Agency Monitoring Patterns for Value Networks

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Abstract. Value network models represent an arrangement of actors, activities and objects of business value configured to satisfy a market segment's need. As some actors might act unreliably due to unpredicted weaknesses, opportunism that threat value co-creation, monitoring becomes an issue necessary for designing a realistic value model. The research question addressed in this paper is how value network models could be designed with a preventive monitoring organization. We therefore propose a monitoring task ontology and five agency communication patterns for this end. The ontology blends principles of Multiple Agency, Speech Acts, Enterprise Ontology and Value Modeling. We demonstrate the utility of the ontology with a case-based scenario from the Smart Metering markets, and a conformity-test supported by the e^{3}value tool. The case scenario comes from the Directive 2009/72/EC of the European Parliament.

Keywords: Agency theory · Ontology · Smart metering · Value networks

1 Introduction

Value networks aggregate economically responsible actors exchanging objects of business value to satisfy a market segment's need [1]. Value models describe the economic communication underlying this type of information system, which is driven by a shared interest in positive profit [2]. However, realistic value models should account for unreliable behavior of its constituencies. This scenario can be analyzed from an Agency viewpoint, whereby consumers might act as principals, who need to control back-end suppliers acting as third-parties, and to cooperate with intermediaries acting as agents or regulators [3–5]. Yet from this perspective, monitoring becomes an intrinsic issue of the initial configuration of a value network, and the search for core business objects and proof of performance becomes one.

Adopting a Design Science perspective [6], the question addressed here is *how value models could be designed with a preventive monitoring organization.* From an organizational perspective [7], this question splits into: *Whose perspective, or which*

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constituency's point of view, is the dominant? What domain of activity is focused on? What level of analysis is used? What time frame is employed? What type of information are to be used? What referent is employed? To cope with these issues, we propose a monitoring task ontology and five Agency communication patterns for value network modeling. Ontologies are evaluated with specific frameworks that define requirements for verification, validation and assessment [8]. In this paper, the ontology is partially validated via demonstration of a case scenario in Smart Metering for Renewables [9].

The following sections are organized as follows: in Sect. 2, a brief theoretical background is presented, covering some of the fundamental concepts of Value Network Modeling, Enterprise Ontology and Speech Acts; in Sect. 3, the monitoring task ontology and the Agency monitoring patterns for value network modeling are described in detail; in Sect. 4, we elaborate on the theoretical validation of the ontology via case-based scenarios of a Smart Energy Metering value network; and we discuss the research results achieved thus far in Sect. 5.

2 Theoretical Background

Value Modeling is a young discipline of Information Systems and Software Engineering. The e^3value tool [2] is a framework for analysis of networked businesses, supported by a tool for profitability analysis. The tool is based on an ontology describing economic concepts such as actors, market segments, business activities and objects of economic value. However, the concept of a *value transfer* is ambiguous, as value is perceptual, and therefore cannot be transferred, but only communicated. This conceptual issue is somehow treated in e^3value with the assumption that senders and receivers of value propositions share the same perception on valuation. As a decision support system, e^3value models are *predictive*, expressing only promises, but not assurances of value creation.

On a process viewpoint, the *Enterprise Ontology* proposed by Dietz [10] deepens the structure of an individual organization by describing its constituent processes with communication patterns adapted from Searle's Speech Acts Theory [11]. The ontology assumes that internal Enterprise actors engage on production acts (i.e. *p-acts*, e.g. production, use and consumption of resources) and coordination acts (i.e. *c-acts*, e.g. request, offering and acceptance). Production acts are communicated through coordination acts among pairs of actors, which comprises the *operational axiom* of the theory. The *transactional axiom* defines transactions as combinations of operations organized as communication pattern involving two actors. The *composition axiom* specifies how transactions are organized as business processes. Finally, the *distinction axiom* describes the role of human actors on interpreting business intra-organizational processes with ontological, datalogical and infological acts.

Searle's work on *Speech Acts* has inspired many applications of Artificial Intelligence, specially the design of multi-agent communication protocols, whereby rational agents express the meaning of their actions and plans. Speech Acts can be used to profile behavior through communication. For instance, Searle and Vanderveken's classification of illocutionary acts can be combined with the Role-Based Access Control (RBAC) model [12] to classify Agents' behavior. We take this direction on classifying Agency monitoring behavior in value networks, as described in the following section.

3 Agency Monitoring Patterns for Value Networks

3.1 Monitoring Task Ontology

A *business need* is the starting point to configure a value network. The dominant *Agency viewpoint* is the monitor's: a role played by the final consumer, according to the Service-Dominant Logic [13]. A business need has a *monitoring rationale*, which is the cause of monitoring, dependent on the nature of the business, e.g. business opportunity, weakness or threat [14]. The *monitored domain* is the back-end value activity assigned to the suppliers. A *monitoring plan* is represented by a policy, further elaborated as patterns. The *status* of a business need is assessed with a measure of value (an enumerated class of disjoint value partitions including *value surplus*, *value balance* and *value shortage*) (Fig. 1).

A *policy* is defined as a composition of roles performed by *actors*, *activities* and *objects*, resembling the Role-Based Access Control (RBAC) metamodel [12]. Actors relate to activities via coordination acts, and activities relate to objects via production acts. A *core object* is what satisfy a consumer's need (e.g. energy, water, or a hotel service); a *proof-of-performance object* (PoP) is an image of a core object produced by witnessing or experience (e.g. metering reports or consumers' rating); a *certification and accreditation object* (CnA) is the key to unlock access to private proof-of-performance objects (e.g. responsible party accreditations); and a *counter-object* is the price paid in exchange of any kind of object [15]. Activities are defined by production acts changing the nature of business objects (e.g. produce, consume, bundle, distribute, grant or transfer). The definition of a policy is polymorphic, deriving the five Agency monitoring patterns described later. The patterns represent plans whereby the monitor could obtain core objects and corresponding proof. Nonetheless, a selection mechanism is necessary to differentiate similar value propositions, which leads to a discussion on subjective valuation of objects.

The *value* of a business object splits into classes of *objective* and *subjective values*. The former is described as a quadruple of *time*, *location*, *quantity* and *quality*, accounting for how production acts transform the intrinsic nature of value objects. The latter is perceptual, defined by communication acts uttered by actor-roles. Examples of subjective values relevant to businesses include *reliability*, *responsiveness* and *trust* [16–18]. Subjective values are enumerated with five value partitions extracted from the SERVQUAL model: *ideal*, *forecasted*, *equitable*, *deserved* and *minimum tolerable performance* [16]. A subjective value has two roles, the definition of which depends on who communicates the valuation [19]. A monitor declares his *expected value*, whereas a monitoring agent testifies (i.e. by experience or witnessing) or reports (i.e. via second-hand proofs) his *perceived value*. The logic behind the roles of subjective values is that the monitor relies preventively on monitoring agents' evaluation of the perceived value of a product or a service. For instance, trip planners such as Trivago and TripAdvisor, rank hotel services based on consumers' rating [20]. Finally, a value proposition is a composite association of

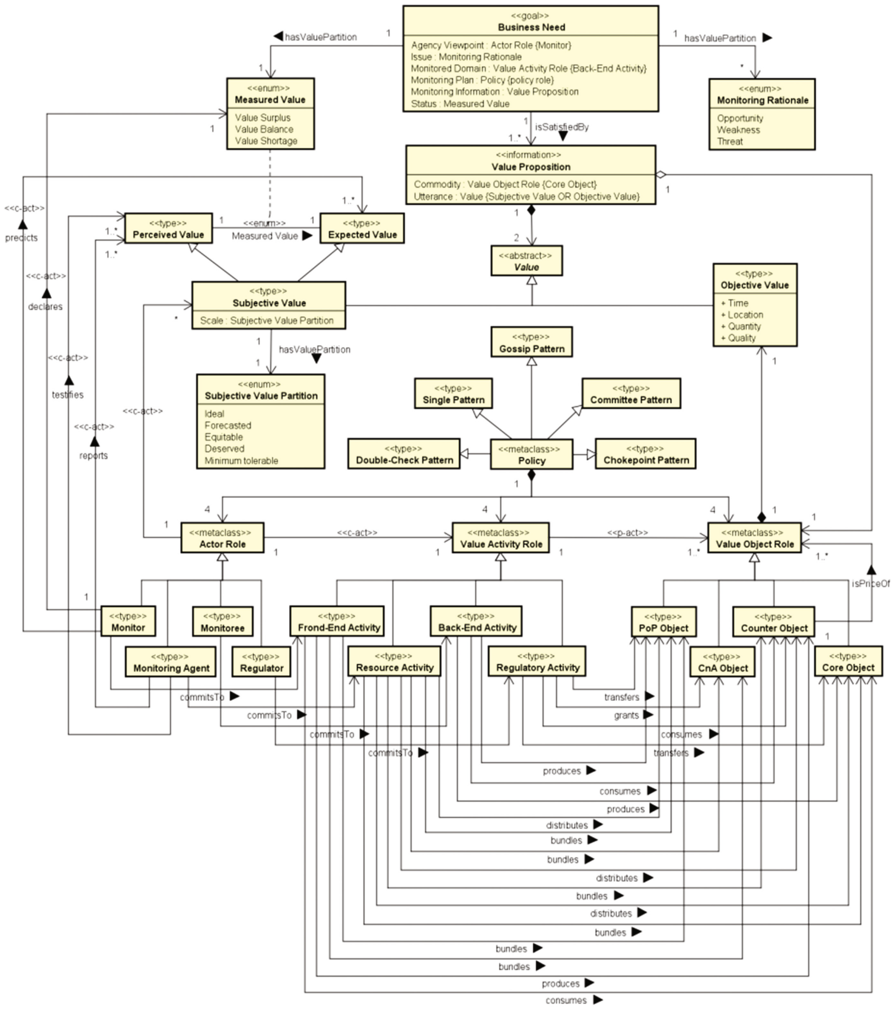

Fig. 1. Monitoring task ontology for value network modeling.

a core object, and respective objective and subjective values. The OR-restriction is based on Description Logics, as object values and subjective values are distinct, admitting no common instances. The value proposition of a core object might satisfy a business need. To close the cycle, the monitor declares the *status* of a business need as a *measured value*, which is represented as an association class for subjective assessment of the difference between expected and perceived values.

3.2 Agency Monitoring Patterns

Single Monitoring Pattern

Context: whenever the monitor delegates no monitoring responsibility (vide Fig. 2).

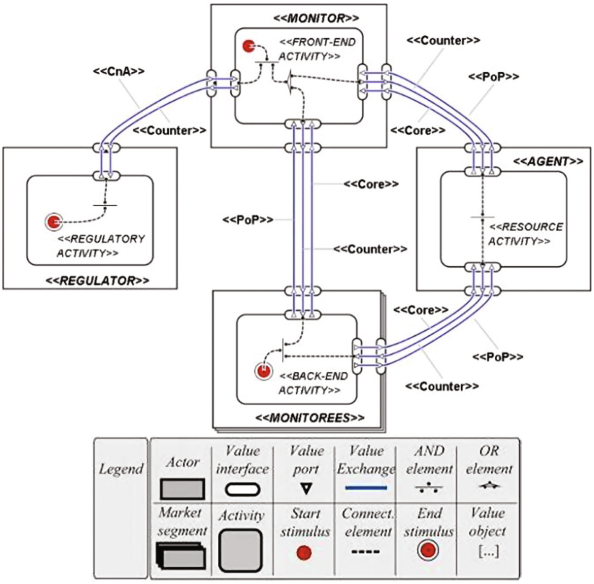

Fig. 2. Single monitoring pattern.

Solution: The monitor consumes core business objects produced by back-end suppliers, bundled by an agent, or from both. To validate core objects, the monitor bundles a CnA object granted by the regulator to access proofs produced by agents or *monitorees*. The strategy is selfish, as the monitor must monitor both agents and third-parties.

Economic effectiveness: the monitoring price ranges from two to three counter-objects produced by the monitor, consumed by the regulator and bundled by agents or *monitorees*.

Double-Check Monitoring Pattern

Context: when the monitor *partially* delegates his monitoring responsibility (vide Fig. 3).

Solution: this pattern is based on proof triangulation. The monitor consumes core objects produced by *monitorees* (or bundled by agents), bundles a monitoring certification granted by the regulator, and bundles proofs produced by *monitorees* (or bundled by agents). The agents are also granted with a monitoring certification.

Economic effectiveness: is the same as for the single pattern, but the monitor has an option to bundle proofs produced by *monitorees* and bundled by agents.

Chokepoint Monitoring Pattern

Context: whenever the monitor *fully* delegates his monitoring responsibility for not engaging in direct economic exchange with back-end suppliers.

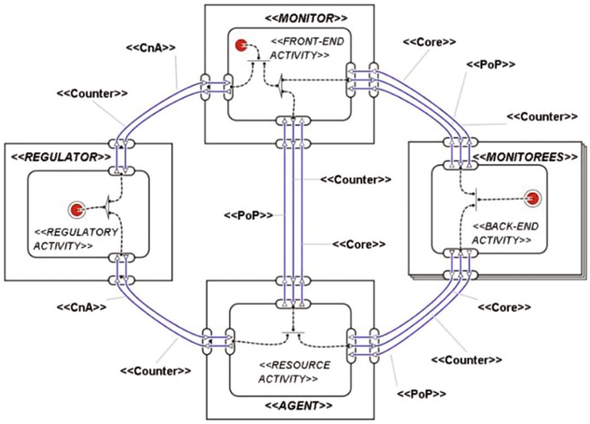

Fig. 3. Double-check monitoring pattern.

Solution: the monitor uses an agent as a front door to access bundles of core and proof objects produced by end suppliers, and bundled or transferred by agents. The pattern creates a chain of delegated monitoring agents granted with monitoring accreditations. The bottom agent is granted with a CnA object to monitor end suppliers while being monitored by a certified chokepoint agent (vide Fig. 4).

Economic effectiveness: the monitoring price is simplified into one counter-object produced by the monitor and bundled or distributed by the entry agent, with the advantages of the double-check pattern for bundling core and proof objects.

Committee Monitoring Pattern

Context: whenever the monitor partially delegates his monitoring responsibility to at least two agents, assembling a committee to monitor back-end suppliers.

Solution: the monitor consumes core objects produced by back-end suppliers, or bundled by the agents. The monitor also bundles proofs produced directly by back-end suppliers, or bundled by agents. All the members of the monitoring committee formed by the monitor and the two agents are certified by a regulator. The monitor operates as a dashboard, whereby all kinds of objects flow throughout the value network (vide Fig. 5).

Economic effectiveness: the monitoring price ranges from two to four counter-objects produced by the monitor, consumed by the regulator or the *monitorees*, and bundled, transferred or distributed by the agents.

Gossip Monitoring Pattern

Context: whenever the monitor fully delegates his monitoring responsibility to an agent, obtaining core and valid proof objects from distinct paths within the network.

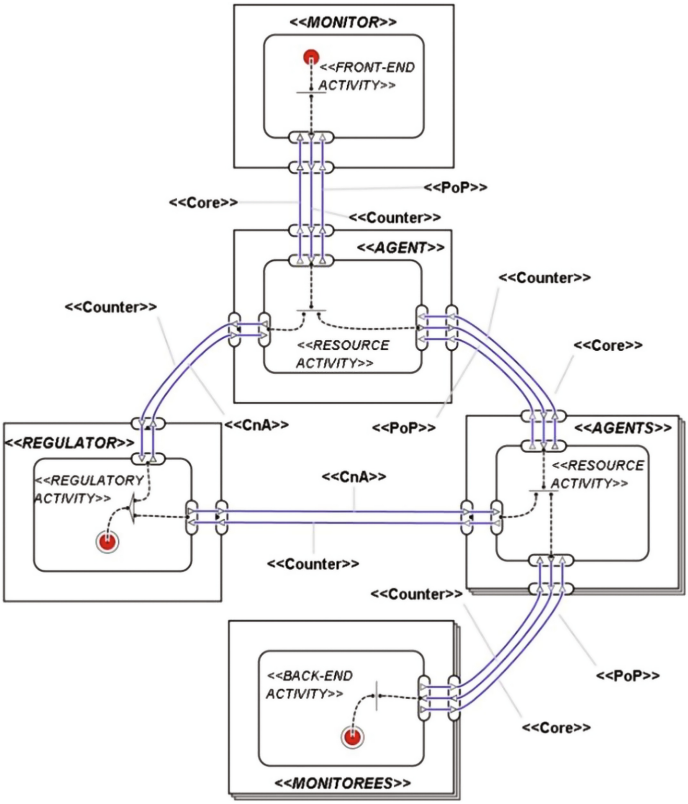

Fig. 4. Chokepoint monitoring pattern

Solution: this pattern evolves on the chokepoint pattern by considering a direct exchange between the monitor and back-end suppliers, and a triangle of regulated monitoring agents. The monitor consumes a core object produced by the back-end suppliers, and a corresponding proof bundled by a chokepoint agent. A market segment of agents has direct access to core and corresponding proof objects produced by the *monitorees*. The proof object flows within a circuit of certified agents throughout, which explains the name of the pattern (vide Fig. 6).

Economic effectiveness: the monitoring price comprehends exactly two counter-objects produced by the monitor, respectively consumed by the final end-suppliers and bundled or distributed by an agent.

4 Theoretical Validation: A Case Scenario in Smart Metering

The Directive 2009/72/EC [9] normalizes common rules for liberalized European energy markets. This liberalization transforms the top-down energy supply chain into a peer-to-peer value network of actors operating with accredited and certified roles of

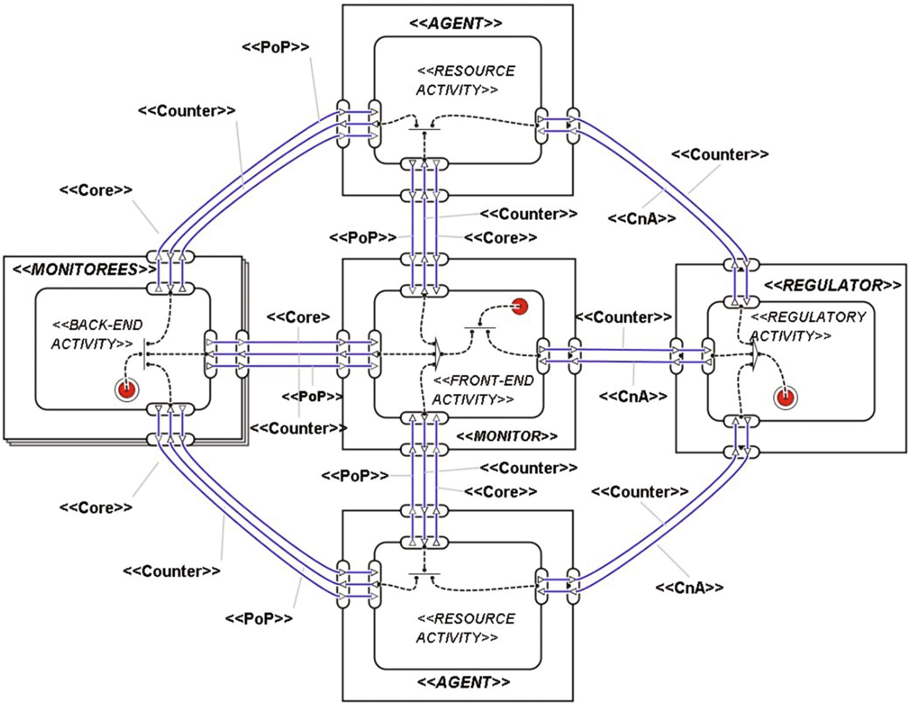

Fig. 5. Committee monitoring pattern.

producing, bundling, distributing, transferring and metering energy. Due to environmental drivers, however, these value networks shall most rely on renewables (e.g. wind, solar and biomass energy). The intermittency of renewables makes energy production activities unreliable by weakness, described in the monitoring task ontology as a monitoring rationale of a consumer willing to consume this type of commodity. However, renewables represent also a business opportunity for smart metering operators. Among many services, smart meters provide decision support for energy trade based on market price signals. Still, European reports on smart metering initiatives have uncovered barriers to the adoption of the technology by the population. Householders are specially concerned about security of private consumption information when choosing a metering operator. Privacy is a subjective value, and can only be assessed by experience. The case question is *how a householder could choose among metering operators whose services ever experienced*. Assuming the householders' viewpoint as service-dominant, the case question is translated into *how a smart metering value model could be designed with a preventive monitoring organization*. We use this problem to demonstrate the modeling utility of our monitoring task ontology based on a narrative analysis of three concepts: goal, policy and value proposition.

Goal Analysis. The self-monitored value model for the case is illustrated in Fig. 7. A householder operates as a Balance Responsible Party (BRP) in the Energy market, by consuming less or selling unused energy via demand-response control supported by

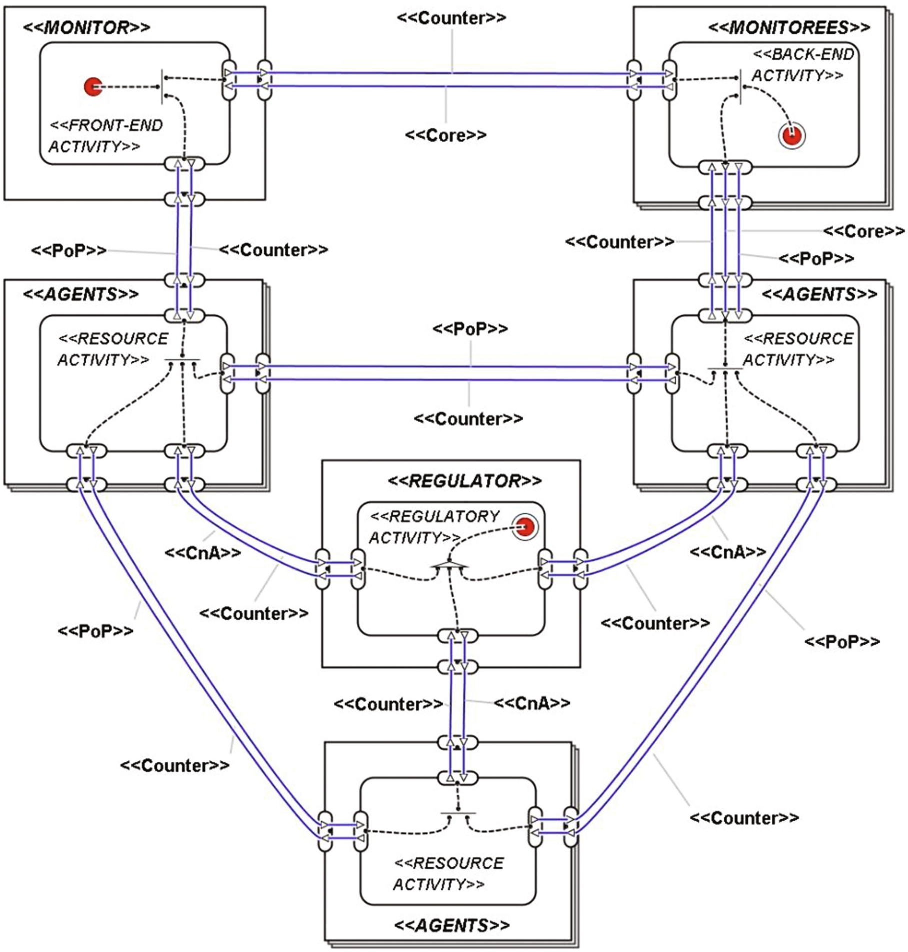

Fig. 6. Gossip monitoring pattern.

smart meters. The BRP has the dominant viewpoint as a monitor, and is motivated by the opportunity to create value surplus out of smart metering assets produced as core objects by a market segment of Metering Operators. The BRP needs metering assets with best value propositions not only for objective value, i.e. time, location, quantity and quality of measurement, but also for subjective value of service, such as privacy. To demonstrate how the BRP could achieve this goal, his monitoring plan is organized as a committee monitoring pattern described as follows.

Policy Analysis. The BRP's business need can be filled through alternative pathways. To have direct access to *metering assets*, the BRP needs a Metering Responsible Party (MRP) *accreditation* granted by the Transmission System Operator (TSO), who is committed to manage metering reports. The proof-of-performance of a metering asset is a *metering account report*, which describes objective measurement values. To have indirect access to metering assets, the BRP has the option to consume *metering reports* distributed by an MRP-Aggregator (Energy aggregators with an MRP accreditation) or by MRP-DERs (Distributed Energy Resources with an MRP accreditation, e.g. wind turbine owners). The counter-object exchanged as the price of an MRP accreditation is an open monitoring channel, as the TSO needs a dashboard of Energy metering commodities. The proof-of-performance of a metering report is a *metering audit report*, which is distributed by the activity of managing metering assets assigned to MRP-Aggregators or MRP-DERs. *Metering audit reports bundle and validate metering account reports*. In the most complete scenario of the value network model depicted in Fig. 7, the BRP form a triple *committee* with the MRP-Aggregator and MRP-DERs to preventively monitor the activity of metering energy assigned to Metering Operators. Counter-objects seal the price paid in exchange of all the accreditation, core and proof objects of the network, in compliance to the principle of economic reciprocity.

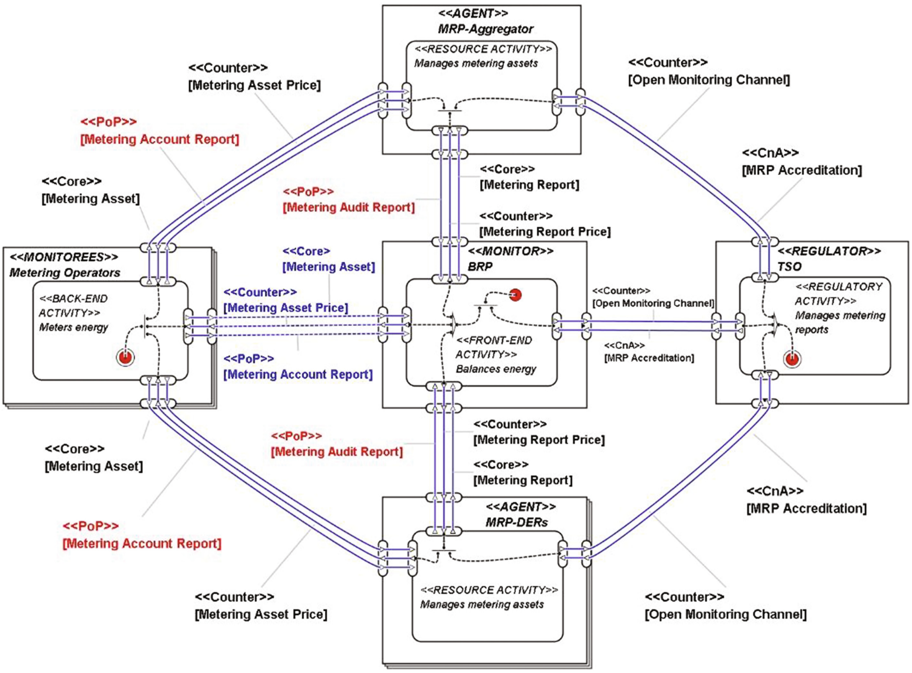

Fig. 7. Smart metering value network model organized by the *committee monitoring pattern.*

Value Proposition Analysis. a policy pattern answers the monitor's questions of *what*, *who* and *how* to monitor within a value network, but not *why*, which points to the monitor's *goal status* of *value surplus*. All the Agency monitoring patterns described in Sect. 3 are *effective* in describing plans to satisfy a monitor's need with core business objects. However, Business and Economics research have demonstrated that value surplus depends not only on objective values, but also on subjective ones [17–20]. In a value network, objective values are necessary, but insufficient for the monitor to *declare* value surplus. In our case scenario, it is not the cheapest metering asset that might satisfy a householder's need, but instead, the prospective value surplus generated by this technology. The question now shifts to how a householder operating as a BRP could choose a Metering Operator, based on subjective values to be returned by the metering asset, which leads to an *economic efficiency* issue internal to the monitoring pattern organization.

The *committee pattern* favors delegated monitoring. The core object subject to value proposition analysis is the *metering asset* owned by Metering Operators, and its corresponding proof is the *metering account report* produced by Metering Operators, bundled by MRP-Aggregators or MRP-DERs, and distributed back to BRPs as *metering audit reports*. Both DERs and Aggregators use the metering asset technology, thereby acquiring *experience* to assess the level of *privacy* offered by the smart metering assets. The agents have the option to transfer this subjective value assessment to BRPs upon accreditation. The rest of the value proposition analysis is summarized in Table 1.

Table 1. Value proposition analysis based on the committee monitoring pattern.

	MRP-aggregator (agent)	MRP-DERs (agent)	BRP (monitor)
Core Object	Metering asset	Metering asset	Metering asset
Proof Object	Metering audit report	Metering audit report	Metering account report
Objective value	(15 min, national, GWh, 0.75)	(15 min, national, MWh, 0.85)	(15 min, local, kWh, 0,90)
Subjective value	Forecasted privacy	Equitable privacy	Equitable privacy
Measured value	*Value surplus*	*Value balance*	**Value surplus**

As an image of the core object, the proof object can be used to prospect the value of monitoring. In our example, the *objective value* of a metering report can be assessed by its monitorability, i.e. *time*, *location*, *quantity* and *quality* of energy measurement. For instance, the *metering audit reports* distributed by Aggregators are published every 15 min, nationwide, in the order of GWh, with a predictability factor for renewables around 75%. Equivalent measurement attributes apply to assets managed by the other members of the committee. However, choosing a meter based on subjective values is different: the BRP has the option to delegate this task to the agents. According to the monitoring ontology, the BRP could prospect the *expected value* of privacy offered by the meter asset as *equitable*, whereas DERs could report or testify the same value *perceived* as *equitable*, and the Aggregators, as *forecasted*. The difference between monitors' expected value and agents' perceived value is defined in the ontology as *measured value*: an enumerated class of partitions for value surplus, shortage or balance.

Hence, comparing the *equitable privacy* expected by BRPs with the *forecasted* and *equitable* perceptions of value reported by the agents leads to a value surplus and a value balance, respectively. If the BRP considers the Agents' evaluation as valid, then a *value surplus* is set as the *status* of the *business need*, closing the ontology interpretation.

5 Conclusions and Future Research

The main contributions of this work are threefold: (1) the Agency monitoring patterns simplify the design of realistic value network models; (2) the semi-formal logic of delegated Agency monitoring emphasizes the business relevance of subjective values and supports the economic efficiency analysis of the monitoring patterns, which is an aspect missed by fellow researchers [2]; and (3) the case demonstration opens a discussion about the modeling utility of the ontology on describing socially relevant case scenarios, such as the search for privacy-preserving smart metering assets. The actors and activities described in the value network model designed for the case are regulated, and the communication channels for the monitoring objects can be supported by e-Commerce and e-Government solutions for social feedback on private and public infrastructure services. At least three immediate research directions will extend this work. First, the formalization of the ontology in Web Ontology Language (OWL) will support automatic model checking of the Agency monitoring patterns within a value network model, besides enabling querying and reasoning of specific model properties. Second, the library of patterns might be extended with unexplored classes of patterns, e.g. anti-patterns, green value patterns or adaptation patterns. Third, the ontology shall be evaluated regarding its users' acceptance, ease of use and perceived modeling utility.

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