-effective organizational model.

First, according to VMO, the monitoring of a value constellation is considered as a business need. A monitoring need, as a specific type of business need, demands monitoring objects. These objects are acquired by the cost of counter-objects given in return. Moreover, these objects are provided by competent monitoring parties that compose a monitoring value constellation. From this perspective, VMO can be used in conjunction with the *e3value* mechanism of profitability analysis. From this point and on, the cost-effectiveness of the monitoring is resumed to an accountability problem.

Second, as structured by VMO, a value constellation can be monitored through a reconfiguration of its organizational roles. The outcome of such a reconfiguration is the so-called monitoring value constellation, which is built on top of an ordinary value constellation. In practical terms, this approach reuses the existing resources of a value constellation for its self-monitoring. This has been demonstrated on the Customs Case presented in this chapter. According to the demonstration given, no extra resources were considered as necessary to define a monitoring value constellation for this case. Therefore, from the perspective of this case, VMO has been evaluated as cost-effective.

4.4.2 Practical Efficiency

Yet according to the research design of VMO, the practical efficiency of this model has been associated to a demonstration of *monitoring reliability*. The Customs Case has also been used for this purpose. Reliability here has been demonstrated based on two assumptions considered in the case: (1) of a monitoring value constellation as a closed monitoring system; and (2) of a monitoring value constellation as a cross-monitoring system.

The first assumption is derived from the definition of a monitoring value constellation. The logic of this system is of a closed value constellation, in which performance deviations are easily sensed by all the participants. That is, the social organization of this system is structured in such a way that most of the objects carry indirect monitoring information about one another. This has been demonstrated through the indirect relationships among the value objects of the Customs Case.

The second assumption also comes from the definition of a monitoring value constellation. The cross-monitoring assumption is based on the idea that the monitoring objects received by the monitoring principal of a value constellation have been previously evaluated by the other actors of the constellation. This has been demonstrated in the Customs Control case through the cross-monitoring involving the two monitoring agents of the underlying value constellation. As part of this assumption, it can be considered that the monitoring agents of a value constellation may themselves be monitoring principals according to their own monitoring perspectives. The illustration of these concepts on the Customs Control case somewhat characterizes VMO as a (potentially) cost-effective Service monitoring logic.

4.4.3 Best Practices

Simply put, there have been two best practices documented during this case study application. The first one is concerned with the check of consistency between VMO and the models of the case study. The second one regards the compositional aspect of the final monitoring value constellation model.

The first best practice is that the application of VMO in a case like the one addressed here demands considerable human expertise on the underlying Business domain. This is especially the case during the assignment of the monitoring roles to the resources that compose the core business value constellation. Although it is envisioned that such a mechanism can be fully automated in future research, the position advocated here is the one of VMO to be used as both an IT artifact and as a set of business strategy guidelines.

The compositional aspect of the monitoring value constellation model has also its utility. The models produced for this case have been demonstrated in sequence. However, each model actually adds a new layer of monitoring information to the original model of the value constellation.

4.4.4 Limitations

The main limitation of this case application regards the missing feedback from practitioners about the conceptual soundness of the models produced. Therefore, the results achieved through this case comprise more a theoretical demonstration than a pragmatic evaluation.

4.5 Discussion

In this chapter, a report on the application of VMO on a case in Customs Control has been presented. The elements of practice of this case have been provided as a courtesy of participants of the DINALOG project. As part of the contribution of this research, these elements of practice have been transformed into the model of a value constellation. From this model, a monitoring value constellation has been derived through the use of VMO. The purpose of such has been to evaluate the practical applicability of the concepts defined in this candidate ontology.

The main results of this case evaluation comprised a demonstration of the practical effectiveness and efficiency of VMO. Practical effectiveness has been related to the cost-effectiveness of the monitoring value constellation model derived for the case. Practical efficiency, though, have been associated with a demonstration of monitoring reliability of the same model. Moreover, the evaluation has also provided some best practices and limitations on the use of VMO in real-world business cases like the one addressed here. The main best practice reported is that using VMO reinforces the utility of VMO as a strategic organizational model, thereby requiring considerable human judgment based on business expertise. The main limitation of this evaluation is that it does not include feedback of practitioners from the Customs Control domain. However, this limitation is also posed as a direction for future research.

The next chapter reports on the evaluation of VMO through a case study in Renewable Energy. In this case, a deeper discussion is provided on the utility of the value proposition and value experience models.

Chapter 5: A Case in Renewable Energy

What I dream is an art of balance.

Henri Matisse (1869 – 1954), *O Magazine*, April (2003)

5.1 Introduction

This chapter reports on the application of VMO on a business case from the Renewable Energy market. It complements, therefore, the *ontology application-focused evaluation* accomplished in this research. As published in (Silva and Weigand, 2011b), this case has been initially used to *explore* the research problem addressed in this thesis and to test the applicability of VMO in its first version (so-called 'Enterprise Monitoring Ontology'). As reported here, the case has an extended scope, being used to *confirm* the applicability of the current version of VMO. The research context of the case is briefly described as follows.

The business case reported here is part of the research evaluation resources provided by the VALUE-IT project (2008-2012). Overall, the main goal of this project has been to develop mechanisms and techniques to improve the process of configuring value constellations. VMO comprises partial accomplishment of this goal. Originally, VALUE-IT has comprised a research collaboration involving three knowledge institutions, two technology partners and two public organizations in the Netherlands. The ones directly involved in this business case comprise the Energy Research Center of the Netherlands (ECN)[6] and Tilburg University. ECN is the leading Dutch institute for innovation in the energy sector. Currently, most of this innovation is related to the development of technologies for analyzing the sustainability of emergent energy markets. Due to progressive liberalization, the current organization of energy markets much resembles the one of a value constellation. This brings to the possibility of using value modeling (cf. the *e3value* framework) as a decision-support tool for communicating innovative business strategies in the Energy sector.

Briefly stated, the case brings about the scenario of a value constellation composed of different market segments of energy suppliers trading renewable energy. Due to the stochastic nature of this type of energy, it is assumed that the amount of energy promised as a value object often deviates from the amount of energy that is actually delivered. This constitutes the first monitoring problem of this case. In order to partially cope with this problem, the initial energy supply scenario is extended with the inclusion of energy metering parties, which are assumed to provide trusted energy metering assets and services. Although somewhat coping with the monitoring problem firstly mentioned, the inclusion of these actors brings further monitoring problems to the underlying value constellation. These problems include: (1) the need of organizing the monitoring information disclosure and governance of the

[6] www.ecn.nl

constellation; and (2) the difficulty to assess the value returned by the metering assets and services. These problems have been posed as some of the main barriers on the adoption of the Smart Metering technology European-wide[7].

Therefore, the Service monitoring problems of this case represent a challenging research opportunity for evaluating the applicability of the concepts defined in VMO. The first problem mentioned above demands a logic of *Service monitoring organization and governance*, whereas the second one, a logic of *Service monitoring valuation*. Therefore, as part of the main contributions of this work, a monitoring value constellation has been designed for this case, derived through the use of VMO. This monitoring constellation is described in this chapter along its corresponding monitoring policy models and monitoring valuation models. Rather than final solutions for this case, these models comprise only a proposal of alternative monitoring strategies for the referred business market. Since its original publication in (Silva and Weigand, 2011b), this proposal has been elaborated in cooperation with practitioners from ECN. The monitoring policies (i.e. monitoring organization) described in this proposal have been evaluated by practitioners from ECN and scholars from the Conceptual Modeling field as theoretically sound. In this thesis, the models of monitoring indicators (i.e. monitoring valuation) comprise additional research contribution and are proposed for discussion.

This chapter is organized as follows. In **section 5.2**, a value model describing the core business value constellation of this case is presented, along with its participant actors, value activities and value objects. This value constellation merges the markets of Renewable Energy supply and Smart Metering services. In **section 5.3**, the proposal of a monitoring value constellation is presented for this case. The proposal comprehends models of alternative monitoring policies and value indicators. In **section 5.4**, a discussion is provided on how this case demonstration contributes for evaluating the practical effectiveness and efficiency of VMO. This in turn includes comments on the best practices and limitations of the VMO application on the case. Last, some closing remarks and open issues about this case are provided in **section 5.5**.

5.2 Core Business Value Constellation

The increasing global demand for energy has pushed the inclusion of renewable energy (e.g. biomass, solar and wind power) in the electricity markets. From the perspective of environmental sustainability, the benefits brought by these resources are somewhat evident. However, from an economic perspective, the benefits are controversial. Intermittent resources such as solar panels and wind turbines often fail on delivering the estimated amount of energy. From one side, this brings extra risks and imbalances to the electricity markets. From another side, such risks may also

[7] European Smart Metering Alliance (ESMA): Annual Report on the Progress in Smart Metering (2010)

bring opportunities for businesses dealing with risk mitigation. Such businesses may include, for instance, markets of monitoring services.

Hence, the business case brought to discussion in this chapter comprises an intersection between the markets of Energy supply and Energy metering. The intersection is captured as a value constellation model, which is described as follows.

5.2.1 Actors, Value Activities and Value Objects

The value constellation model describing this business case is depicted in **Figure 5-1**. This model is compliant with the EU Directive 2004/54/EC[8], which regulates the basic business roles in vigor within the European electricity markets. Some of the actors considered here already operate as typical monitoring parties. Nonetheless, it is worth to note that this model does not represent yet a monitoring value constellation as defined in VMO. Instead, this model encompasses only the core business value constellation of the underlying business case. The model is described below, according to its participant actors, respective value activities of competence and exchanged value objects.

Balance Resource Party (BRP)

All the electricity suppliers accredited as Balance Responsible Parties (BRP) have the obligation to provide estimates of the amount of electricity to be produced to the Transmission System Operator (TSO – suppressed in this model). Such estimates, called *energy programs*, must be provided each 15 minutes, so as the TSO can have a big picture on the energy flow in the whole system. Currently, renewable energy resources can be accredited as BRPs. However, when a wind turbine fails, for example, it has to pay balancing costs to the TSO. There are two ways a BRP can cope with the implied penalties: (1) to pay the imbalance costs directly to the TSO, which can be high, as the TSO offers transparent balancing by using its own reserves; or (2) to use its own portfolio of small-scale Distributed Energy Resources (DER) to cope (potentially) with the imbalance. The second option pushes the BRP to freelance on the electricity wholesale market so as to discover a bundle of DERs to cope with the imbalance. This last option has a high business value to the BRP, as it may not only cope with the caused imbalance, but also generate profit.

This is the point where the model depicted in **Figure 5-1** actually starts. A BRP is the business consumer of this value constellation. It performs the value activity of *balancing energy demand*. To perform this value activity, this party engages in collaboration with three other actors. The first one is the market segment of the *Energy Retailers*, which is assumed here to operate as an intermediary between BRPs and the small-scale DERs. The BRP receives bundled *renewable energy* from the Energy Retailers in exchange of *money*. Energy retailers and DERs are assumed to

8 European Parliament and Council. Common Rules for the Internal Market in Electricity. EU Directive 2004/54/EC. In: Official Journal of the European Union, July 15 (2003)

produce only renewable energy. To mitigate the risks of this commodity, the BRP may optionally collaborate with Energy metering asset parties. Recently, the metering competence has also become subject of liberalization in Europe[9]. Thus, the BRP has three options for measuring the energy produced by both Energy Retailers and DERs: (1) through a Metering Asset Provider, to which it has to pay a *metering asset fee*; or (2) through a Metering Asset Manager, to which it has to pay a *metering service fee*; or (3) by itself, through accreditation as a metering responsible party. These options are denoted by the logical 'OR' connector, placed inside the BRP's value activity.

Energy Retailers

This market segment operates as a broker between the BRP and the small-scale DERs. In the specialized literature, *Energy Retailers* are also referred as *aggregators* (Kamphuis et al., 2007; Warmer et al., 2007). They are competent to perform the value activity of *retailing energy*. To perform this activity, Energy Retailers buy *renewable energy* from DERs and resell it to the BRP. Besides, these parties have also implied collaboration with both metering asset parties. To the Meter Asset Provider (MAP), they provide an *open monitoring channel* and a *meter asset fee* in exchange of a *metering asset*. To the Meter Asset Manager (MAM), they provide (private) *metering data* and a *metering service fee* in exchange of a *metering service*. As denoted by the logical 'AND' placed within the value activity of *retailing energy*, all the four value transactions are necessary. The rationale for the collaboration with the metering asset parties is explained through the description of competence of these parties.

Distributed Energy Resources (DER)

This market segment comprises the small-scale energy producers from the renewable energy market. The energy produced by an individual DER has its value increased if sold in aggregation. Collectivity in this case improves the overall reliability of this type of energy. Thus, DERs acquire a better visibility in this market through the mediation provided by Energy Retailers. This market segment performs the value activity of *producing energy*. To perform this activity, the DERs engage in direct collaboration with three other actors. To the Energy Retailers, they provide *renewable energy* in exchange of *money*. To the Meter Asset Provider (MAP) they provide an *open monitoring channel* and a *metering asset fee* in exchange of a *metering asset*. From the Meter Asset Manager (MAM) they receive a *metering service* in exchange of *metering data* and a *metering service fee*. As denoted by the logical connector 'AND', these three value transactions are necessary for the operation of the referred value activity.

[9] NMa/DTe: Electricity Metering Code Conditions within the meaning of Section 31, subsection 1b of the Electricity Act 1998, Informal Translation. Office of Energy Regulation (part of the Netherlands Competition Authority), September 4 (2007)

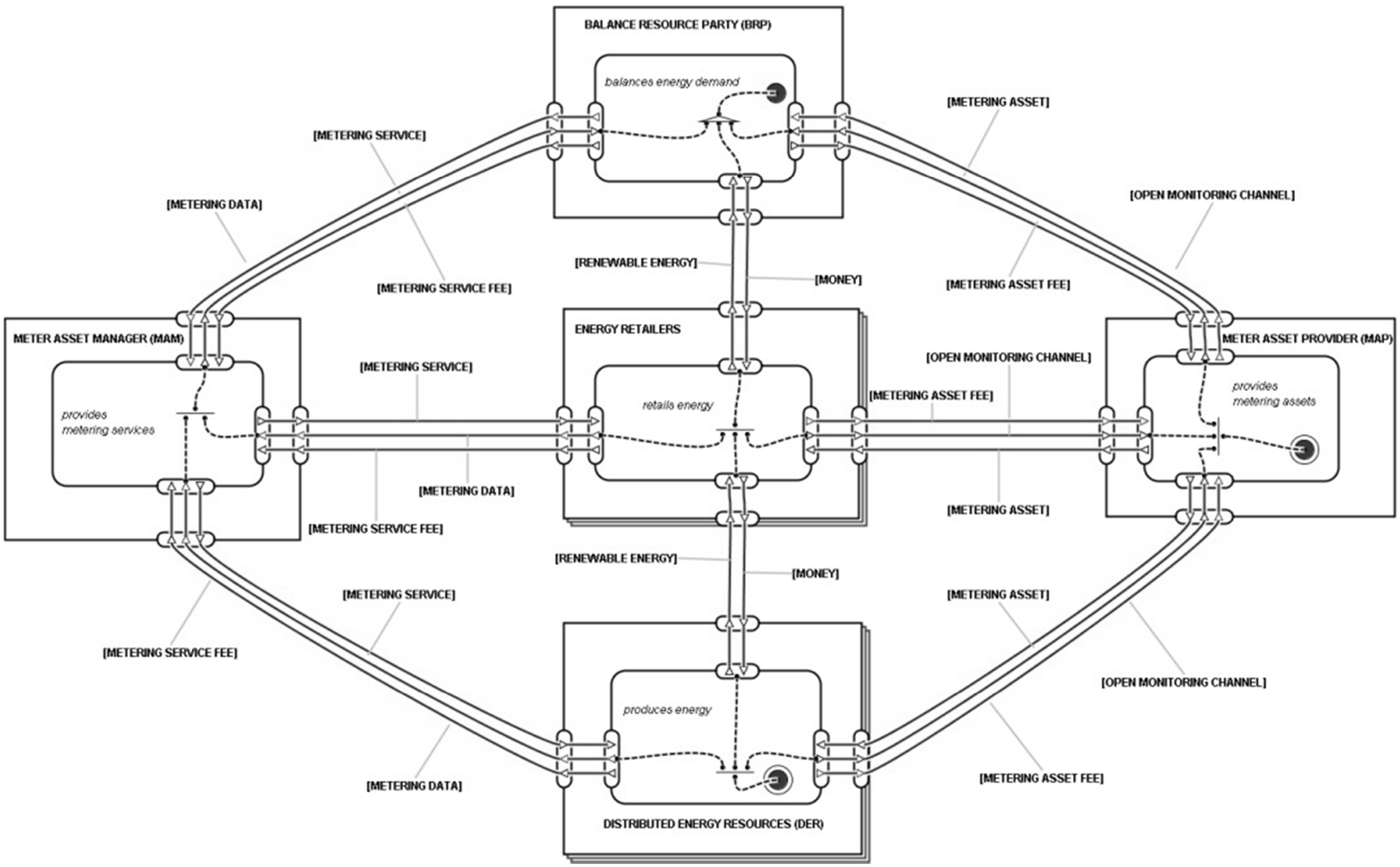

Figure 5-1: Renewable Energy market: core business value constellation model

Meter Asset Provider (MAP)

This actor comes from the market of Smart Metering service providers. Smart Metering comprise the next generation of energy metering infrastructure and services aimed to provide means for managing the consumption and production of energy in a more sustainable way. The architecture of the Smart Metering technology somewhat conforms to the Autonomic Computing vision (Kephart and Chess, 2003). A Smart Metering system (e.g. a neighborhood of intelligent households) is composed of a set of self-managed elements. Each element (e.g. intelligent households and combined heating and power – CHP) has a controlled and a controlling unit. The *controlled* unit comprises all electric devices within the house, furnished with Smart Metering interfaces. The *controlling* unit, however, comprises the Smart Metering assets, which provide not only metering capabilities, but also automated controlling facilities based on the technical principle of *demand-response*. This principle refers to the regulation of energy production and consumption by matching environmental needs with market price stimuli. Smart meters implement this principle. They use market stimuli of energy prices to control energy production and consumption devices. For example, a smart meter asset can emit a signal to reduce the energy consumption of an air conditioning system during a period of the day when the energy price is high.

A *Meter Asset Provider* (MAP) provides the Smart Metering assets. In the scenario depicted above in **Figure 5-1**, this actor plays a strategic risk-mitigation role. All the energy suppliers (i.e. BRP, Energy Retailers and DERs) may be interested in monitor (mutually) their respective activities of competence. As mentioned before, these activities are all sources of risk, due to the intermittent nature of the renewable energy. Thus, the MAP performs the value activity of *providing metering assets.* It does so by providing *metering assets* in exchange of an *open monitoring channel* and a *metering asset fee*. In this business case, these exchanges apply to all the energy suppliers involved. This is represented by the 'AND' logical connector placed within the MAP's value activity. Hence, the energy suppliers may be interested not only in monitoring their own internal energy production and consumption, but also their partners'. This is supported through the exchange of an *open monitoring channel*. This value object is critical for the Smart Metering technology. This is due to that the level of intrusiveness of the Smart Metering technology is subject to agreement between Smart Metering service providers and users. From a business strategy perspective, an *open monitoring channel* for Smart Metering is the value object that most closely approaches the measurement of internal performance. Value exchanges involving this type of object are subject of market regulation (NMa/DTe, 2007).

Meter Asset Manager (MAM)

This actor comes from a related segment of the Smart Metering market. They normally operate in association with the Meter Asset Providers (MAP). In the scenario depicted above, the collaboration between these two parties has been suppressed. This business collaboration has been considered as irrelevant for this case evaluation. Hence, for this case, what is relevant is the type of service provided by this actor, which is also critical for risk mitigation in the underlying business market.

A Meter Asset Manager (MAM), therefore, provides advanced Smart Metering services, such as customized metering services (Koponen, 2008). These reports may include, for instance, detailed monitoring information about schemes of bonuses, compensations and warranties related to energy production and consumption. Therefore, they play a critical role in this market in terms of providing evaluation-based services. Both MAMs and MAPs are part of a market in liberalization. This brings two opportunities for exploring this market. First, the users of this facility can choose among different providers of Smart Metering assets and services. Second, that the metering responsibility itself has become subject of open accreditation. That is, in order to reduce (potentially) monitoring costs, energy suppliers can also obtain the accreditation necessary to operate as metering responsible parties.

Therefore, in order to perform the value activity of *providing metering services*, a Meter Asset Manager may engage in collaboration with three actors from this market. It does so by providing *metering services* in exchange of *metering data* and a *metering service fee* to all the energy suppliers involved. It is assumed that all three value transactions involving these objects are necessary, what is represented through the 'AND' logical connector placed inside the referred value activity. This also reinforces the critical role of this actor as a risk mitigation alternative. Together with the Meter Asset Provider, this actor explores monitoring opportunities in this case.

5.2.2 Monitoring Problem

The case addressed here provides venue for the analysis of many monitoring scenarios. Hence, it is worth to isolate one narrative story about the monitoring problem of relevance here. The discussion now returns to the ontological questions to be addressed through a VMO application.

Who wants to monitor whom?

All the energy supply parties included in the scenario described above may be interested in monitoring one another. Nevertheless, according to VMO, the dominant monitoring perspective taken here is on the consumer's side. Thus, the BRP is interested in monitoring the activity of the Energy Retailers and the DERs.

What to monitor?

As mentioned before, it is assumed in this case that the BRP freelances in the energy wholesale market to cope with its responsibility of energy balancing towards a Transmission System Operator (TSO) – left out of the model. It is also assumed that the commodity in trade (renewable energy) is intermittent. Therefore, all the value activities of the constellation are sources of risk – not due to opportunism, but to limited capability of delivering expected performance. Such factors put the value activity *balancing energy demand* (performed by the BRP) in a condition of risk. Hence, the value activities of *retailing energy* and *producing energy* are the monitoring subjects in this case, which constitute the core competences of the Energy Retailers and DERs, respectively.

Why to monitor?

The monitoring rationales of this case are the same advocated in this thesis: *risk mitigation* and *market exploitation*. It is assumed that the BRP has to pay imbalance costs to an external TSO. It does so by engaging in the market represented by the value model depicted above. This market, though, is not stable. Hence, if the BRP does not cope with its own imbalances through the profit generated by this alternative market, it may fall into another level of imbalance. However, this high-risk market also constitutes business opportunities for all the actors involved. For the metering parties, the opportunity is noticeable. For the BRP, as a consumer of the metering technology, the opportunity is at least twofold. First, the BRP is left with different options for monitoring its counter-parts, including partially and fully-delegated monitoring alternatives. Each of these options has *explicit* monetary *value*, assessed through the counter-object of *money*, given in exchange. Second, another important issue in this case comprises the assessment of the *implicit value* generated by this technology. This can only be done internally, by the BRP.

How to monitor?

If considered as a business (exploitation) opportunity, the market described above demands a strategy of *monitoring organization* and *monitoring valuation*. Regarding the monitoring organization, it is necessary to define alternative monitoring policies specifying who can provide which information to whom. This is a problem of monitoring governance and privacy, subject of public agreement among the members of the constellation. Regarding the monitoring valuation, this is a matter of competitive advantage. While the explicit value of the monitoring technology may comprise necessary motivation for the parties to engage in this business, the implicit value of this technology ought to be kept as private as possible, for the sake of competitive advantage.

5.2.3 Problem Assumptions

There are three important monitoring assumptions to be considered in this case, which are described as follows.

Trusted Smart Metering Parties Assumption

The Smart Metering technology (assets and services) are both considered as trusted. By consequence, the metering value activities and metering parties are also trusted. Hence, the parties from the Energy Supply sector constitute the monitoring foci. Opportunistic behavior is not the issue of this case either. Risk here is essentially related to the intermittent nature of the renewable energy traded.

Closed Monitoring Assumption

This assumption refers to the definitions proposed in VMO. In this business case, it is assumed that the underlying value constellation ought to be monitored per se. Thus, no external actors are included. The underlying business market has already plenty of monitoring elements. The value constellation depicted in **Figure 5-1** can be interpreted as a semi-formal representation of a *virtual power plant,* as referred by Kok, (2009). A virtual power plant is a business collaboration model specifying the amount of energy prospected to be delivered by a collectivity of energy suppliers. Such a model may include supporting parties, such as the energy metering parties mentioned above.

Cross-Monitoring Assumption

Based on the organization of the referred value constellation, it is assumed that all the parties apply concurrent monitoring strategies against one another. Therefore, the monitoring evaluation performed by the final consumer relies on previous evaluation performed by the other actors. Cross-monitoring here supports risk mitigation.

5.3 Monitoring Value Constellation

This section describes the process of transforming the core business value constellation of the Renewable Energy case into a monitoring value constellation. Analogous to the Customs Control case, this is done through: (1) identifying a monitoring need within the constellation; (2) designing monitoring policies to achieve this need; and (3) defining monitoring indicators relevant for the measurement of the monitoring need. These steps are described as follows.

5.3.1 Monitoring Need

The Balance Resource Party (BRP) has the dominant monitoring perspective of this case. This party wants to monitor the activities performed by the Energy Retailers and DERs. This requires additional information that confirms delivery of performance. Many resources may be necessary to produce this kind of information, ranging from the energy itself to metering assets and convenient metering services. Although necessary, this information may not be sufficient for assessing the final value of the monitoring from the BRP's perspective.

Therefore, in order to satisfy its internal monitoring needs, the BRP can be perceived as the monitoring consumer of the referred value constellation. The problem now shifts to discover alternative configurations within the same value constellation that provides the monitoring objects necessary to achieve this monitoring need. This brings to the formal definition of a monitoring need, restated below:

$$
\begin{aligned}
MonitoringNeed \equiv\ & ValueMonitoringConstruct \ \sqcap \\
& \forall\ \boldsymbol{isMonitoringGoalOf.MonitoringPrincipal} \ \sqcap \\
& \exists\ isEstimatedThrough.ValuePropositionIndicator \sqcap \\
& \exists\ isEstimatedBy.MonitoringPrincipal \sqcap \\
& \forall\ \boldsymbol{isAchievedThrough.MonitoringObject} \sqcap \\
& \forall\ isMeasuredBy.MonitoringPrincipal \sqcap \\
& \forall\ isMeasuredThrough.ValueInUseIndicator
\end{aligned}
$$

Based on the assumptions given for this case, it has to be demonstrated here that it is possible to monitor this value constellation through the reorganization of its internal roles. Hence, the problem now is to find alternative value transactions within the underlying value constellation whereby the necessary monitoring objects could be obtained. According to VMO, these alternatives assume the form of monitoring policies. The outcome of a monitoring policy is a monitoring object, which fills partially the monitoring need of the monitoring principal. The other part of the monitoring is performed internally by this actor. Some alternative monitoring policies for this case have been identified and proposed for discussion in the next sub-section.

5.3.2 Monitoring Policies

Two monitoring policies have been identified for this case, which are depicted below in **Figures 5-2** and **5-3**. The policies respect the monitoring problem assumptions of the case. As depicted in the pictures, all the monitoring roles are again annotated with UML-like stereotypes. The monitoring policies are identified in the pictures by highlighting their corresponding value creation paths in solid lines. The target monitored value activity is highlighted in grey. The explanation of both policies is provided below the pictures.

Monitoring Policy 1: Monitoring Energy Retailers' Activity

The first monitoring policy specifies the value transactions whereby the BRP could monitor the Energy Retailer's Activity. The monitoring policy is depicted below in **Figure 5-2**. Again, the starting point of this model is the BRP operating as a monitoring principal. From this point, the subsequent monitoring roles of the system can be identified. A recap on the main relationships governing this model is provided below.

$$
\begin{aligned}
&MonitoringPrincipal \equiv ActorRole \sqcap \\
&\qquad \forall\, hasMonitoringGoal.MonitoringNeed \sqcap \\
&\qquad \exists\, estimates.MonitoringNeed \sqcap \\
&\qquad \forall\, measures.MonitoringNeed \sqcap \\
&\qquad \exists\, \boldsymbol{hasCompetence.MonitoringActivity} \sqcap \\
&\qquad \forall\, \boldsymbol{hasPossession.CounterObject} \sqcap \\
&\qquad \forall\, \boldsymbol{hasOwnership.MonitoringObject} \sqcap \\
&\qquad \forall\, hasAuthority.ValueInUseIndicator \sqcap \\
&\qquad \exists\, isActorParticipantOf.MonitoringPolicy \\
&MonitoringAgent \equiv ActorRole \sqcap \\
&\qquad \forall\, \boldsymbol{hasCompetence.MonitoringActivity} \sqcap \\
&\qquad \forall\, \boldsymbol{hasPossession.MonitoringObject} \sqcap \\
&\qquad \forall\, \boldsymbol{hasOwnership.MonitoredObject} \sqcap \\
&\qquad \exists\, hasAuthority.ValuePropositionIndicator \sqcap \\
&\qquad \exists\, isActorParticipantOf.MonitoringPolicy \\
&MonitoringThirdParty \equiv ActorRole \sqcap \\
&\qquad \forall\, \boldsymbol{hasCompetence.MonitoredActivity} \sqcap \\
&\qquad \forall\, \boldsymbol{hasOwnership.CounterObject} \sqcap \\
&\qquad \forall\, \boldsymbol{hasPossession.MonitoredObject} \sqcap \\
&\qquad \exists\, hasAuthority.ValuePropositionIndicator \sqcap \\
&\qquad \exists\, isActorParticipantOf.MonitoringPolicy
\end{aligned}
$$

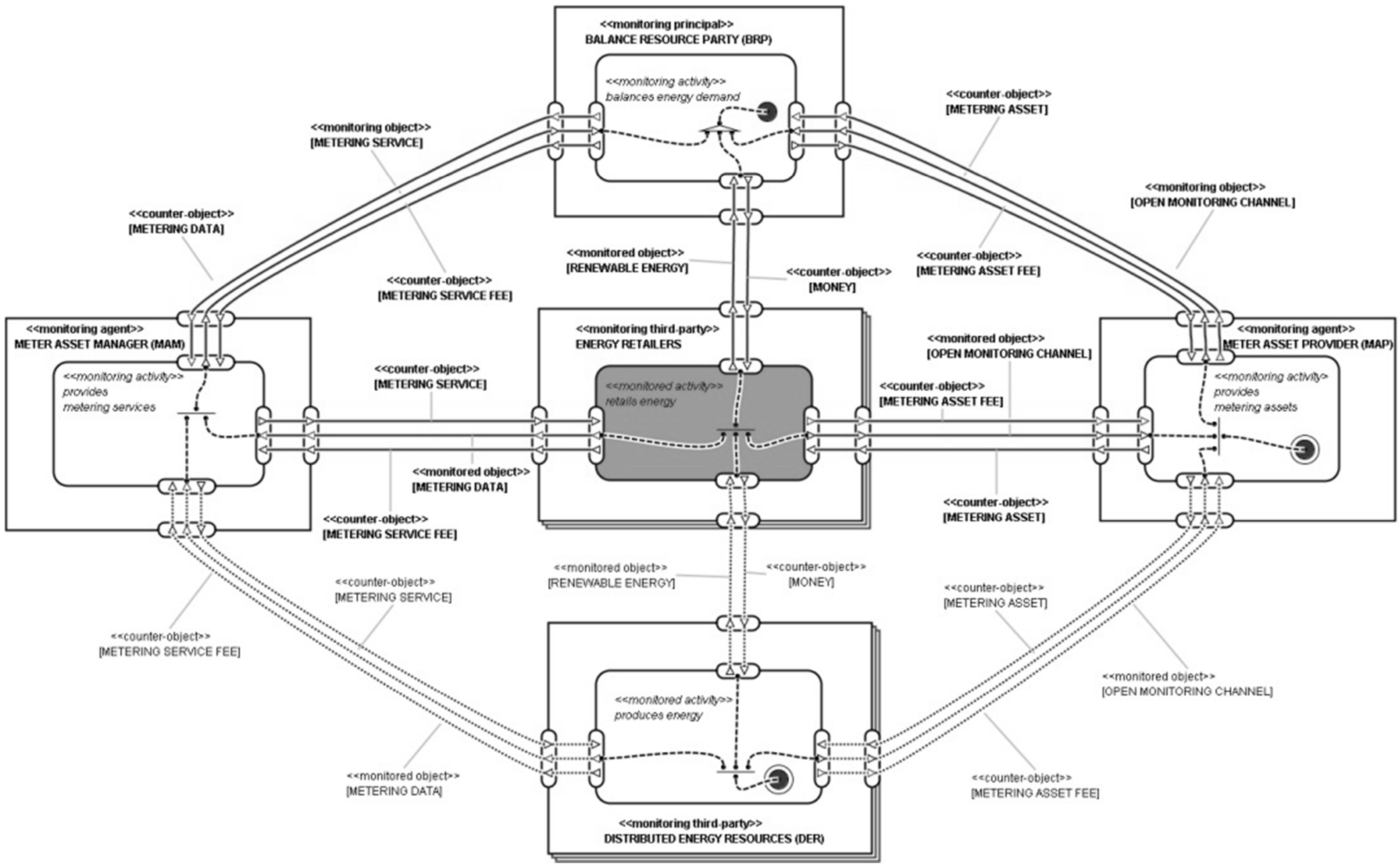

Figure 5-2: Smart Metering monitoring policy: Energy Retailers with focal monitored activity

The monitoring policy depicted above is described as follows. Here, the BRP has the dominant monitoring perspective, thereby acting as the monitoring principal of the constellation. This actor wants to monitor the DERs, which act as monitoring third-parties. Both metering parties play the role of monitoring agents. At least two monitoring options can be identified.

In the first option, the BRP would partially delegate the monitoring activity to the metering parties. In this case, BRP should acquire the value objects necessary to monitor the Energy Retailers' value activity. These objects are provided by the Meter Asset Provider (MAP). Thus, the monitoring value transactions include:

(1) Energy Retailers provide an *open monitoring channel* as a monitored object to MAP;
(2) MAP transfers the ownership of the *open monitoring channel* (as a monitoring object) to the BRP, along with a *meter asset* (as a counter-object);
(3) BRP receives *energy* from the Energy Retailers;
(4) BRP uses the monitoring objects provided by MAP to perform the monitoring;
(5) All the other counter-objects close the economic reciprocity of the value transactions.

It is worth to remark that these steps do not compose an algorithm. The notion of time ordering does not exist in a value model. Instead, all the transactions are considered as concurrent, taken from an economic perspective.

In the second monitoring option, the BRP could fully delegate the monitoring activity to the Meter Asset Manager (MAM). In this case, it is assumed that MAM already has all the value objects necessary to perform the monitoring activity. Thus, this second monitoring pathway comprises:

(1) Energy Retailers disclose private *monitoring data* (as a monitored object), to MAM;
(2) MAM transforms the *metering data* into a *metering service* (as a monitoring object);
(3) MAM offers the resulting *metering service* to BRP, at the cost of a *monitoring fee*.

These value transactions describe some of the monitoring alternatives that a BRP may have available within the underlying monitoring policy. It can be noticed that no external actors, value activities or value objects are included. All the elements identified in the core business are reorganized according to monitoring roles. Some objects have their roles changed from one transaction to another. This is the special case of the *open monitoring channel*, which is disclosed by the Energy Retailers to MAP as a monitored object. However, when offered by the MAP to the BRP, this same object has the role of a monitoring object. The rationale for such is not explicitly represented in this model. However, although related, each of these transactions constitutes a different monitoring agency relationship. These relationships, therefore, imply different monitoring constraints, which may include, for instance, regulations on direct monitoring disclosure from one actor to another.

Monitoring Policy 2: Monitoring DER's Activity

The second monitoring policy specifies the monitoring value transactions whereby the BRP could monitor the Distributed Energy Resources (DER). The monitoring policy is depicted below in **Figure 5-3**, and described as follows.

The BRP remains as the monitoring principal of the value constellation. Although not depicted in this picture, it is assumed that BRP may have engaged on previous value transactions with the DERs. Although costly, the scenario of a BRP managing directly the energy produced by a bundle of DERs is possible. Thus, in order to monitor the DERs, BRP may engage in two monitoring collaborations, one for each metering party. The first monitoring pathway comprises:

(1) DERs disclose an *open monitoring channel*, as a monitored object, to MAP;
(2) MAP discloses the *open monitoring channel*, as a monitoring object, to the BRP (further monitoring disclosure constraints may apply to this agreement);
(3) BRP acquires the *open monitoring channel* from MAP, along with a meter asset (the BRP could therefore monitor DERs almost directly);
(4) Meter asset and meter asset fee close the economic reciprocity of the underlying value transactions.

Another alternative monitoring pathway is described below:

(1) DERs disclose private *metering data* to MAM;
(2) MAM transforms *metering data* and produces *metering services* that are offered to BRP;
(3) BRP uses the *metering services* provided by MAM;
(4) *Metering data* and *metering service fee* close the economic reciprocity of the value transactions articulated.

The policy models described above are complementary. They compose the basic organization of the monitoring value constellation proposed for this case. Now the problem shifts on to assess both explicit and implicit value of the metering technology.

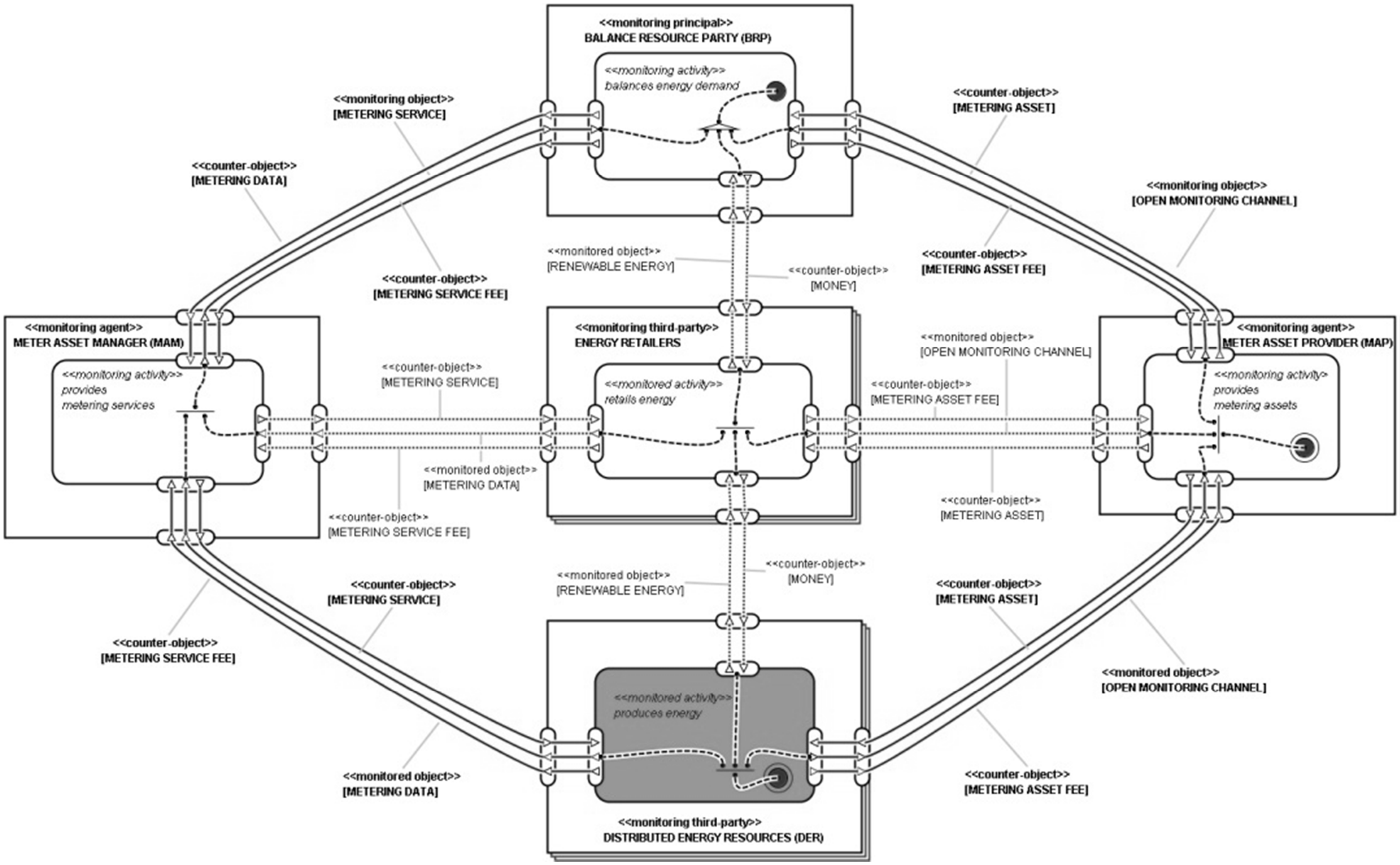

Figure 5-3: Smart Metering monitoring policy: Distributed Energy Resources with focal monitored activity

5.3.3 Monitoring Indicators

In the business case addressed here, there is both individual and collective interest on the information about the value generated by the Smart Metering technology. For the participants of this business, this information is critical not only to *enter* the referred value constellation, but also to *remain* on it. VMO defines axioms for representing both *explicit* and *implicit* value of the monitoring information. These axioms can be visualized in *value proposition models* and *value experience models*. These models have been derived for the underlying business case and are described next.

Value Proposition Model

A *value proposition model* for this business case is depicted in **Figure 5-4**. The model contains *explicit* value propositions offered by providers of monitoring information to the respective users. This is represented through the annotations placed on top of the highlighted monitoring objects, prefixed with a question mark (e.g. ?HIGH_VALUE). Yet, this model complements the monitoring policy models shown previously in this chapter. The modeling purpose here is *preemptive*. That is, the information contained in this model should be used to *estimate* the value to be generated by the monitoring information flowing in this constellation.

In this case, the values considered as relevant for proposition include *reliability* and *responsiveness*. According to the SERVQUAL scale, *reliability* is defined as "the ability to perform the promised service dependably and accurately" (Parasuraman, Berry and Zeithaml, 1991, p.9). This attribute is critical for the value transactions involving the energy suppliers. The goals of internal value generation of these actors are assumed to be dependent not only on the monetary value of the energy delivered, but also on the reliability (as an intangible value) brought by this commodity. In this model, *reliability* offered as a value proposition denotes an intention of the service providers to create long-term value transactions with the respective service consumers of the monitoring information. In the example, the reliability propositions have a *neutral value*, for as optimistic value promises made on renewable energy would be of a high-risk.

Responsiveness is a value of critical relevance for the value transactions involving energy metering parties. Yet according to the SERVQUAL scale, *responsiveness* is defined as "the willingness to help customers and to provide prompt service" (Parasuraman, Berry and Zeithaml, 1991, p.9). This business value is especially important to differentiate relatively new technologies in exploratory markets. This is the particular case of the Smart Metering assets and services. Hence, in the model depicted below, *responsiveness* offered as a value proposition denotes an intention of the metering parties to differentiate their services in this new market. In the example, all responsiveness propositions have *high value*, for this is a market runs around monitoring information and the metering technology used is assumed to be trusted.

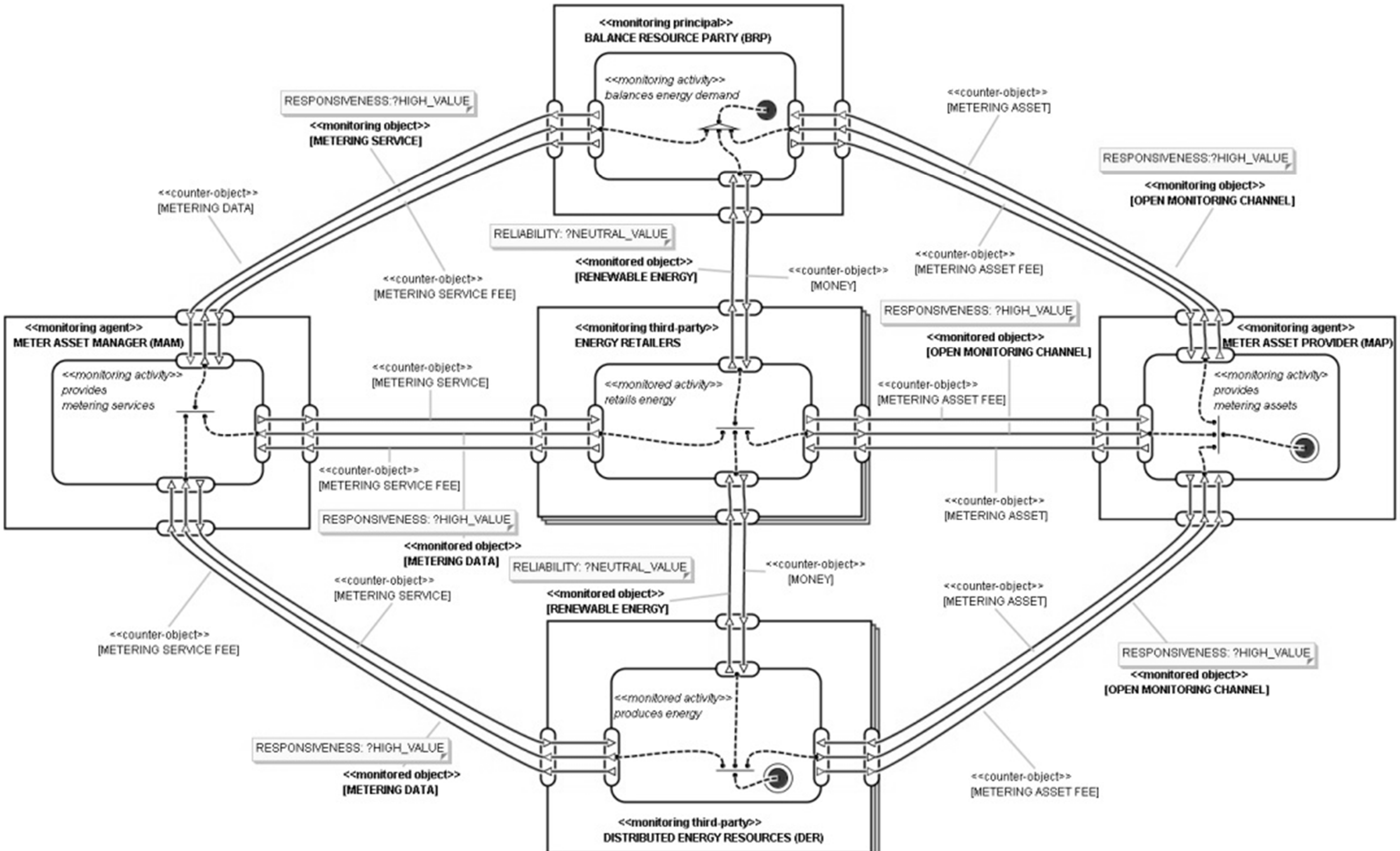

Figure 5-4: Smart Metering monitoring value constellation: value proposition model

Value Experience Model

The corresponding *value experience model* for this business case is depicted in **Figure 5-5**. The model contains the assessments of the *implicit* value generated by the monitoring information. Therefore, the modeling purpose here is *reactive*. It is assumed that the value propositions have been delivered and further experienced at the consumer's side. This is graphically represented prefixing the value attributes with an exclamation mark (e.g. !LOW_VALUE).

The model depicted below is taken from the dominant perspective of the monitoring principal of the value constellation. In this case, it contains the monitoring evaluation performed by the BRP. It is therefore assumed that this model is private to this actor. It is also illustrated that the *responsiveness* offered by the Metering Asset Provider has generated *high value* at the BRP's side, whereas the *responsiveness* offered by the Metering Asset Manager has generated a *low value*. On the energy supply side, it is shown that the *reliability* offered by the Energy Retailers has generated a *low value* at the BRP's side. It is worth to remark that these comprise different monitoring Agency relationships, involving different types of monitoring objects. Moreover, in this case, the modeling purpose of these (value) monitoring indicators is not to distinguish monitoring information of equivalent value. Instead, the purpose here is to demonstrate that, although the consumer's goal of a monitoring value constellation may be *achieved* by some monitoring object, it can only be *measured* through the value that these objects can generate.

For example, in a near future, it is expected that even ordinary households shall enter the energy supply market as BRPs. In this scenario, these households will have the option to trade energy by consuming less or producing more energy – this last option is already the case of households producing their own energy through Combined Heating and Power (CHP) devices (Warmer et al., 2007). The technical infrastructure necessary to implement this scenario has been developed by Smart Metering parties. However, the adoption of the Smart Metering technology has been target of controversial debates. The mains issues raised by potential consumers of this technology in Europe are concerned with the problems of privacy and measurement of the *value* brought by this monitoring technology. It seems that a wide adoption of such a technology will depend not only on its monetary value (covered by metering asset and service fees), but also on values considered as important for the consumer's market segment, such as the *convenience*, *responsiveness*, *reliability* and *safety* brought this technology.

In summary, as demonstrated by this case, the utility of a value experience model is individual and private at the (monitoring) service consumer's side. This type of model can be used to support a service consumer to decide on remaining or leaving a value constellation. Decision here is reactive, for as the (implicit) value of a service can only be measured *after* its experience and use at the service consumer's side.

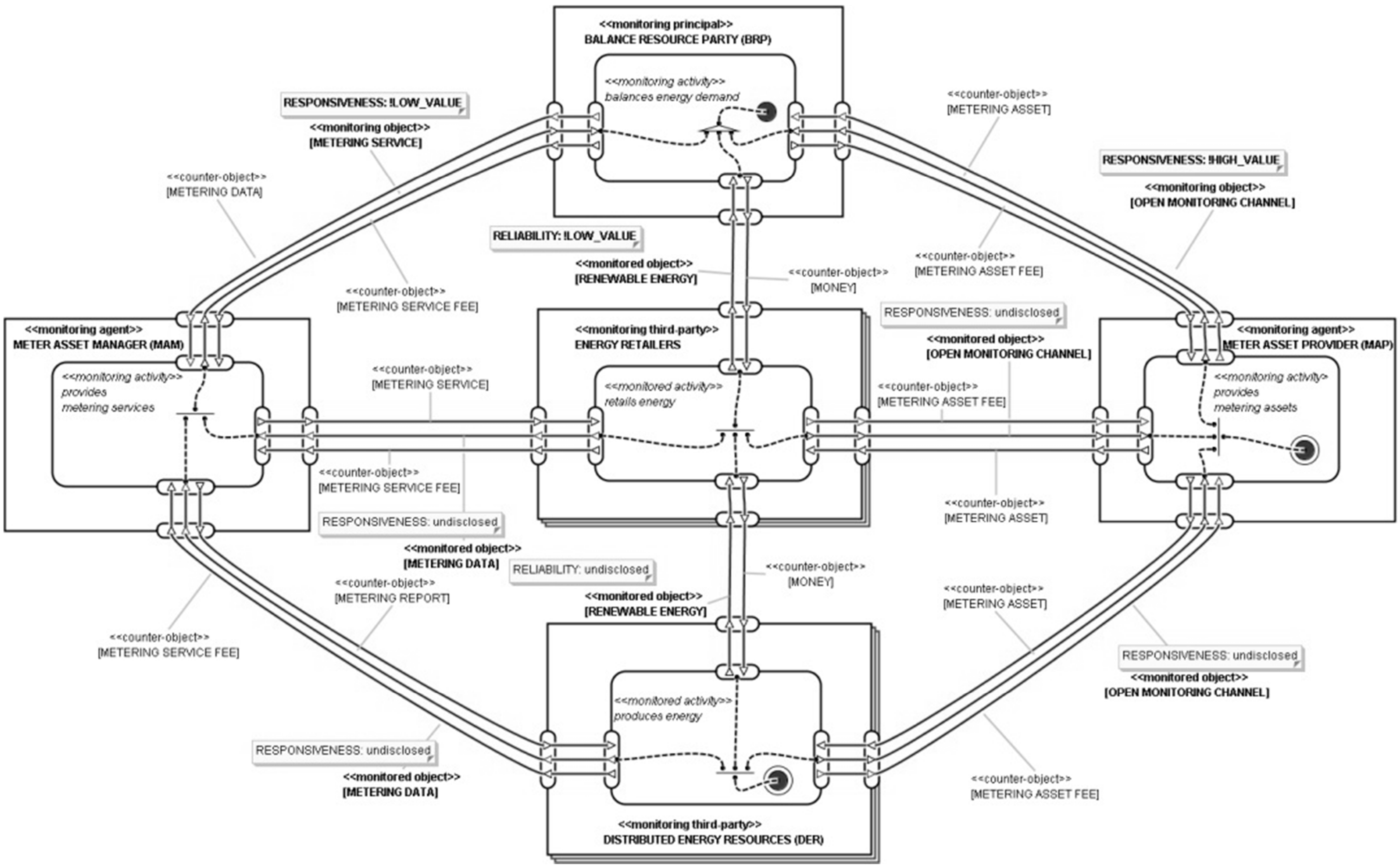

Figure 5-5: Smart Metering monitoring value constellation: value experience model

5.4 Application-Based Ontology Evaluation

In this section, a discussion is provided on evaluating the application of VMO on the Renewable Energy case. The ontology is evaluated according to the practical effectiveness and practical efficiency of its corresponding monitoring models. Additionally, some of the best practices and limitations encountered on this application are reported.

5.4.1 Practical Effectiveness

In this work, practical effectiveness has been associated to the (economic) *cost-effectiveness* of a monitoring value constellation. At a first glance, the cost-effectiveness of the monitoring logic behind this system can be assessed through the profitability analysis mechanism already provided by the *e3value* framework. Thus, after defining the monitoring goal and monitoring policies of a monitoring value constellation, its profitability share is reduced to an accounting problem, which falls out the scope of this research.

However, VMO can also be evaluated as a cost-effective mechanism from an organizational perspective. It is assumed in VMO that the budget available for monitoring a value constellation is limited to its own ordinary structure of actors, value activities and value objects. No external resources should be used. In the Renewable Energy case, this budget has not been exceeded. Therefore, from an organizational perspective, VMO has been evaluated as cost-effective for this business case.

5.4.2 Practical Efficiency

For the evaluation of VMO, practical efficiency has been associated to a demonstration of monitoring *reliability*. In the Renewable Energy case, monitoring reliability has been partially demonstrated through the *closed monitoring assumption*, i.e. no external resources have been added to monitor the constellation. However, the *cross-monitoring assumption* has been demonstrated as critical for this case. That is, it can be deduced that the monitoring information provided to the BRP is reliable, for as it is assumed that this same information is evaluated by the corresponding monitoring agents and third-parties.

5.4.3 Best Practices

This business case provided two practical problems to be addressed with VMO. The first problem was related to the indirect disclosure of monitoring information in value constellations. The second one was related to the difficulty of assessing the value returned by the Smart Metering technology. Both problems should be treated from a Business domain (strategic) viewpoint. Besides, the referred business case is essentially exploratory, describing more futuristic scenarios than consolidated markets.

Rather than definitive solutions for these problems, the models presented in this chapter comprise only propositions of business strategies for this futuristic market. Together with the candidate ontology, the alternative monitoring value constellation described here has been posed for open discussion among practitioners from the Business domain of this case.

As a minor contribution, the use of VMO in conjunction with the *e3value* graphical notation is aimed to provide a unified visualization of monitoring information disclosure in value constellations. This is particularly useful for cases involving multiple monitoring Agency. In these cases, monitored objects (as primary evidences) can be indirectly disclosed by the corresponding monitoring objects (as secondary evidence). This is especially difficult to track in complex business-to-business value constellations, where value activities of *production*, *consumption* and *use* are just part of a value *transformation* event, as defined by (Andersson et al., 2006).

5.4.4 Limitations

There are some practical issues threatening the validity of the application-focused ontology evaluation reported in this chapter. First, many elements of the core business value constellation of this case are futuristic. Hence, the business analysis provided here is essentially exploratory, based on documentation about the progress of Smart Metering European-wide. Second, the cost-effectiveness evaluation is purely analytical, for as no real quantitative or qualitative data has been disclosed by the business partners involved in this research. Last, only the monitoring policy models presented here have been evaluated as sound by practitioners from ECN. The monitoring indicator models are proposed here for additional discussion and evaluation.

5.5 Discussion

In this chapter, a report on the application of VMO on a business case from the Renewable Energy sector has been presented. This case has been originally provided by practitioners of the Energy Research Center of the Netherlands (ECN), in the context of the VALUE-IT project. This report closes the application-focused ontology evaluation of this research, according to the Ontology Engineering methodology adopted here. Along with the Customs Control case, the case reported in this chapter has been aimed to validate the practical utility of VMO.

The Renewable Energy case brought to light two specific problems of Service monitoring in business-to-business collaborations. The first problem has been related to indirect disclosure of private monitoring information in value constellations. The second one has been related to the difficulty of assessing the value of shared monitoring technologies, such as Smart Metering assets and services. In return, a proposal of a monitoring value constellation model has been provided as a contribution to this case. Rather than definitive solutions for the problems in discussion, the model proposed here is aimed to serve as a basis for discussion and evaluation among practitioners from the Energy Management sector.

The main contribution of this chapter comprises the evaluation of VMO as a *cost-effective* and *cost-efficient* organizational model. VMO has been evaluated as *cost-effective* because it structures the monitoring of a value constellation as a role-based system. That is, it is based on the logic that a monitoring system does not necessarily need to be constructed from entirely new operations to fulfill a certain monitoring demand. Instead, it can be built through stereotypes defining behavioral specifications (contracts) to be filled by actors, operations and objects that already participate in that system. VMO has also been evaluated as *cost-efficient* because it defines internal monitoring valuation models that can be used in combination. Hence it is assumed that the information flowing in a monitoring value constellation is mutually evaluated by all the participants of this system. Such logic is aimed to make the internal monitoring of a value constellation as efficient as possible. The claims of practical effectiveness and efficiency of VMO (as a candidate ontology) have been partially validated through the model demonstration based on the Renewable Energy case.

Another important contribution of this chapter comprises the characterization of VMO as a decision-support system. This has been demonstrated through the models of monitoring indicators. These models are based on the logic that, in a value constellation, a consumer's goal may demand more than creation of monetary value. It may also demand subjective values such as reliability and responsiveness. Hence a value proposition model contains estimates of these subjective values, whereas a value experience model contains the actual measurement of these values. The former can be used with a *preemptive* purpose so as to motivate actors to engage in a value constellation. The latter, however, can be used with a *reactive* purpose so as to motivate actors to remain or leave the constellation.

The next chapter reports on the evaluation of VMO as an externally valid proposition of a candidate ontology. Hence it situates this research contribution in the area of Business Service Design, according to the main companion and rival ontologies related to the research problem addressed in this work.

Chapter 6: Related Work

Honest differences are often a healthy sign of progress.

Mahatma Gandhi (1869 – 1948)

6.1 Introduction

This chapter brings a discussion related to the external validity of VMO as a research contribution in Service Design and Engineering. More precisely, the contribution is analyzed from the perspective of related work in Business Service Design, classified here as companion and rival ontologies. The confrontation of VMO with its main rival ontology – the *e3control* ontology – corresponds to the *user-focused ontology evaluation*, according to the Ontology Engineering methodology adopted in this work.

The main companion ontologies referred here comprise the *e3value* ontology (Gordijn, 2002), the Enterprise Ontology (Dietz, 2006) and the Business Reference Ontology (Andersson et al., 2006). These models provided some of the main grounding concepts used in the construction of VMO. The *e3value* ontology is not only the main companion of VMO, but also its target implementation system. It provides concepts of economic flow and exchange in value constellations. The Enterprise Ontology comprises adaptation and application of principles of Language Action Perspective (LAP) for Business Process Design. Last, the Business Reference Ontology (BRO) merges concepts of the Resource-Event-Agent (REA) model (McCarthy, 1982) with concepts of the *e3value* ontology so as to define the notion of a business event. Therefore, VMO extends and integrates some of the concepts provided by these companion ontologies.

The main rival ontology considered here is the *e3control* ontology, which is part of a framework for configuring controls against opportunistic behavior in value constellations (Kartseva, 2008). The *e3control* ontology is considered as a rival of VMO because it proposes an alternative modeling solution to solve the problem of monitoring value constellations. However, the solution is given from a Control Theory perspective. Hence, the evaluation problem considered in this chapter is to demonstrate which ontology is more appropriate to use on solving the problem of designing strategic models for monitoring value constellations.

For the sake of external validity, an ontology evaluation framework has been adopted for comparing these two ontologies. The framework is the ONTOMETRIC, proposed by Lozano-Tello and Gómez-Pérez (2004). ONTOMETRIC comprises a method which allows users to measure the suitability of existing ontologies, according to the requirements of their systems. Part of this method comprehends a multi-level set of parameters for comparing the adequacy of ontologies on solving a certain problem. These parameters range from general ontology attributes (e.g. representation language) to more specific ones (e.g. reasoning potential). In this work, only the general attributes have been considered, which characterize an ontology according to its content, representation language, methodology used, tool support and cost of use.

Nevertheless, the ONTOMETRIC evaluation reported here corresponds to the perspective of an ontology engineer. That is, the evaluation itself comprises only an indication of quality of VMO. This indication is posed here for further evaluation of practitioners and users of *e3control* and VMO.

This chapter is organized as follows. In **section 6.2**, the research contribution given in VMO is situated within the research context of Service-Oriented Computing. **Section 6.3** brings an overview of the main companion and rival ontologies of VMO. In **section 6.4**, *e3control* and VMO are compared according to the ontology evaluation parameters specified by the ONTOMETRIC framework. The comparison is aimed to validate the claim of quality of VMO. Finally, some discussion and closing remarks are provided in **section 6.5**.

6.2 Research Context

In order to justify the selection of the main related work considered for analysis in this chapter, it is worth to return to the research context of this work, previously introduced in **Chapter 1**.

The research reported here is part of a research agenda in Service-Oriented Computing published by Papazoglou et al. (2008). According to the authors, the research area of Service-Oriented Computing is internally organized in four sub-areas: (1) Service Foundations; (2) Service Composition; (3) Service Management; and (4) Service Design and Development (Service Engineering). The contribution given in VMO falls into the intersection between *Service Management* and *Service Design*. As a *Service Management* mechanism, VMO defines a monitoring logic grounded on Agency Theory and Service-Dominant Logic. As a *Service Design* mechanism, this monitoring logic is aimed to be applied on the Business domain (Business Strategy level). Therefore, it can be used in conjunction with frameworks for Business Service Design.

A Business Service Design specifies how enterprises collaborate through service provisioning on the Business strategy level. It therefore describes policies and rules governing business collaborations. As an architectural viewpoint, it can be used as a driver for configuring inter-Enterprise business processes and IT services (Papazoglou et al., 2008). Yet, a Business Service Design normally conforms to a specific business viewpoint, which corresponds to a specific rationale motivating business collaborations. A relevant business viewpoint comprises the profitability share among the participants of a business collaboration. The specification of a Business Service Design may involve many related activities or tasks, such its initial feasibility analysis, configuration and management. These activities can be supported by design frameworks, aimed to furnish business analysts with automated or semi-automated facilities to produce and maintain Business Service Design models. This is the particular case of the *e3value* framework, proposed by Gordijn (2002).

As a Business Service Design tool, the *e3value* framework has been originally aimed to support the configuration of value constellation models. The main modeling resources provided by this framework comprise: (1) an ontology of economic exchange; (2) a corresponding graphical notation; (3) a set of methodological guidelines for deriving the value viewpoint on Service provisioning; and (4) a semi-automated mechanism of profitability analysis. However, according to the research agenda proposed in (Gordijn et al., 2008), this framework has been envisioned as a reference driver for configuring sustainable business processes and IT service realizing a value constellation. The original idea was to use *e3value* models as a prelude of business process models. Based on that, a business process model would only be deployed and enacted after a previous analysis of its economic feasibility, performed on the basis of a corresponding value model.

However, the sustainability of a value constellation (and its corresponding business processes and IT services) depends not only on its initial profitability share, but also on how its encompassed value transactions are managed. Management here includes Service monitoring. The research perspective advocated in (Gordijn et al., 2008) has initially posed the problem of monitoring value constellations as a primarily technology problem, relegated to the business process and IT service viewpoints. However, a different vision is proposed in (Silva and Weigand, 2011a), whereby the same problem is also classified as a Business domain (strategy) problem. In line with this vision, VMO has been proposed as a monitoring logic to be used in conjunction with the *e3value* framework. The idea behind VMO is to consider Service monitoring as part of the initial configuration of a value constellation. Therefore, it injects a monitoring logic into the specification of value models.

VMO grounds not only on principles of Agency and Service-Dominant Logic, but also on principles of Business Service Design. These principles have been adopted from other ontologies, which are classified here as *companion* and *rival* ontologies. The next section brings a summary of these ontologies, with an emphasis on the main concepts extracted and adapted from these theories.

6.3 Related Work

The literature review reported in **Chapter 2** had the purpose to explore research opportunities in the area of Service monitoring in general, including mainly works in Business Activity Monitoring (BAM), Process Mining and Web services monitoring technologies. However, the related work reported in this chapter includes only the works most closely related to Business Service Design and Service monitoring.

6.3.1 Companion Ontologies

By *companion ontology* it is meant here an ontology from which some of the main concepts of VMO have been adopted and extended. The main companion ontologies considered for analysis comprise: the *e3value* ontology (Gordijn, 2002), the

Enterprise Ontology (Dietz, 2006) and the Business Reference Ontology (Andersson et al., 2006). These ontologies are summarized as follows.

The *e3value* Ontology

The *e3value* ontology is the grounding model of the *e3value* framework, proposed by Gordijn (2002). The ontology defines a basic structure of economic communication for multi-party business collaborations (vide **Figure 6-1**). The communication is based on basic principles of economic exchange, flow and reciprocity. Based on this communication structure, the model of a value constellation can be defined. A value constellation has been originally referred to as a set of actors exchanging objects of economic value so as to satisfy a consumer's need (Normann and Ramírez, 1993).

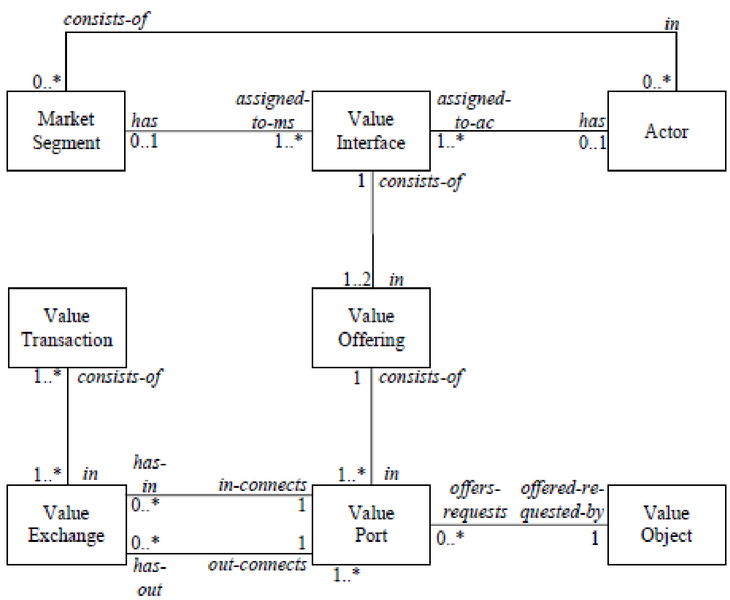

Figure 6-1: Snapshot on the *e3value* ontology [extracted from (Gordijn, 2002, p. 48)]

One of the main modeling purposes of using the *e3value* ontology is to assess the *economic profitability* generated by a value constellation. Profitability share is considered as a critical success factor mainly during the feasibility analysis of this type of system. However, the ultimate goal of a value constellation is the development of sustainable business collaborations among its participants. The sustainability of a value constellation depends not only on the profitability generated by its initial configuration, but also on how its constituent activities are managed along the time. Management here includes monitoring, more specifically, the monitoring of critical activities within a value constellation.

Therefore, VMO extends the *e3value* ontology with a Service monitoring logic. The core of this logic is the concept of a *monitoring value constellation*, which has been referred to as *an ordinary value constellation enriched with self-monitoring capabilities*. The organization of this system starts from a service consumer's need of monitoring the behavior of another actor, whose performed value activity is a possible source of fraudulent operation. Monitoring information about the monitored activity is obtained through actors within the value constellation which have granted access to the required information. These actors act as monitoring agents, and the value transactions between the service consumer and these agents are themselves Agency relationships. Therefore, the sustainability of a value constellation is made dependent on the effectiveness and efficiency of these monitoring relationships.

More specifically, VMO extends the *e3value* ontology by defining monitoring roles for actors, value activities and value objects. The monitoring roles are typically Agency-oriented. According to this system, an actor may act as a *monitoring principal*, a *monitoring agent* or a *monitoring third-party*. Value objects may assume the role of a *monitoring object*, a *monitored object* or a counter-object. Yet, a value activity may assume the role of a *monitoring activity* or a *monitored activity*, according to the role of its performing actor. The behavior of monitoring actors, value activities and value objects is mutually defined through Communication Action relationships. These in turn include relationships of *competence*, *responsibility*, *authority*, *ownership* and *possession*. More specific relationships include *production*, *consumption* and *use*, holding between value activities and value objects. Other supporting concepts, such as the concepts of *value proposition indicator* and *value-in-use indicator* are described in detail in **Chapter 3**.

In sum, VMO closely relates to the *e3value* ontology in many points. First, it extends *e3value* with monitoring Agency roles, establishing a Service monitoring logic for value constellations. Second, it organizes a monitoring mechanism as part of the configuration of a value constellation. Third, it uses the economic communication relationships of the *e3value* ontology as an implementation system. Last, together with the *e3value* ontology, it establishes the *Value Activity Monitoring* viewpoint on business collaborations.

The Enterprise Ontology

Another important related work is the Enterprise Ontology, proposed by Dietz (2006). This ontology can also be used to describe business collaborations in general. It contains explicit references to fundamental theories in Language Action Perspective (LAP), specially the conceptual frameworks proposed by Austin (1962), Searle (1969) and Habermas (1981). Hence, it is also distinguished by using the concepts of *production* and *coordination acts* as the main building blocks of the communication system supporting the operation of the modern Enterprise.

According to this ontology, the operation of an enterprise can be fully described by the articulation of three main elements: *actors*, *production operations* and *coordination operations*. An actor has the authority to perform both types of operations. A *production operation* relates an actor to a business object to be produced. A *coordination operation* relates two actors by the business objects they communicate. Actors are assigned to production operations via relationships of business *competence*, and to coordination operations via relationships of *responsibility*. An operation is described according to its state: before being performed, operations comprise business *acts*, whereas after successful execution, they constitute business *facts*. The relationships between Enterprise actors, production operations and coordination operations define the *operational axiom* of the theory. The other derived axioms comprise the *transactional axiom* (describing how operations follow a transactional pattern), the *composition axiom* (describing how transactions are composed) and the *distinction axiom* (describing how the utility of different business objects is apprehended and distinguished by the resources that implement the Enterprise). Yet, the ontology defines an *organizational theorem*, which defines how the distinction axiom works throughout the architectural layers that structure the modern Enterprise, e.g. business processes and IT services.

Some of the concepts defined in the Enterprise Ontology have been adopted in VMO. For instance, the concept of a *production operation* corresponds to a *value activity* in VMO, whereas a *coordination operation* corresponds to a *value exchange*. Yet, the Enterprise Ontology relationships of business *authority*, *competence* and *responsibility* have also been adopted in VMO: *monitoring actors* are related to *monitoring indicators* via relationship of authority; *monitoring actors* are related to *monitoring activities* via competence; and ordinary *actors* are related to *value exchanges* through responsibility. Moreover, in VMO the assignment of monitoring actors to monitoring activities resemble an *operation axiom* in Enterprise Ontology. Accordingly, the assignment of monitoring actors to value exchanges resembles a *transaction axiom*. Last, the articulation of monitoring transactions (including monitoring principals, monitoring agents and monitoring third-parties) in a monitoring policy in VMO also resembles a *composition axiom* in Enterprise Ontology.

Nonetheless, some other concepts from the Enterprise Ontology have been extended in VMO. This is the case of the *distinction axiom*. In Enterprise Ontology, the utility of the distinction axiom is not made clear from a business perspective. However, in VMO, the distinction axiom corresponds to the concept of *indicator*, which assumes the roles of a *value proposition indicator* at the service provider's side and a *value-in-use indicator*, at the service consumer's side. In the specific context of a monitoring value constellation, indicators are used for distinguishing monitoring objects, characterizing the efficiency of a monitoring agent in terms of delivered monitoring objects.

In sum, VMO includes and extends some of the Communication Action constructs of the Enterprise Ontology. VMO is also conformant with fundamental literature in Language Action Perspective. However, on what regards the extension of the Enterprise Ontology distinction axiom, VMO extends this concept from the perspective of Allwood (1976). According to this author, there are other two types of communication acts forming the structure of a communication action instance – *apprehension acts* and *display acts*. These acts modify a *coordination act*. That is, the information coordinated between a sender and a receiver has its meaning modified at both sides. In VMO, the Allwood's concepts of apprehension and display acts have been adapted so as to define the concepts of value proposition and value-in-use indicators.

The Business Reference Ontology

The Business Reference Ontology comprises the last work related to VMO. This ontology actually integrates concepts from many other Business Design models, including the *e3value* ontology (Gordijn, 2002), the Resource-Event-Agent (REA) model (McCarthy, 1982), and the Business Model Ontology (Osterwalder, 2004). As denoted by its descriptor, this ontology was originally designed to integrate disparate views on Business Service Design, serving as an interoperability model for mutual alignment and evolution of the integrated models.

VMO includes some of the concepts defined in the Business Reference Ontology. These concepts comprise types of production acts that are specific from accounting and economic flow systems, such as the ones described by the REA model. These production acts include the basic operations of *production*, *use* and *consumption* of economic resources in business collaborations. These stereotypes have been adopted in VMO so as to characterize the behavior of *monitoring activities* according to their relationships with *monitoring objects*.

Nevertheless, from the best knowledge available in this research, there has been no published evidence about the evolution and maintenance of the Business Reference Ontology.

6.3.2 Rival Ontology

By *rival ontology* it is meant here an ontology which is aimed to solve a problem that is equivalent or more general than the one addressed by VMO. From the best knowledge available thus far, there are no frameworks or ontologies available for solving the problem of monitoring value constellations. However, the work that most closely relates to VMO is the *e3control* ontology (and framework), proposed by Kartseva (2008). This ontology is part of a framework for configuring controls against opportunistic behavior in value constellations. It can be used to cope with the problem of monitoring value constellations, but only indirectly. In order to provide an initial discussion on how this ontology relates to VMO, a summary of *similarities* and *differences* between the management mechanisms defined by these two ontologies is provided as follows.

Similarities

The *e3control* ontology is part of a framework for designing controls against opportunistic behavior in networked organizations. As denoted by its descriptor, the *e3control* ontology is based on Control Theory, and therefore, addresses Service monitoring from a rather general perspective. However, similar to VMO, *e3control* extends the *e3value* ontology with a Service management logic. Hence, the similarity between the management logic of these two ontologies can be resumed in the following points:

(1) *Economic communication infrastructure:* both models rely on the basic concepts of economic exchange and flow defined by the *e3value* framework. In this respect, no reconceptualization is proposed by any of these ontologies.
(2) *Profitability analysis mechanism:* both models make explicit references to the economic feasibility of the Service monitoring logic. That is, the effectiveness of the monitoring mechanisms defined by each of the two models is referred to as an accountability problem. Such a problem can be solved through the use of the profitability analysis mechanism already provided by the *e3value* framework.
(3) *Information assumption:* both models consider monitoring information as a purchasable commodity. That is, the exchange of monitoring information is subject to governance rules. This assumption is common to Agency Theory and Control Theory.
(4) *Preemptive Service monitoring logic:* both models describe monitoring as part of the configuration and initial feasibility analysis of a value constellation.

These similarities somewhat strengthen the utility of the *e3value* framework as a basic terminology of economic communication. However, there are disparate differences between these models which ought to be considered by a potential user.

Differences

The main differences between VMO and *e3control* are also related to the Service management logic defined by these models. The differences are summarized in the following points:

(1) *Monitoring organization:* according to VMO, a value constellation can be monitored through a reconfiguration of its internal organizational roles. That is, the same actors, value activities and value objects that compose an ordinary value constellation are reorganized as a monitoring value constellation. However, the monitoring pattern defined in *e3control* structures a monitoring scenario of a value constellation as a separated structure, with additional actors, value activities and value objects. In sum, while the monitoring organization of VMO is role-based, the monitoring (pattern) organization described in *e3control* is essentially type-based.
(2) *Monitoring sustainability assumption:* the principle of economic reciprocity is often referred as critical for the sustainability of business collaborations in general (Mankiw, 2006). According to VMO, the most important object of economic exchange is the monitoring object. This type of object in turn is offered in exchange of corresponding counter-objects. Nonetheless, in *e3control*, controlling objects often interleave core business value constellations, being exchanged for core business objects. Such an approach makes difficult to assess the economic sustainability of controlling strategies, for as these strategies become dependent on the controlled businesses.
(3) *Monitoring information asymmetry*: according to the theoretical guidelines provided in VMO, unreliable monitoring objects may trigger new Agency

problems on the value transactions composing a monitoring value constellation. This issue is treated by adopting a Service-Dominant logic. According to this logic, the reliability of a monitoring object is ultimately assessed by the service consumer of the value constellation, which is assumed to act as a monitoring principal in the system. The rationale of such logic is to bound recursive inclusions of monitoring agents watching other agents within the value constellation. However, *e3control* does not include or refer to an alternative logic to cope with threats of unreliable controlling mechanisms.

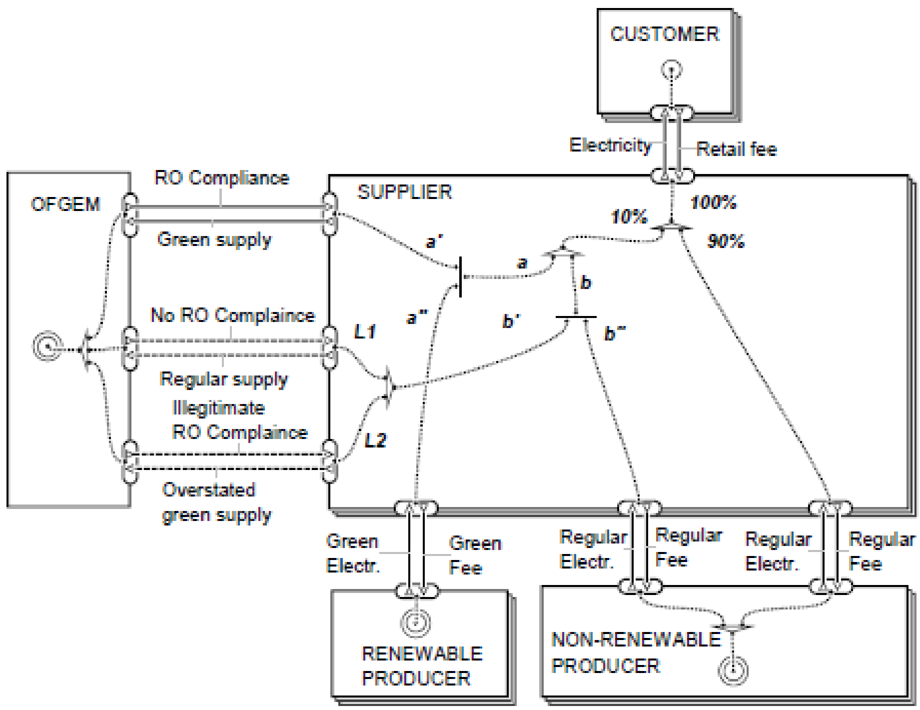

Figure 6-2: *e3control* sub-ideal value model for the problem of not supplying green electricity, extracted from (Kartseva, Gordijn and Tan, 2009)

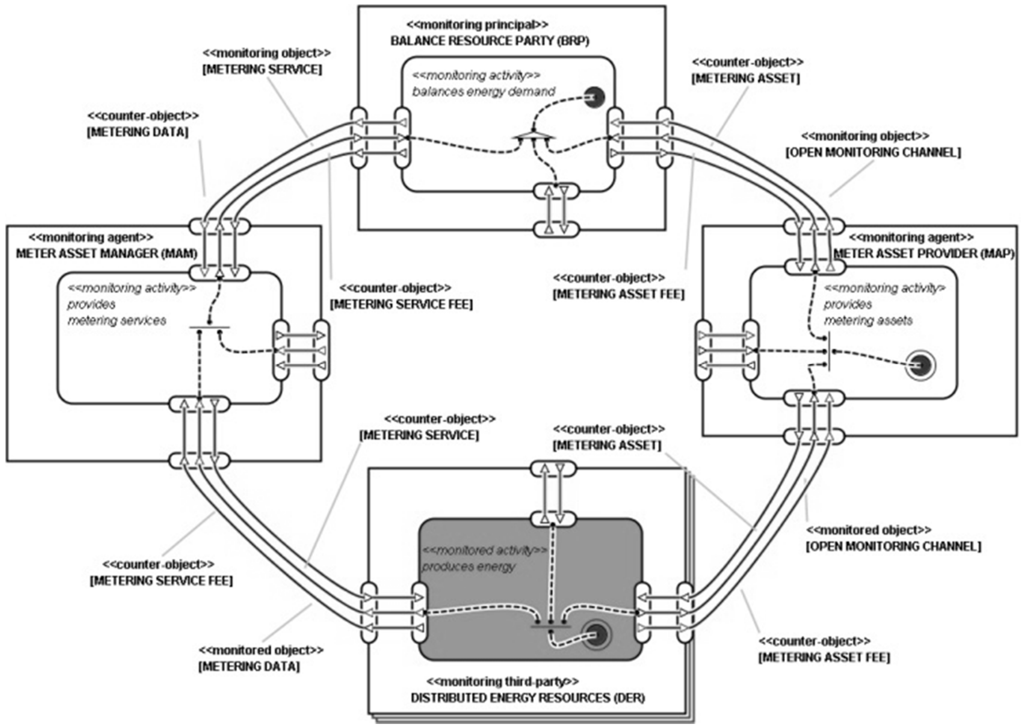

Figure 6-3: VMO monitoring policy for the Renewable Energy case

Some of the organizational differences between these two models can be identified on **Figures 6-2** and **6-3**. The models depict different scenarios from similar business cases in Renewable Energy. The dotted lines in **Figure 6-2** denote value transactions involving controlling objects, whereas solid lines, transactions involving core business objects. Hence, in this model, the management logic interleaves the core business logic of the value constellation. Differently, the VMO model depicted in **Figure 6-3** encompasses a separated monitoring logic. That is, all the business roles considered here are pertinent to a market of (business) monitoring services.

6.4 User-based Ontology Evaluation

This section brings about an evaluation of quality of VMO as a candidate ontology. For the sake of external validity, the evaluation is based on criteria provided by an external ontology evaluation framework. The framework adopted here is the ONTOMETRIC (Lozano-Tello and Gómez-Pérez, 2004), which is a framework for assessing the adequacy of existent ontologies on meeting a certain system's requirements. The ontologies considered for evaluation here comprise the VMO and its rival, the *e3control* ontology. Adequacy in this case is evaluated according to the perspective of a potential user of the ontology. Hence, ONTOMETRIC comprises a *conformity check* framework supporting a *user-based ontology evaluation*. This type of evaluation is part of the research design of this work, described in **Chapter 2**.

The evaluation is reported as follows. First a brief description of the evaluation criteria adopted from ONTOMETRIC is given. Second, a discussion is provided on the main evaluation results. It must be noted that this evaluation is focused on the modeling attributes of the ontology as a design artifact, and not as a mechanism design (e.g. a Service management logic or theory). Moreover, this evaluation conforms to the perspective of an ontology engineer. Thence, this perspective is posed for discussion and further evaluation by final users of the two evaluated ontologies.

6.4.1 Evaluation Criteria

The ONTOMETRIC framework provides a taxonomy of 160 characteristics for comparing existing ontologies. The so-called *multilevel framework of characteristics* is part of a method for choosing ontologies according to their suitability to solve a certain modeling problem or to meet a specific system's requirements. The method has partial automated support, yet demands considerable human interpretation and expertise. The taxonomy is headed by five basic ontology attributes: *content, language, methodology, tool support* and *costs*. The taxonomy can be applied partially of fully, depending on the level of precision desired for the ontology comparison. In this research, only the basic five attributes have been considered. Some of them have been adapted so as to better describe the application scope of the referred ontologies. The attributes are explained as follows.

(1) *Content*: this attribute is related to the modeling purpose of the ontology. More specifically, it refers to the *knowledge* required to solve a user's problem or to meet a system's functional requirements. Such a knowledge must be explicitly represented in the ontology, or provided in terms of additional documentation and guidelines complementing the corresponding ontology model.

(2) *Representation language*: this basic attribute is essential for the communication and understandability of the theory defined in the ontology. From a Design Science perspective, it is desirable that an ontology, as a design artifact, is expressed through the use of a formal language or mathematical constructs.

(3) *Methodology:* this corresponds to the Ontology Engineering methodology adopted for the construction and maintenance of the ontology. The rigor whereby a certain ontology is produced comprises an important indicator of quality of this ontology.

(4) *Tool support*: according to ONTOMETRIC, tool support corresponds to the automation facilities for editing and manipulating ontologies in general. Here, this attribute has been adapted so as to refer to the tool support necessary to specify and maintain the *e3value* models produced by the referred ontologies. Such a facility has been considered as of a high relevance in the scope of this research.

(5) *Cost*: yet according to ONTOMETRIC, this attribute has been referred originally as the cost of an ontology as a knowledge asset acquired by an

organization or enterprise. However, this is not the case for the evaluation of *e3control* and VMO as candidate ontologies. Therefore, this attribute has been adapted here so as to refer to the cost of learning how to use the ontology.

A comparison between the *e3control* ontology and VMO is provided in **Table 6-1**. It summarizes how the ontologies meet the ONTOMETRIC attributes cited above. A discussion on the comparison is provided in the next sub-section.

Table 6-1: ONTOMETRIC-based comparison between e3control and VMO

ONTOMETRIC Criteria	e3control ontology	VMO
Content	Controlling mechanism design (Control Theory-based)	Service monitoring logic (Agency Theory and SDL-based)
Language	Unified Modeling Language (UML)	Web Ontology Language (OWL)
Methodology	Unspecified	Ontology Engineering Methodology (Sure, Staab and Studer, 2009)
Tool Support	*e3value* Modeling Framework	*e3value* Modeling Framework
Cost of Learning	Pattern-based Reasoning	Ontology-based Reasoning

6.4.2 Ontology Quality Evaluation

The general interpretation of **Table 6-1** is given as follows.

(1) Regarding the *knowledge content* offered, *e3control* describes a controlling mechanism design, whereas VMO specifies a Service monitoring logic. In this sense, VMO provides a treatment to the problem of monitoring a value constellation that is more specific than what is provided by *e3control.*

(2) The *e3control* ontology is specified in the Unified Modeling Language, whereas VMO is formalized in Web Ontology Language (OWL). The OWL language is currently the *de facto* standard in knowledge representation for Semantic Web applications. It allows for automated correctness and consistency check of its constituent axioms. VMO is expressed in OWL functional syntax (as an IT design artifact) and also in OWL abstract syntax (as an axiomatic theory addressed to business analysts).

(3) There is no explicit reference about the use of a consolidated Ontology Engineering methodology for the construction of the *e3control* ontology. Conversely, the process of construction and evolution of VMO has been oriented according to the Ontology Engineering methodology proposed by (Sure, Staab and Studer, 2009). The methodology chosen has a high-level of

flexibility and maturity. It has been applied in this research to cope with alternative cycles between theory review and case-study application.

(4) Both ontologies rely on the facilities for model analysis provided by the *e3value* framework. In practical terms, this means that the models derived by both ontologies can be specified, analyzed and maintained by the use of the referred platform. Both ontologies make explicit reference to the utility of profitability analysis provided by the *e3value* framework.

(5) The *e3control* ontology is complemented by patterns to describe recurrent controlling scenarios (including monitoring scenarios), whereas VMO is based on the concept of operational stereotyping (or role-based logic), which is more flexible on encompassing multiple monitoring scenarios without confusing the designer with several intermediate models. Moreover, patterns are often difficult to combine on covering complex modeling scenarios, and often demand adjustments by the use of "glue patterns". Last, patterns can also be perceived as alternative interpretations of a same ontology.

In sum, according to the evaluation criteria provided above, VMO is considered more appropriate than the *e3control* to solve the problem of designing models for monitoring value constellations. The claim of quality of VMO is especially valid considering its attributes of representation language, Ontology Engineering methodology adopted and cost of learning. This report closes the ontology evaluation cycle of this research.

6.5 Discussion

In this chapter, a discussion about the main related works of this research has been provided. The works included here comprised specific contributions in the area of Business Service Design, which is part of a research roadmap in Service-Oriented Computing. The main focus of this chapter has been to validate the claim of ontology quality of VMO. The verification of this claim has been supported by a conformity check framework for comparing ontologies, which has been used here to support a user-based ontology evaluation.

The works included in the analysis of this chapter have been classified as companion and rival ontologies. The main companion ontologies comprises the *e3value* ontology (Gordijn, 2002), the Enterprise Ontology (Dietz, 2006) and the Business Reference Ontology (Andersson et al., 2006). From these models VMO imports basic concepts of economic flow, Communication Action and operational stereotyping – all considered as fundamental for a Service monitoring logic.

Special attention has been paid on the comparison between VMO and its rival, the *e3control* ontology. From a more functional perspective, the ontologies have been compared according to identified similarities and differences. It has been stated that the Service monitoring logic defined by these ontologies share the same economic communication infrastructure (defined in the *e3control* ontology). However, the models produced by these ontologies differ to a great extent on internal organization and separation of the Service management logic from the core Business logic.

Last, this chapter also reported on the evaluation of the quality of VMO as a problem-solving (candidate) ontology. The evaluation comprised a conformity check based on the ONTOMETRIC framework, which is a method for assessing the adequacy of an ontology for solving a certain conceptual modeling problem or to meet a certain system's requirements. The evaluation results have indicated that VMO is more adequate than *e3control* for solving the referred monitoring problem. The claim of quality of VMO has been grounded on its attributes of Ontology Engineering methodology used, representation language and cost of learning. However, the reported evaluation results correspond to the perspective of a single ontology engineer. These results are posed here for further verification by potential users of both ontologies.

The evaluation provided in this chapter therefore closes the ontology evaluation cycle of this research. In the next chapter, the main results and contributions of this research are presented along with some of the limitations encountered and directions for future work.

Chapter 7: Conclusion and Future Work

The important thing is not to stop questioning.

Albert Einstein (1879 – 1955)

7.1 Research Summary

This thesis comprehends a research effort to solve the problem of monitoring value constellations. This problem has two immediate components: (1) the need of Service monitoring logic for value constellations; and (2) the need of a design artifact to formally represent such logic. In order to fill these needs, a candidate ontology has been proposed and described in this document as an alternative solution to cope with the respective research problem. The so-called Value Monitoring Ontology (VMO) is a task ontology describing Service monitoring logic for value constellations. It is also the basis for the establishment of a Business domain viewpoint in Service monitoring, so-called Value Activity Monitoring viewpoint. Therefore, it leverages Service monitoring to a problem of Business Strategy.

The research design of this work has been primarily oriented by fundamental principles of Design Science (Hevner et al., 2004). Additionally, the research design has been aligned to a well-founded Ontology Engineering methodology proposed by Sure, Studer and Staab (2009). This methodology has been adopted here due to its level of flexibility and maturity, which are considered as critical factors in practical research. In this work, the flexibility of this methodology has been explored so as to guide the construction of VMO along cycles of theoretical alignment and progressive case-study applications. The objective of such has been to turn VMO into an ontology that balances theoretical soundness and practical usefulness.

The main motivation of this research has been to leverage Service monitoring to a question of Business Strategy. As reported in **Chapter 2**, a literature review published in (Silva and Weigand, 2011a) has indicated an absence of frameworks and mechanisms for designing business requirements for Service monitoring. In this same publication, it has also been reported that, currently, the design of business requirements for Service monitoring starts from the business process viewpoint. This partially explains the substantial amount of research contributions in Business Activity Monitoring and, more recently, in Process Mining. However, business requirements for Service monitoring involve business strategy and metrics of business value, which are not normally derived from the business process viewpoint, which is more focused on process communication and process performance metrics. Yet, even for the sake of Business-IT alignment, it becomes necessary to start designing business requirements of Service monitoring from the Business domain viewpoint, through a business logic perspective. Therefore, VMO is an attempt to fill this absence, establishing a value viewpoint on Service monitoring, so-called *Value Activity Monitoring*. According to this viewpoint, Service monitoring is designed as a business strategy, part of the initial configuration of a value constellation. In this sense, VMO establishes Service monitoring logic and a corresponding ontology for describing value constellations enriched with Service monitoring strategies.

The proposition of VMO as candidate ontology has been justified under claims of ontology effectiveness, efficiency and quality. The validation of these claims has involved a composition of different ontology evaluation types. These in turn included a mix of real-world case studies, literature review, conformity checking and prototyping. The evaluation results indicated that VMO is a sound research contribution to the areas of Value Modeling, Business Service Design and Service-Oriented Computing.

The rest of this last chapter is organized as follows. In **section 7.2**, the discourse is returned to the research questions introduced in **Chapter 2**, along with the corresponding solutions found along the development of this work. The evaluation of these solutions is summarized so as to validate the claim of this research. In **section 7.3**, the main contributions of this work are described from the specific research context of Value Modeling, to the scope of Business Service Design and Service-Oriented Computing. In **section 7.4**, the main limitations of VMO as an IT design artifact are discussed. Last, s**ection 7.5** closes the discourse of this thesis by presenting a research agenda for the continuation of this research endeavour.

7.2 Claim Validation

This section reports on the main results achieved by means of this research. The report is organized according to the research questions introduced in **Chapter 2**, which are followed by corresponding solutions, summary of evaluation results and claim validation. **Questions 1-2** provide a theoretical background for the other questions. **Questions 3-5** are more related to the claim validation of VMO as candidate ontology.

Research Question 1: What are the requirements for monitoring value constellations?

This question has been decomposed into four other questions related to the theoretical background necessary to establish the Service monitoring logic for value constellations. This theoretical background has been presented in **Chapter 2** and is summarized as follows.

(1) *Who wants to monitor whom in a value constellation?*

The value transactions that compose a value constellation can be perceived as Agency relationships. Each of these relationships is a potential source of information asymmetry problems. The main information asymmetry of a value transaction is that it expresses only promises, but not assurances to create value. Such asymmetry becomes evident in value transactions involving service provisioning, where the risk is higher at the service consumer's side.

Thus, the monitoring of a value constellation starts to be analyzed from the context of its constituent transactions, with a *service consumer* willing to monitor if a *service provider* performs his internal value activity (as a service) according to the initial promise.

(2) *What has to be monitored?*

The *value activity* performed by the *service provider* constitutes the main monitoring subject of a value constellation. As a practical guideline for the service consumer, special attention should be paid to monitor activities that are suspect of fraudulent or opportunistic operation.

(3) *Why to monitor?*

Risk mitigation and *market exploitation* comprise some of the main reasons for a service consumer to monitor suspicious value activities in a value constellation. Risks mitigation in this case is associated with the provisioning of monitoring objects that disclose hidden behavior of a certain service provider. These monitoring objects in turn can be explored as the main business commodity of a market of monitoring services.

(4) *How to monitor?*

The disclosure of private verifiable information in a closed value constellation may constitute an organizational problem. For the service consumer, the problem becomes to explore existing value transactions whereby the necessary monitoring information could be obtained at the least possible cost. However, these monitoring transactions are themselves Agency relationships, with Agency problems of information asymmetry. That is, unreliable monitoring agents (and corresponding value activities and objects produced) may trigger recursive inclusion of agents watching over other agents. An alternative proposed to cope with this issue comprised to combine monitoring Agency with a Service-Dominant logic. Based on that, the effectiveness of a monitoring agent is assessed through the monitoring object he produces, whereas his efficiency is characterized by the value generated by these objects, at the service consumer's side.

Research Question 2: How have these monitoring requirements been represented?

(1) *How has the ontology been represented?*

The ontology has been originally represented as a semi-formal model described in UML. The model has evolved along different versions, published in (Silva and Weigand, 2011b) and (Silva and Weigand, 2012). These versions correspond to different case-based applications, which have been used to refine the ontology. In this thesis, the current version of VMO is described in Web

Ontology Language (OWL). The model is presented in OWL abstract syntax in **Chapter 3**, and in OWL functional syntax in the **Appendix** of this thesis.

(2) *What resources were used to build the ontology?*

The construction of VMO has been aligned to the Ontology Engineering methodology proposed by Sure, Staab and Studer (2009). This methodology has been found as appropriate to be used in this research due to its level of flexibility and maturity. The flexibility of the methodology has been explored on making VMO an outcome of successive cycles of theoretical alignment and case-based applications. The main theoretical resources used to build VMO include fundamental literature in Agency Theory (Eisenhardt, 1989; Jacobides and Croson, 2001; Shapiro, 2005) and Service-Dominant Logic (Vargo and Lusch, 2004; Vargo and Akaka; 2009; Grönroos and Ravald, 2011). The main practical resources used here include documentation about business cases in Customs Control, Intellectual Property Rights and Renewable Energy. As reported in (Silva and Weigand, 2011b), the information about the Renewable Energy case has been collected directly from practitioners from the Energy Research Center of the Netherlands.

Research Question 3: How effective is VMO as candidate ontology?

This question splits in two groups of related questions. The first group is related to the effectiveness of VMO regarding its monitoring logic. The second group is related to the effectiveness of VMO as a knowledge representation model.

(1) *How effective is VMO in theory?*

a. *What criteria of theoretical effectiveness have been considered?*

VMO is grounded on general principles of Agency Theory. One of these principles states that, in Agency-based relationships, additional monitoring information is a *purchasable commodity*, and therefore, should be obtained by only competent monitoring parties. This principle has been considered as a basic requirement for VMO, as a model that defines Service monitoring logic for value constellations.

b. *How has VMO been evaluated regarding this criterion?*

This question has been addressed in VMO in two steps. First, VMO formalizes the concept of a *monitoring need*, which is a business need of *monitoring objects*, i.e. monitoring information, according to an Agency Theory jargon. These monitoring objects can be produced by actors, value activities and value objects that already compose a value constellation. Second, VMO formalizes the concept of a *monitoring policy*, which defines who can provide which monitoring information to whom. A monitoring value constellation is an ordinary value constellation reorganized according to monitoring roles. The concept of a value constellation complies with the principle of monitoring information as a purchasable commodity, stated above as a theoretical effectiveness criterion. Therefore, according to this criterion, VMO is an effective model in theory.

(2) *How effective is VMO in practice?*

a. *What criteria of practical effectiveness have been considered?*

According to the research design presented in **Chapter 2**, practical effectiveness has been referred as the *cost-effectiveness* of the monitoring models produced through the use of VMO in practical scenarios. In this research, the definition of cost-effectiveness has been derived from the definition of a monitoring value constellation. According to this definition, the actors, value activities and value objects that compose a value constellation comprise the budget available for its own internal monitoring. Therefore, VMO will be effective in practice only if its corresponding models do not exceed this budget.

b. *How has VMO been evaluated regarding these criteria?*

VMO has been applied in three real-world business cases, from the sectors of Customs Control, Intellectual Property Rights and Renewable Energy. The core business logic of each of these cases has been formalized in a respective value constellation model. For each of these models, a corresponding monitoring value constellation has been produced. In all cases, it has been demonstrated that the monitoring value constellations produced have not exceed the budget of its internal actors, value activities and value objects for its own monitoring. Therefore, according to the definition of cost-effectiveness given above, and based on the results reported from the case-studies, VMO was evaluated as cost-effective in practice.

Research Question 4: How efficient is VMO as candidate ontology?

This question also splits in two groups of related questions. The first group is related to the efficiency of VMO regarding its monitoring logic. The second group regards to the effectiveness of VMO as a knowledge representation model.

(1) *How efficient is VMO in theory?*

a. *What criteria of theoretical efficiency have been considered?*

According to the monitoring logic of VMO, a monitoring value constellation is considered effective only if it copes with its own internal demands of monitoring objects, constrained by internal policies. However, from an internal perspective, it is always possible to make this system as efficient as possible at the service consumer's side. Efficiency in this context refers to how equivalent monitoring objects could be distinguished at the consumer's side. This constitutes a problem of Service evaluation, which has been treated from a Service-Dominant logic perspective. If monitoring objects are offered as *monitoring services*, then they can be distinguished according to the following fundamental principles in Service-Dominant logic (vide Vargo and Akaka, 2009, p. 35):

- **FP7**: *The enterprise cannot deliver value, but only offer value propositions, i.e. the firm can offer its applied resources and collaboratively (interactively) create value following acceptance, but cannot create/deliver value alone.*
- **FP10**: *Value is always uniquely and phenomenological determined by the beneficiary, i.e. value is idiosyncratic, experiential, contextual, and meaning laden.*

Therefore, VMO will be efficient in theory if its monitoring logic complies with these fundamental principles.

b. *How has VMO been evaluated regarding these criteria?*

VMO extends the concept of a value object, as originally defined in the *e3value* ontology (Gordijn, 2002), with the concept of (value) *indicator*. Hence, while the concept of a value object denotes basic economic values (e.g. cost and amount-of-matter), the concept of *indicator* expresses information about the subjective value of an economic object. An indicator is used to distinguish value objects in general. From the service provider's side, an indicator expresses a value proposition, whereas from the service consumer's side, a value experience. The definition extends to monitoring objects, as specific types of value objects. Consequently, monitoring objects also become subject of value proposition and value experience. Therefore, through the formalization of the concept of an indicator, VMO is compliant with the Service-Dominant logic principles cited above. By these means, VMO is an effective model in theory.

(2) *How efficient is VMO in practice?*

a. *What criteria of practical efficiency have been considered?*

As mentioned throughout this thesis, the construction of VMO has been driven by elements of practice provided by real-world business cases. A critical element of practice encountered in these cases comprised the need of a reliable Service monitoring logic. Monitoring *reliability* can be considered as a practical view on monitoring efficiency. However, each case has demanded a different treatment on monitoring reliability. Based on that, VMO will be efficient in practice through a general demonstration of reliability of its internal Service monitoring logic.

b. *How has VMO been evaluated regarding this criterion?*

The *reliability* of the Service monitoring logic expressed in VMO has been grounded on two assumptions. The first assumption is based on that, in a monitoring value constellation, all the actors, value activities and value objects assume a well-defined monitoring role. The definitions of monitoring roles are based on basic relationships of Communication Action. This has been referred throughout the text as closed monitoring assumption. The second assumption comprises that the monitoring objects offered to a service consumer of a value constellation are previously evaluated through multiple Agency relationships. This has been referred here to as *cross-monitoring* assumption. It has been demonstrated through the models presented in **Chapters 4** and **5** that these assumptions hold for the case studies used in this research. Therefore, based on the demonstration reported from these cases, VMO is considered as an efficient model in practice.

Research Question 5: What quality attributes distinguishes VMO among its rival ontologies?

(1) *What criteria have been used to evaluate the quality of the ontology?*

Ontology *correctness*, *consistency* and *completeness* comprise some of the main quality attributes of candidate ontologies (Brank, Grobelnik and Mladenic, 2005; Noy, Guha and Musen, 2005; Vrandesic, 2010). These attributes can be checked automatically, through the use of ontology edition and reasoning platforms. They indicate the quality of an ontology as an IT artifact.

(2) *How has VMO been evaluated regarding these criteria?*

VMO has been formalized on OWL2 functional syntax (vide Appendix). The correctness check has been supported by the Protégé[10] tool. The internal consistency of the ontology has been checked by the use of the Fact++ reasoner, integrated in the Protégé platform. Completeness here has been evaluated by using the reasoned to find possible instances of the concepts formalized in the ontology.

For the sake of external validity of quality, VMO has been compared to its rival ontology, the *e3control* ontology, proposed by Kartseva (2008). The comparison was based on general ontology characteristics prescribed by the ONTOMETRIC framework (Lozano-Tello and Gómez-Pérez, 2004). Accordingly, the two ontologies were compared according to representation language used, cost of learning, Ontology Engineering methodology adopted and tool support. As reported in **Chapter 6**, VMO is posed as more adequate than its rival for solving the problem of monitoring value constellations.

[10] Protégé 4.1 Release, Stanford Center for Biomedical Informatics Research (BMIR), Stanford University School of Medicine, available for download at: http://protege.stanford.edu

> Therefore, based on the quality criteria stated above, and corresponding evaluation, the claim of quality of VMO is valid.

In sum, the claims of *effectiveness*, *efficiency* and *quality* of VMO have been evaluated through a combination of different ontology evaluation methods. Based on the evaluation results reported throughout this thesis, and according to the research design proposed for this work (vide **Chapter 2**), this candidate ontology comprehends a relevant design artifact and valid contribution to the addressed research area.

7.3 Research Contributions

This section summarizes the main research contributions given by this research according to the classification of research sub-areas in Service-Oriented Computing.

A Contribution to Value Modeling

As emphasized along this text, the *e3value* framework realizes a relevant viewpoint in Business Service Design. This viewpoint is driven by the economic profitability factor that motivates enterprises to engage in collaboration in value constellations. It has also been mentioned that the sustainability of a value constellation depends not only on its initial configuration, but also on how its constituent activities and transactions are managed along the time. Management in this case includes mechanisms for controlling, monitoring and reconfiguring value constellations, according to specific stakeholders' requirements. It is part of the vision of Value Modeling, as a relatively recent research area, to leverage the *e3value* framework to a reference framework for design and management of business services, especially in the context of networked business collaborations (Gordijn et al., 2008; Weigand et al., 2011).

In order to pave such a vision, relevant contributions have been given recently in terms of frameworks for managing *e3value* models. Some contributions have been focused on providing additional support for the configuration of value constellations, as it has been the case of the contributions given by Pijpers et al. (2012) and Rázo-Zapata et al. (2012). Some other contributions have provided additional logic for controlling and managing value constellations from a decentralized controlling perspective. This has been the case of the contributions given by Kartseva (2008) and Hulstijn and Gordijn (2010). As the main related work of this research, the work of Kartseva (2008) represents important advances in controlling logic for value constellations. Its implied managerial implications for Service monitoring represent also another important achievement. However, such implications are not sufficient to justify the work of Kartseva as sufficient to cope with (value activity) monitoring problems that may arise in the context of value constellations. Such problems constitute a research area in its own, demanding a more specific coverage and treatment by means of a specific logic for Service monitoring for value constellations.

Therefore, VMO comprises a response to such a demand, providing Service monitoring logic for enriching *e3value* models with strategic monitoring information.

The logic proposed considers the monitoring of a value constellation as a problem of Business Strategy, which ought to be tackled by business analysts. The logic is described in a *de facto* standard language for ontology representation (vide **Chapter 3** and **Appendix**). As a complement, VMO brings a set of practical guidelines documented from its application in real-world case studies. It is the purpose of VMO to complement (and not to replace) the *e3control* mechanism on the design of Service monitoring strategies for value constellations. In this sense, VMO is offered here as knowledge asset aimed to extend the *e3value* library of mechanisms and techniques to manage value constellation models.

A Contribution to Business Service Design

As reported in **Chapter 2**, the literature review published in (Silva and Weigand, 2011a) has revealed an absence of frameworks and mechanisms for designing monitoring services from a business perspective. In practice, these services start to be configured from a business process viewpoint, supported by driving technologies such as Business Activity Monitoring and Process Mining. However, these technologies do not prescribe how monitoring services interact from a business perspective. Such interaction is normally constrained by business regulations and policies defining how strategic monitoring information is exchanged among enterprises engaged in business collaboration. Moreover, the design of these policies is normally responsibility of business analysts, and not of IT developers. Therefore, there is a demand of frameworks and mechanisms to furnish this group of stakeholders with a Business domain viewpoint on Service monitoring design.

The construction and proposition of VMO is in line with this demand. Rather than a consolidate architectural viewpoint, this candidate ontology is posed more as an attempt to leverage the design of Service monitoring to the Business domain viewpoint. VMO is therefore aimed to be evaluated by practitioners and scholars from the Business Service Design area so as to establish the so-called Value Activity Monitoring viewpoint in future research. Meanwhile, it already comprises an option to furnish business analysts with a basic vocabulary for designing Service monitoring requirements from a value-driven perspective.

Moreover, it is also intended that the Service monitoring logic defined in VMO brings indirect contributions to companion ontologies. This is the particular case of the Enterprise Ontology, proposed by Dietz (2006), which provides a mechanism for configuring and describing business processes from a Language Action Perspective (LAP). More specifically, the concepts of *value proposition indicator* and *value-in-use indicator* can be combined with what is defined in Enterprise Ontology as *distinction axiom*. This combination can provide specific logic for designing evaluation services to be used to support networked business collaborations.

Last, VMO also brings concepts that can be incorporated to the Business Reference Ontology, proposed by Andersson et al. (2006). A concept perhaps worth of discussion is the concept of *indicator*, which splits the *e3value* concept of value object into components of objective (economic) value and subjective value.

A Contribution to Service-Oriented Computing

Finally, and from a more general perspective, VMO brings a research contribution to the big area of Service-Oriented Computing (SOC). According to (Papazoglou et al., 2008), the big area of Service-Oriented Computing is organized in the following sub-areas: (1) *Service Foundations*; (2) *Service Composition*; (3) *Service Management*; and (4) *Service Design* and *Development* (or *Service Engineering*). The contribution of this work falls into the intersection between Service Management and Service Design and Development.

As a contribution to Service Management, VMO brings an alternative logic for Service monitoring. As presented in this thesis, the logic mixes fundamental principles of Agency Theory with principles of Service-Dominant logic. Such logic can be particularly useful on the design of autonomic computing capabilities for Service Management. According to VMO, Service monitoring can be perceived as a self-manageable system, amenable to sustainability analysis. Therefore, the concept of a monitoring value constellation can be adapted in SOC so as to describe Service monitoring systems in general.

Yet in line with this research agenda, the sub-area of Service Management and Service Design has included specific calls for contributions in *Design Principles for Engineering Service Applications* and *Service Governance Techniques*. To the former, the research reported here brings a contribution in terms of design principles specific for the design of *monitoring service* systems. This is the particular case of a monitoring value constellation, which describes a system of monitoring services from a business perspective. To the latter, this research brings an alternative viewpoint that defines Service monitoring as a subject of business governance and regulation.

7.4 Limitations

This section reports on some of the main limitations constraining the research contributions given in this work. These limitations have been classified along *automation*, *maturity*, *scalability* and *usability* limitations, which are documented as follows.

Automation limitations

This limitation is related to how a monitoring value constellation is currently configured. According to the practical guidelines provided in **Chapter 2** (and formalized in **Chapter 3**), the construction of a monitoring value constellation involves the steps of *defining monitoring goals*, *monitoring policies* and *monitoring indicators*. Each of these steps produces a layer of information that can be added progressively to the final model of the value constellation. However, the modeling tasks denoted by these steps are currently accomplished manually. Although human expertise is required in this case, part of these tasks can be supported by automated facilities. The ontology specification provided in the **Appendix** of this thesis already provides the grounding vocabulary to be shared by the applications implementing these facilities. A possible application would consist of a Protégé plugin supporting the automated translation of OWL instances of monitoring value constellations into corresponding *e3value* graphical models. Other planned applications include tool support for automated discovery, selection and composition of business monitoring services and monitoring policies of a value constellation.

Maturity limitations

This limitation is related to the consolidation of the Value Activity Monitoring viewpoint as a Business domain perspective on Service monitoring. As mentioned throughout this thesis, the process of constructing VMO has involved alternative cycles of theoretical alignment and case study applications. For each cycle, a different version of the ontology has been produced.

The cases used in this research already shed new light on Service monitoring in general, by bringing monitoring problems of a strategic order. However, in order to establish a consolidated Business Design viewpoint on Service monitoring, VMO must be applied in more business cases. Special emphasis ought to be given to cases involving a combination of Service provisioning with exchange of ordinary business commodities or to purely Service-Oriented scenarios.

Scalability limitations

This limitation is related to the applicability of VMO in large-scale value constellations. As reported in **Chapters 3-5**, the case study scenarios used in this research have been limited to include a maximum of five strategic actors and market segments. For the sake of tractability, such a reduction has a point and utility of Business Strategy, for as the monitoring scenario can be easily replicated. Replication is a critical requirement in business strategy (Winter and Szulanski, 2001). However, for the sake of robustness and scalability of its Service monitoring logic, VMO must be applied in models describing large-scale value constellations. Relevant scenarios to be explored in this case would comprise: (1) value constellations with multiple concurrent monitoring policies; (2) value constellations with multiple monitoring principals; and (3) value constellations with goal conflicts among monitoring principals and corresponding agents. Nonetheless, the scalability limitation referred here would also require a treatment on the automation limitations of VMO. Automation in this case is essential for the configuration and analysis of conflicting monitoring policies in a value constellation.

Usability limitations

This limitation is related to the acceptance of VMO from the Business Service Design community. A critical requirement for the acceptance of a candidate ontology by a certain knowledge domain community refers to the understandability of the model. From a Design Science perspective, this is related to how the model is described in a formal language or mathematical notation so as to be evaluated by a certain research community.

The current version of VMO reported in this thesis evolves in formalization regarding its predecessor semi-formal models, published in (Silva and Weigand, 2011b) and (Silva and Weigand, 2012). These models had a role during the phases of initial feasibility analysis and refinement of VMO. However, perceived ease of use and perceived usefulness are critical factors for user acceptance of Information Technology (Davis, 1989). Thus far, VMO has not yet been evaluated regarding these aspects, which indicate a current limitation of usability of this model.

7.5 Research Outlook

In order to partially overcome the limitations cited above, a brief research agenda is proposed in this section to extend the work started with VMO. This agenda comprises four specific calls for collaboration with companion research communities. The agenda closes this thesis as a proposal for further development on the Value Activity Monitoring viewpoint.

A Call to the Ontology Engineering Community

In order to overcome the limitations of *usability* and *maturity* of VMO, a call for contributions is addressed here to the Ontology Engineering research community. On what regards the referred limitations of *usability*, additional user-based evaluation is necessary. Thus, evaluation provided by Ontology engineers and final users are both desirable. More specifically, it is of particular interest in this research to collect results from user-based evaluation of the comparative use of VMO and *e3control* on solving the problem of monitoring value constellations.

Moreover, in order to overcome the limitations of *maturity* of the ontology, additional user-based evaluation can also be used so as to produce new versions of the ontology. Successive application of VMO on new business cases may also be useful to refine its Service monitoring logic. By means of successive applications in other business cases, it is expected that VMO will be reduced to a smaller set of axioms, but with more specificity on the logic of Service evaluation and valuation. As a last call for this community, new evaluations on the cost-effectiveness and cost-efficiency of VMO as a decision-support mechanism are especially desirable.

A Call to the Enterprise Engineering Community[11]

As referred in this thesis, the Enterprise Ontology proposed by Dietz (2006) has provided some of the fundamental concepts in Communication Action adopted and extended in VMO. However, the viewpoints covered by these two ontologies are

[11] Dietz, J.L.G. (ed.): Enterprise Engineering: The Manifesto, Final Version (January 2011), http://www.ciaonetwork.org/publications/EEManifesto.pdf

different. While VMO is focused on inter-Enterprise communication aspects of Service monitoring, the Enterprise Ontology is focused on the intra-Enterprise communication aspects of business process configuration.

Despite these differences, both ontologies include, indirectly, the concept of *evaluation services*. In the Enterprise Ontology, the *distinction axiom* denotes a Service evaluation function that is realized by different actors within the Enterprise, and throughout different architectural layers. In VMO, the concept of (value) indicator denotes an evaluating value activity performed within the domain of the service consumer of a value constellation. Both concepts can be combined so as to produce logic and corresponding viewpoint on evaluation services.

From a very general perspective, this type of service could be of essential utility on the design of Service Management applications. Evaluation services have been referred by Weigand et al. (2009) as part of the configuration of business services.

It is of special interest here to investigate how evaluation services could be included in a value constellation and how they would impact on the sustainability of this system. For the realization of evaluation services, it would be of interest to investigate how these services could be implemented as part of the internal architecture of the Enterprise – something that could be analyzed through the application of the Enterprise Ontology.

Towards Automated Configuration of Monitoring Value Constellations

In order to overcome the VMO limitations of automation support and scalability, a research call for collaboration is addressed to the companion research communicated in (Rázo-Zapata et al., 2012). This research is also part of the VALUE-IT project, mentioned throughout this thesis. It extends the *e3value* framework by providing support for automated configuration of value constellation models. The underlying mechanism is based on a logic for describing, discovering, selecting and composing services from a business perspective. Such a facility could also be used so as to automate the process of configuring a monitoring value constellation.

Thus, in line with this work, some questions of relevance for future investigation are provided as follows, along with a corresponding explanation and research direction:

(1) *How to describe Business monitoring services?*

Explanation: as defined in VMO, the model of a monitoring value constellation comprises a formal representation of a collective monitoring service. However, in order to automate the process of configuring this type of constellation from its constituent participants, it becomes necessary to describe the services provided by each of them, in a machine-readable representation language.

Research Direction: the work published in (Rázo-Zapata et al., 2012) reports on how business services can be represented for automated configuration of value constellations. The representation ontology used can be extended by the axioms of VMO so as to describe business monitoring services.

(2) *How to automatically discover, select and compose Business monitoring services?*

Explanation: in addition to the description of the monitoring services, the configuration tool must be extended so as to include the definition of the monitoring policies restricting the composition of the monitoring services.

Research Direction: to extend the mechanism described above with functionality for composing monitoring services under constraints defined by value-driven monitoring policies.

(3) *How to configure a monitoring value constellation and its encompassed monitoring policies automatically?*

Explanation: a monitoring value constellation is composed of multiple internal policies involving triangulations of monitoring agents, principals and third-parties. These policies may conflict or overlap in many instances.

Direction: to extend the referred configuration mechanism with a logic for conflict resolution for value monitoring policies. Part of this logic could be automated and part could also be provided in terms of best practices and policy management rules.

In sum, the above questions comprise a short description of a research project. By automating the process of configuring a monitoring value constellation, it is also intended to overcome some of the limitations of scalability mentioned above. From a more general perspective, such automation can also be a critical factor of acceptance of the *Value Activity Monitoring* viewpoint as a practical Business Design framework.

From Value Activity Monitoring to Business Activity Monitoring

Finally, a last call for research collaboration is addressed to another companion research, communicated in (Fatemi, Sinderen and Wieringa, 2010). This research is also part of the VALUE-IT project.

Its original purpose has been to develop mechanisms for mapping value models into process coordination models. Therefore, in potential, it provides interoperability infrastructure for mapping the *Value Activity Monitoring* viewpoint into a corresponding Business Activity Monitoring viewpoint.

Hence, also in line with this work, some research questions of relevance for future investigation are given below:

(1) *How to map Key Value Indicators (KVIs) to Key Performance Indicators (KPIs)?*

Explanation: the concept of *indicator*, as defined in VMO, corresponds to the minimal unit of monitoring information relevant to a monitoring value constellation. It constitutes a prelude of what could be called *Key Value Indicator* (KVI). However, Key Value Indicators are not supposed to be Key Performance Indicators (KPIs). The latter actually corresponds to Process Performance Metrics (PPMs), which are used to measure performance of intra-organizational business processes.

Research Direction: it is of interest to investigate how KVIs will map to KPIs. In theory, KVIs correspond to the monitoring information that is relevant for businesses involved in a value constellation. Yet in theory, KVIs are more comprehensive than KPIs, thereby demanding further decomposition on the business process layer so as to be measured. The work of Etzioni (1989) provides the concept of humble decision-making, which comprises a principle of decision-making based on the least available amount of monitoring information. This principle can be investigated in the future so as to describe more precisely what would be a KVI in practice. Moreover, reduction of KVIs to a subset of relevant information could potentially reduce the complexity of mapping KVIs into corresponding KPIs.

(2) *How to translate a monitoring value constellation and its internal policies into monitoring processes?*

Explanation: it is also of interest to investigate how the *Value Activity Monitoring* viewpoint will be used as a prelude for a Business Activity Monitoring (BAM) viewpoint. BAM is still the state-of-the-art in business process monitoring, and must be considered as a target implementation system.

Research Direction: the mapping between the referred viewpoints will demand a robust infrastructure or mechanism for mapping value models to process models. The research published by (Fatemi, Sinderen and Wieringa, 2010) have reported on a pattern-oriented method for translating value models into corresponding business process (coordination) models. A research direction worth of attention is to investigate about the robustness of this model on translating the *Value Activity Monitoring* viewpoint into its corresponding Business Activity Monitoring viewpoint.

In sum, the above questions comprise another short description of a future project that will give continuity to this research. This is also convergent with the initial vision of configuring a business process monitoring infrastructure from the value viewpoint, originally published in (Silva and Weigand, 2011a). Such a vision also justifies the title of this thesis, which expresses a research endeavour of establishing *Value Activity Monitoring* as a prelude of a Business Activity Monitoring (BAM) viewpoint.

Appendix: Value Monitoring Ontology (OWL 2 Model)

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business management activity. Therefore, VMO is proposed as a task ontology,
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IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
        <ObjectIntersectionOf>
```

```
            <Class IRI="#ActorRole"/>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#estimates"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#hasCompetence"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringActivity"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isActorParticipantOf"/>
                <Class IRI="#MonitoringPolicy"/>
            </ObjectSomeValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#measures"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasAuthority"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasMonitoringGoal"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasOwnership"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringObject"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasPossession"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject"/>
            </ObjectAllValuesFrom>
        </ObjectIntersectionOf>
    </EquivalentClasses>
    <EquivalentClasses>
        <Class IRI="#MonitoredActivity"/>
        <ObjectIntersectionOf>
            <Class IRI="#ActivityRole"/>
            <ObjectSomeValuesFrom>
                <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#consumes"/>
```

```
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#uses"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isActivityParticipantOf"/>
                <Class IRI="#MonitoringPolicy"/>
            </ObjectSomeValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#produces"/>
                <Class IRI="#MonitoredObject"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#isCompetenceOf"/>
                <Class IRI="#MonitoringThirdParty"/>
            </ObjectAllValuesFrom>
        </ObjectIntersectionOf>
    </EquivalentClasses>
    <EquivalentClasses>
        <Class IRI="#MonitoredObject"/>
        <ObjectIntersectionOf>
            <Class IRI="#ObjectRole"/>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isObjectParticipantOf"/>
                <Class IRI="#MonitoringPolicy"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isOwnershipOf"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringAgent"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isOwnershipOf"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isUsedBy"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringActivity"/>
            </ObjectSomeValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasReciprocity"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
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                <ObjectProperty IRI="#isOwnershipOf"/>
                <ObjectUnionOf>
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IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringAgent"/>
                    <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
                </ObjectUnionOf>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#isPossessionOf"/>
                <Class IRI="#MonitoringThirdParty"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#isProducedBy"/>
                <Class IRI="#MonitoredActivity"/>
            </ObjectAllValuesFrom>
        </ObjectIntersectionOf>
    </EquivalentClasses>
    <EquivalentClasses>
        <Class IRI="#MonitoringThirdParty"/>
        <ObjectIntersectionOf>
            <Class IRI="#ActorRole"/>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#hasAuthority"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
            </ObjectSomeValuesFrom>
            <ObjectSomeValuesFrom>
                <ObjectProperty IRI="#isActorParticipantOf"/>
                <Class IRI="#MonitoringPolicy"/>
            </ObjectSomeValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasCompetence"/>
                <Class IRI="#MonitoredActivity"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasOwnership"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject"/>
            </ObjectAllValuesFrom>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#hasPossession"/>
                <Class IRI="#MonitoredObject"/>
            </ObjectAllValuesFrom>
        </ObjectIntersectionOf>
    </EquivalentClasses>
    <EquivalentClasses>
        <Class IRI="#ValuePartition"/>
        <ObjectIntersectionOf>
            <Class IRI="#ValueMonitoringConstruct"/>
            <ObjectUnionOf>
                <Class IRI="#HighValue"/>
                <Class IRI="#LowValue"/>
                <Class IRI="#NeutralValue"/>
            </ObjectUnionOf>
            <ObjectAllValuesFrom>
                <ObjectProperty IRI="#isInformationRealizationOf"/>
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```
                <Class IRI="#Indicator"/>
            </ObjectAllValuesFrom>
        </ObjectIntersectionOf>
    </EquivalentClasses>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <Class IRI="#e3valueConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasActorRole"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringAgent"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasActorRole"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
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    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasActorRole"/>
            <Class IRI="#MonitoringThirdParty"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasResponsibility"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueExchange"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#in"/>
            <Class IRI="#MarketSegment"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
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    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectMinCardinality cardinality="1">
            <ObjectProperty IRI="#has"/>
            <Class IRI="#ValueInterface"/>
        </ObjectMinCardinality>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        <ObjectExactCardinality cardinality="1">
            <ObjectProperty IRI="#performs"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueActivity"/>
        </ObjectExactCardinality>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <Class IRI="#ValueMonitoringConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isEstimatedBy"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isEstimatedThrough"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isAchievedThrough"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringObject"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
```

```
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isMeasuredBy"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isMeasuredThrough"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isMonitoringGoalOf"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueActivity"/>
        <Class IRI="#e3valueConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueActivity"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasActivityRole"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringActivity"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueActivity"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasActivityRole"/>
            <Class IRI="#MonitoredActivity"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
```

```
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueActivity"/>
        &lt;ObjectMinCardinality cardinality="1"&gt;
            &lt;ObjectProperty IRI="#has"/&gt;
            &lt;Class IRI="#ValueInterface"/&gt;
        &lt;/ObjectMinCardinality&gt;
    &lt;/SubClassOf&gt;
    &lt;SubClassOf&gt;
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueActivity"/>
        &lt;ObjectExactCardinality cardinality="1"&gt;
            &lt;ObjectProperty IRI="#is_performed_by"/&gt;
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        &lt;/ObjectExactCardinality&gt;
    &lt;/SubClassOf&gt;
    &lt;SubClassOf&gt;
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueExchange"/>
        &lt;Class IRI="#e3valueConstruct"/&gt;
    &lt;/SubClassOf&gt;
    &lt;SubClassOf&gt;
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueExchange"/>
        &lt;ObjectSomeValuesFrom&gt;
            &lt;ObjectProperty IRI="#isResponsibilityOf"/&gt;
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor"/>
        &lt;/ObjectSomeValuesFrom&gt;
    &lt;/SubClassOf&gt;
    &lt;SubClassOf&gt;
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueExchange"/>
        &lt;ObjectMinCardinality cardinality="1"&gt;
            &lt;ObjectProperty IRI="#in"/&gt;
            &lt;Class IRI="#ValueTransaction"/&gt;
        &lt;/ObjectMinCardinality&gt;
    &lt;/SubClassOf&gt;
    &lt;SubClassOf&gt;
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueExchange"/>
        &lt;ObjectExactCardinality cardinality="1"&gt;
            &lt;ObjectProperty IRI="#has_in"/&gt;
            &lt;Class IRI="#ValuePort"/&gt;
        &lt;/ObjectExactCardinality&gt;
    &lt;/SubClassOf&gt;
    &lt;SubClassOf&gt;
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueExchange"/>
        &lt;ObjectExactCardinality cardinality="1"&gt;
            &lt;ObjectProperty IRI="#has_out"/&gt;
            &lt;Class IRI="#ValuePort"/&gt;
```

```
        </ObjectExactCardinality>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        <Class IRI="#IndicatorRole"/>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isIndicatorRoleOf"/>
            <Class IRI="#Indicator"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isAuthorityOf"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isMeasurementOf"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isPrecededBy"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueObject"/>
        <Class IRI="#e3valueConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueObject"/>
        <ObjectSomeValuesFrom>
```

```
            <ObjectProperty IRI="#hasObjectRole"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueObject"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasObjectRole"/>
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IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringObject"/>
        </ObjectSomeValuesFrom>
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    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueObject"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasObjectRole"/>
            <Class IRI="#MonitoredObject"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueObject"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#hasInformationExpression"/>
            <Class IRI="#Indicator"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <Class IRI="#IndicatorRole"/>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isAuthorityOf"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringAgent"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isAuthorityOf"/>
            <Class IRI="#MonitoringThirdParty"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
```

```
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isEstimationOf"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#isIndicatorRoleOf"/>
            <Class IRI="#Indicator"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isAuthorityOf"/>
            <ObjectUnionOf>
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IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringAgent"/>
                <Class IRI="#MonitoringThirdParty"/>
            </ObjectUnionOf>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#precedes"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#ActivityRole"/>
        <Class IRI="#ValueMonitoringConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#ActorRole"/>
        <Class IRI="#ValueMonitoringConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#HighValue"/>
        <Class IRI="#ValuePartition"/>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#Indicator"/>
        <Class IRI="#ValueMonitoringConstruct"/>
    </SubClassOf>
```

```
    <SubClassOf>
        <Class IRI="#Indicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasIndicatorRole"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#Indicator"/>
        <ObjectSomeValuesFrom>
            <ObjectProperty IRI="#hasIndicatorRole"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
        </ObjectSomeValuesFrom>
    </SubClassOf>
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        <Class IRI="#Indicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#hasIndicatorRole"/>
            <ObjectUnionOf>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator"/>
                <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator"/>
            </ObjectUnionOf>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#Indicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#hasInformationRealization"/>
            <Class IRI="#ValuePartition"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#Indicator"/>
        <ObjectAllValuesFrom>
            <ObjectProperty IRI="#isInformationExpressionOf"/>
            <Class
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueObject"/>
        </ObjectAllValuesFrom>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#IndicatorRole"/>
        <Class IRI="#ValueMonitoringConstruct"/>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#LowValue"/>
        <Class IRI="#ValuePartition"/>
    </SubClassOf>
    <SubClassOf>
        <Class IRI="#MarketSegment"/>
        <Class IRI="#e3valueConstruct"/>
    </SubClassOf>
    <SubClassOf>
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IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal"/>
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        &lt;Class IRI="#ValueMonitoringConstruct"/&gt;
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    &lt;SubClassOf&gt;
        &lt;Class IRI="#ValueInterface"/&gt;
        &lt;Class IRI="#e3valueConstruct"/&gt;
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#ValuePropositionIndicator"/>
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    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isInformationExpressionOf"/&gt;
        &lt;ObjectProperty IRI="#hasInformationExpression"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isInformationRealizationOf"/&gt;
        &lt;ObjectProperty IRI="#hasInformationRealization"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isMonitoringGoalOf"/&gt;
        &lt;ObjectProperty IRI="#hasMonitoringGoal"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isObjectParticipantOf"/&gt;
        &lt;ObjectProperty IRI="#hasObjectParticipant"/&gt;
    &lt;/InverseObjectProperties&gt;
```

```
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isObjectRoleOf"/&gt;
        &lt;ObjectProperty IRI="#hasObjectRole"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#hasOwnership"/&gt;
        &lt;ObjectProperty IRI="#isOwnershipOf"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isParticipantOf"/&gt;
        &lt;ObjectProperty IRI="#hasParticipant"/&gt;
    &lt;/InverseObjectProperties&gt;
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        &lt;ObjectProperty IRI="#hasPossession"/&gt;
        &lt;ObjectProperty IRI="#isPossessionOf"/&gt;
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        &lt;ObjectProperty IRI="#hasReciprocity"/&gt;
        &lt;ObjectProperty IRI="#isReciprocityOf"/&gt;
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        &lt;ObjectProperty IRI="#isResponsibilityOf"/&gt;
        &lt;ObjectProperty IRI="#hasResponsibility"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#hasRole"/&gt;
        &lt;ObjectProperty IRI="#isRoleOf"/&gt;
    &lt;/InverseObjectProperties&gt;
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        &lt;ObjectProperty IRI="#has_in"/&gt;
        &lt;ObjectProperty IRI="#in_connects"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#has_out"/&gt;
        &lt;ObjectProperty IRI="#out_connects"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isEstimatedThrough"/&gt;
        &lt;ObjectProperty IRI="#isEstimationOf"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isMeasurementOf"/&gt;
        &lt;ObjectProperty IRI="#isMeasuredThrough"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#isPrecededBy"/&gt;
        &lt;ObjectProperty IRI="#precedes"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#offers_requests"/&gt;
        &lt;ObjectProperty IRI="#is_offered_requested_by"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;InverseObjectProperties&gt;
        &lt;ObjectProperty IRI="#is_performed_by"/&gt;
        &lt;ObjectProperty IRI="#performs"/&gt;
    &lt;/InverseObjectProperties&gt;
    &lt;DisjointObjectProperties&gt;
        <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#consumes"/>
```

```
        <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#produces"/>
        <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#uses"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty
IRI="http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#measures"/>
        <ObjectProperty IRI="#estimates"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#assigned_to"/>
        <ObjectProperty IRI="#consists_of"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#has"/>
        <ObjectProperty IRI="#has_in"/>
        <ObjectProperty IRI="#has_out"/>
        <ObjectProperty IRI="#out_connects"/>
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    <DisjointObjectProperties>
        <ObjectProperty IRI="#hasActivityRole"/>
        <ObjectProperty IRI="#hasActorRole"/>
        <ObjectProperty IRI="#hasObjectRole"/>
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        <ObjectProperty IRI="#hasAuthority"/>
        <ObjectProperty IRI="#hasCompetence"/>
        <ObjectProperty IRI="#hasResponsibility"/>
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    <DisjointObjectProperties>
        <ObjectProperty IRI="#hasInformationExpression"/>
        <ObjectProperty IRI="#hasInformationRealization"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#hasOwnership"/>
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        <ObjectProperty IRI="#hasRole"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#in"/>
        <ObjectProperty IRI="#in_connects"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isActivityRoleOf"/>
        <ObjectProperty IRI="#isActorRoleOf"/>
        <ObjectProperty IRI="#isObjectRoleOf"/>
    </DisjointObjectProperties>
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        <ObjectProperty IRI="#isAuthorityOf"/>
        <ObjectProperty IRI="#isCompetenceOf"/>
        <ObjectProperty IRI="#isResponsibilityOf"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isConsumedBy"/>
```

```
        <ObjectProperty IRI="#isProducedBy"/>
        <ObjectProperty IRI="#isUsedBy"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isEstimatedBy"/>
        <ObjectProperty IRI="#isEstimatedThrough"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isEstimationOf"/>
        <ObjectProperty IRI="#isMeasurementOf"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isInformationExpressionOf"/>
        <ObjectProperty IRI="#isInformationRealizationOf"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isMeasuredBy"/>
        <ObjectProperty IRI="#isMeasuredThrough"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#isOwnershipOf"/>
        <ObjectProperty IRI="#isPossessionOf"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#is_offered_requested_by"/>
        <ObjectProperty IRI="#is_performed_by"/>
    </DisjointObjectProperties>
    <DisjointObjectProperties>
        <ObjectProperty IRI="#offers_requests"/>
        <ObjectProperty IRI="#performs"/>
    </DisjointObjectProperties>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#Actor</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">There are two immediate
interpretations for the inclusion of the closure axiom here: (1) that actors
can only play the corresponding monitoring roles; and (2) that in the
especific context of a monitoring value constellation, these are the only
roles that can be played by an actor. The latter is the interpretation
adopted here. Same reasoning applies for the roles applicable to value
activities and value objects. In OWL speak, the use of existential
quantification acting along the same property may generate problems of open
world assumption. For instance, here, actors could be assume to play not
only monitoring roles,  but also other roles. Names do not mean much in OWL,
but the final specification must somewhat balance human and machine-
interpretation on the axioms. A closure axiom has been inserted here to
express that the corresponding monitoring roles are the only ones that can
be played by an actor.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#CounterObject</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">Ownership relationships are
perceived from the perpective of the principal. The model itself is derived
from the perspective of the monitoring principal and the monitoring
activity. These elements drive the configuration of the monitoring
constellation.
```

```
A counter object can be offered in economic reciprocity for any other type
of object. Actually, counter-objects are not used to define behavior of any
other modeling construct of the monitoring ontology. However, if the
perspective of the monitoring principal is taken, then it is possible to
identify some relationships of ownerships and possession which can be
applied in order to provide a more precise organization to the monitoring
model.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringAgent</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">Monitoring Agent is
competent for the monitored activity. The logic here is that the Principal
monitors the Third-party indirectly, through the monitoring agents. In case
of a single third-party, the strategy does not seem to be economical.
However, in case the third-party is a market segment, it is worth to reduce
the monitoring effort of the principal. Monitoring the whole constellation
through at least two monitoring agents seems much more economical than
monitoring the market segments directly.

Counter-objects are not used here to define monitoring agents, as they can
have ownership and/or possession relationships with these objects.
Therefore, these objects would not define the behavior of the
agents.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringConstruct</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">This class represents a set
of relevant entitities/particulars for modeling a monitoring value
constellation. </Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringNeed</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral"></Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#MonitoringPrincipal</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">The definition of the
Monitoring Principal in terms of the object is made weaker than the
definition in terms of the value activity that this actor performs.

Monitoring principals have ownership of only monitoring objects. Monitoring
agents have ownership of monitored objects. This guideline is compliant with
the proposition of Agency Theory for monitoring information, which states
that monitoring information is a purchasable commodity.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
```

```
<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValueInUseIndicator</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">This concept corresponds to
the notion of value delivery.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>

<IRI>http://www.semanticweb.org/ontologies/2012/11/Ontology1355320708906.owl
#ValuePropositionIndicator</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">This concept corresponds to
the notion of a value promise.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#ActivityRole</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral"></Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#ActorRole</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral"></Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#CommunicationProperty</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral"></Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#Indicator</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">Map this concept to the
abstract quality dimensions of DOLCE-lite.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#IndicatorRole</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral"></Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#InformationProperty</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">We avoid the restriction of
object properties in terms of domains and ranges. These fillers act not as
restrictions, but as constructors of abstract classes. The use of domains
and ranges often creates very specific descriptions of abstract classes, and
it is common to cause classification inconsistencies. Restrictions on
domains and ranges can easily cause inconsistencies with closure
axioms.</Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <IRI>#e3valueConstruct</IRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">A detailed explanation of
all the modeling constructs of the e3value framework can be found in the
original thesis proposed by Jaap Gordijn:

Gordijn, J.: Value-based Requirements Engineering: Exploring Innovative e-
commerce Ideas, PhD Thesis, University Amsterdam (2002). </Literal>
    </AnnotationAssertion>
```

```
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <AbbreviatedIRI>owl:Thing</AbbreviatedIRI>
        <Literal datatypeIRI="&rdf;PlainLiteral"></Literal>
    </AnnotationAssertion>
    <AnnotationAssertion>
        <AnnotationProperty abbreviatedIRI="rdfs:comment"/>
        <AbbreviatedIRI>owl:topObjectProperty</AbbreviatedIRI>
        <Literal datatypeIRI="&rdf;PlainLiteral">VMO is focused on object
properties. Data types are not relevant in this level of analysis and its
specific modeling is left open as a free implementation option. For the sake
of simplicity, complete classification of inverse properties is supressed
e.g. realizes/isRealizedBy)</Literal>
    </AnnotationAssertion>
</Ontology>
```

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