Check for updates

Towards Green Value Network Modeling: A Case from the Agribusiness Sector in Brazil

Juscimara Gomes Avelino[1], Patrício de Alencar Silva[1](✉), and Faiza Allah Bukhsh[2]

[1] Programa de Pós-Graduação em Ciência da Computação, Universidade Federal Rural do Semi-Árido (UFERSA), Mossoró, Rio Grande do Norte, Brazil
{juscimara.avelino, patricio.alencar}@ufersa.edu.br
[2] Department of Computer Science, University of Twente, 7500AE Enschede, The Netherlands
f.a.bukhsh@utwente.nl

Abstract. The main purpose of a value network model is to prospect the sustainability of business strategies. However, much attention has been paid on the economic issues of value modeling, leaving critical environmental and social issues uncovered. On the environmental scope, this study proposes an ontology for modeling value networks to match Green Computing requirements. The ontology supports semi-automatic configuration of value network models to help business analysts deciding upon alternative value paths to satisfy market segments demanding products or services bundled with green accreditations or certifications. The ontology was built according to guidelines of Design Science in combination with specific methodologies for Ontology Engineering. For the ontology evaluation process, the acceptance, utility and usability of the ontology were evaluated by means of Technical Action Research (TAR) applied in a real-world case from the Brazilian agribusiness sector. Business expert opinion pointed to the viability of the models produced, from both the economic and environmental perspectives.

Keywords: Design Science · Green Computing · Ontology · Sustainability

1 Introduction

According to Normann and Ramirez (1993), a value network is referred to as *a system of business agents exchanging objects of economic value that are transformed into a final product or service demanded by a market segment of consumers* [1]. A value network "model" is a conceptual structure used to prospect the long-term sustainability of a cooperative business strategy model [2]. This type of modeling is currently supported, for instance, by the *e*^{3}*value* framework proposed by Gordijn and Akkermans [3, 4], which is aimed not only for analyzing the viability of businesses, but also for eliciting organizational requirements preluding the specification of business process models. In regards to business sustainability, many contributions of the Value Network Modeling community have been focused on purely economic issues, not to mention, monetary. However, business sustainability demands a harmonization of economic, environmental

© Springer Nature Switzerland AG 2019
H. Panetto et al. (Eds.): OTM 2019, LNCS 11877, pp. 458–475, 2019.
https://doi.org/10.1007/978-3-030-33246-4_29

and social restrictions pushed by societal needs. These two last dimensions have not yet been sufficiently addressed by the Value Network Modeling community.

Hevner and Chatterjee (2010) refer to *Green Computing* as a *set of guidelines or practices for the efficient use of computational resources to achieve business or organizational goals* [5]. The authors identify some critical requirements for Green Computing which ought to be considered during the design of Information Systems. These requirements include, for instance, disposal of electronic waste, end user satisfaction, energy use, management restructuring, regulatory compliance, return on investment (ROI), telecommuting, thin client solutions and virtualization of server resources. However, considering that modern Enterprise architectures are composed by a cross-functional blend of people, data, software, hardware and communication infrastructure, these requirements could be treated progressively, along managerial layers, i.e., from the business strategy level (business value models), along the tactical layer (business process models), to the operational layers (people, infrastructure, intelligent software and sensors). For instance, *end user satisfaction* and *regulatory compliance* are requirements that can be treated by design in value network modeling.

In response to the research agenda of Green Computing proposed by Hevner and Chatterjee (2010) [5], and in line with Wieringa's defense of Design Science as a research methodology to cope with problems of societal relevance [6], in this study are specially concerned with treating the problem of *how value network models could be designed to fill (prospected) consumers' needs for products or services that are bundled with environmental certifications*. From an organizational point-of-view, as proposed by Cameron (1980) [7] and according to the research problem decomposition suggested by Wieringa (2014) [6], this research problem can be decomposed into other questions such as: (1) *what green value network models are*; (2) *what concepts will ground such models*; and (3) *how these concepts will be related to satisfying consumers' needs in compliance with green certifications*.

To treat these questions, we propose an ontology to represent the so-called *green value network models*. These models are based on a Service-Dominant Logic, as proposed by Lusch, Vargo and Tanniru (2010) [8], which settles the consumers' view as dominant over the business actors that compose a value network. In other words, this logic dictates that business actors and corresponding capabilities ought to be arranged in a way that will optimally satisfy the needs of a market segment. Subordinated to the Design Science guidelines adopted, we have followed the formal Ontological Engineering methodology proposed by Uschold and King (1995) [9]. This approach was chosen due to its simplicity of use and its emphasis on the cognitive effort paid during the ontology capture phase – a common issue to be considered on designing new ontological propositions. For the ontology validation, we have combined guidelines proposed by Gómez-Pérez, Fernandez-Lopes and Corcho (2004) [10] and Vrandečić and Sure (2007) [11] into a single validation process comprising: (1) ontology *verification* of consistency, correctness and completeness; (2) ontology *conformance checking* regarding theoretical and practical requirements; and (3) ontology *evaluation* of acceptance, usability and utility. For this last phase, we have evaluated the ontology models based on a real-world case of a Brazilian agribusiness company by combining Technical Action Research with business expert opinion to assess the viability of the value network models inferred.

The rest of this paper is organized as follows. In Sect. 2, we provide a theoretical background in Value Network Modeling, Service-Dominant Logic and Green Computing requirements. In Sect. 3, we describe the ontology for *green value network modeling*. In Sect. 4, we report on the validity of the ontology by presenting the green value models generated for a real-world case from the agribusiness sector in Brazil. The most closely related studies are described in Sect. 5, along with critical assessment of how this proposal advances the current capabilities of value modeling. Conclusions and future research directions are discussed in Sect. 6.

2 Theoretical Background

The concept of a value network is not new. Norman and Ramirez (1993) [1] have introduced the term as an evolution of value chains. In a value network, economically independent actors exchange objects of economic value, which will be ultimately transformed into a product or service that will satisfy the needs of a certain market segment of consumers. Peppard and Rylander (2006) [2] to value networks as business ecosystems, as these structures may collapse or merge multiple value chains to satisfy markets' needs in a reliable way. However, in the Information Systems community, Gordijn and Akkermans (2003) [3] proposed a framework named *e*^{3}*value* for designing value network models. The framework is composed by an ontology of interorganizational exchange behavior, a graphical notation and a profitability calculation mechanism to prospect monetary return on the investment made by the actors cooperating in a value network. Since its initial proposal, the *e*^{3}*value* framework has been applied in several real-world case studies in European markets. Best practices for Value Network Modeling have been documented further by Gordijn and Akkermans (2018) [4]. According to Ionita et al. (2016), a value network model can be used to prelude the specification of a process model, by supporting risk analysis and prospection of profitability share [12].

Consumers' needs comprise the starting configuration point of a value network model. Certain consumers' needs may be complex and possibly filled by products or services of aggregated value, which will be provided not by an only business actor, but by a network of companies or organizations working in cooperation. The more demanding a consumers' need is, the more actors may be necessary to fill it. This is a typical case of market exploitation, which Lusch, Vargo and Tanniru (2010) refer to as Service-Dominant Logic, i.e. the perspective of a consumers' need driving the economic arrangement of business-to-business exchanges and transactions among economically independent actors willing to make profit out of it [8].

However, sustainability-aware markets have pushed the provision of products or services accompanied with evidence of proof of clean production. In Value Network Modeling, critical quests of any business case include "what" the consumer wants, "who" will provide it (i.e. actors and activities) and "how" it will be provided (i.e. how the actors will communicate by economic exchange). In the organic food market, for instance, products and corresponding evidences of clean production may be provided by different value paths. How these value paths could be analyzed, organized and merged into a single value network model is an organizational problem still open in the Value Network Modeling community.

The research agenda for Green Computing proposed by Hevner and Chatterjee (2010) include requirements that vary from efficient energy use in data centers to long-term business strategies of environmental preservation [5]. We believe those requirements ought to be treated progressively, by managerial layers, for the sake of simplicity. In this study, we analyze the requirements of satisfaction of consumers' needs for products and services that demand green regulatory compliance. Despite substantial contributions of the Value Network Modeling community in strategic business modeling, an organizational logic for structuring what would be called "green" value network models is still missing. In the next section, we describe an ontology that will possibly fill this research gap.

3 An Ontology for Green Value Network Modeling

The Green Value Network Ontology (GVNO) organizes the conceptual elements that will compose a *green value network* model. The ontology reconciles the original *e³value* concepts proposed by Gordijn and Akkermans (2003) [3] with extensions proposed by Silva (2013) [13], which blends concepts of Enterprise Engineering proposed by Loucopoulos and Kavakli (1999) [14]; Dietz (2006), e.g. formation of business transactions based on coordination and production acts [15]; Multiple Agency Theory, e.g. Agency roles [16]; Speech Acts Theory, i.e. linguistic grounding of speech acts [17]; Contract Theory, e.g. accountability of value transactions [18]; and Principles of Economics, e.g. the notion of economic reciprocity [19].

The starting point of configuration is an assertion about the *business need* of the final consumer (i.e., a bundle of a core business object with a corresponding proof of green production) to be provided by actors playing multiply agency roles. These objects can be provided through different communication arrangements of roles for *actors*, *activities* and *value objects*. These combinations represent *policies* defining *who exchanges which object to whom* in a *green value network* model.

The ontology was built by following the method proposed by Uschold and King (1995) [9], which includes four steps: (1) *identify* the scope and modeling goal of the ontology; (2) *build* the ontology; (3) *evaluate* the ontology; and (4) *document* the concepts of the ontology. The ontology was formalized in OWL with the Protégé tool[1] to support semi-automatic configuration of *green value network* models. The original code of the ontology is available online for formal verification[2]. The consistency and correctness of the ontology model were checked with the support of the reasoners Fact ++[3], Hermit[4] and Pellet[5]. To facilitate the reader's comprehension, we present the ontology model here using a combination of Description Logics, natural language the OntoGraph[6] tool for ontology visualization (vide Fig. 1).

[1] https://protege.stanford.edu/.

[2] https://www.dropbox.com/s/2cm9rln73ee0r8t/GVN.owl?dl=0.

[3] http://owl.cs.manchester.ac.uk/tools/fact/.

[4] http://www.hermit-reasoner.com/.

[5] https://www.w3.org/2001/sw/wiki/Pellet.

[6] https://github.com/NinePts/OntoGraph

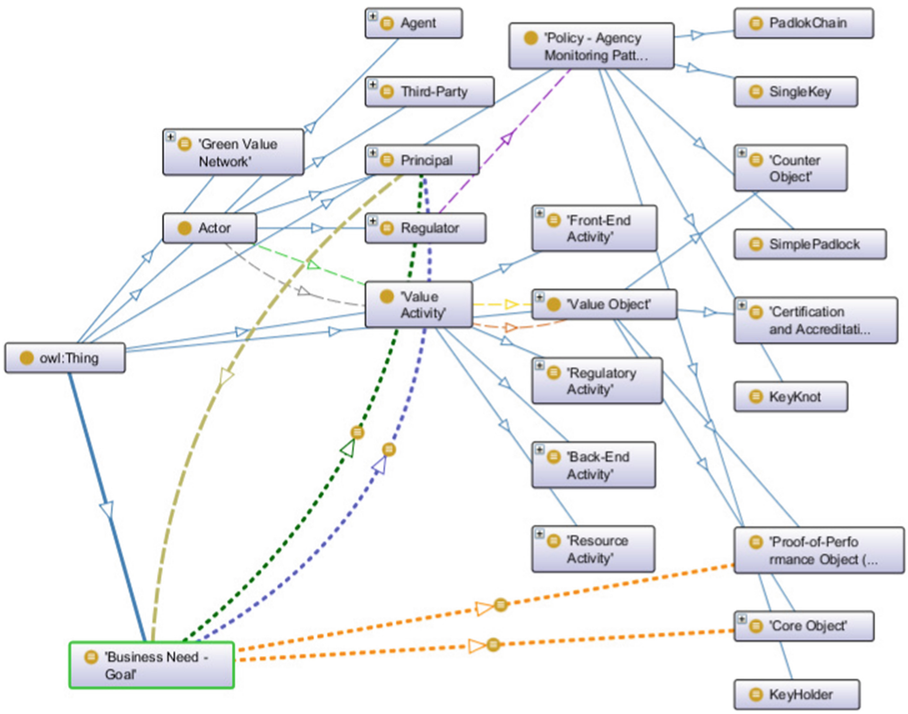

Fig. 1. General visualization of the Green Value Network Ontology in Ontograph

3.1 Defining Roles for Actors, Value Activities and Value Objects

The grounding concepts of a value network model are *actors*, *value activities* and *value objects*. An *actor* represents an economically responsible entity or organization [3]. An actor can be stereotyped by one among four disjoint Agency roles [16] that can be played inside a value network: (1) *principal*, i.e. the final consumer that declares a business need of a product or service, which in a *green value network* model, will be a bundle of a core business product and a proof of green production; (2) *agent*, i.e. an actor delegated by the principal to perform a business transformation activity; (3*) third-party*, i.e. has an indirect business relation with the principal, the role of which can be played by a primary producer operating at the back-end of the value network; and (4) *regulator*, i.e. an entity or organization with authority to grant accreditations or certifications that allow agents to operate in transformational activities.

A *value activity* is the core competency of a business actor. A green value activity aggregates or transfers a value object of environmental certification. A value activity is defined by how it is related to value objects by means of *production acts* [15], e.g. *consumes*, *produces*, *distributes*, *grants*, *bundles* or *transfers*. Each actor-role is assigned to one of four disjoint activity-roles: (1) the *front-end activity* is of competency of the *principal* (2) the *resource activity* is of responsibility of an *agent*; (3) the *back-end activity* is of responsibility of a *third-party*; and (4) the *regulatory activity* is of authority of a regulator. The transformations performed by these types of value activity are formalized below in Table 1.

Table 1. Ontology axioms of activity-role organization for *green value networks* modeling.

Class: FrontEndActivity ≡ ValueActivity ∩ ((*bundles* ∃ (CnAObject ∪ PoPObject)) ∪ (*consumes* ∃ CoreObject)) ∩ (*isCompetenceOf* ∃ Principal) ∩ (*produces* ∃ CounterObject) ∩ (*bundles* ∀ (CnAObject ∪ PoPObject)) ∩ (*consumes* ∀ CoreObject) ∩ (*isCompetenceOf* ∀ Principal) ∩ (*produces* ∀ CounterObject)
Class: ResourceActivity ≡ ValueActivity ∩ ((*bundles* ∃ (CnAObject ∪ CoreObject ∪ CounterObject ∪ PoPObject)) ∪ (*consumes* ∃ CounterObject)) ∩ ((*distributes* ∃ (CoreObject ∪ CounterObject)) ∪ (*grants* ∃ PoPObject) ∪ (*transfers* ∃ CnAObject)) ∩ (*isCompetenceOf* ∃ Agent) ∩ (*bundles* ∀ (CnAObject ∪ CoreObject ∪ CounterObject ∪ PoPObject)) ∩ (*consumes* ∀ CounterObject) ∩ (*distribute* ∀ (CoreObject ∪ CounterObject)) ∩ (*grants* ∀ PoPObject) ∩ (*isCompetenceOf* ∀ Agent) ∩ (*transfers* ∀ CnAObject)
Class: BackEndActivity ≡ ValueActivity ∩ ((*bundles* ∃ (CnAObject ∪ CoreObject)) ∪ (*consumes* ∃ CounterObject)) ∩ ((*grants* ∃ PoPObject) ∪ (*produces* ∃ (CoreObject ∪ CounterObject))) ∩ (*isResponsabilityOf* ∃ ThirdParty) ∩ (*bundles* ∀ (CnAObject ∪ CoreObject)) ∩ (*consumes* ∀ CounterObject) ∩ (*grants* ∀ PoPObject) ∩ (*isResponsabilityOf* ∀ ThirdParty) ∩ (*produces* ∀ (CoreObject ∪ CounterObject))
Class: RegulatoryActivity ≡ ValueActivity ∩ ((*bundles* ∃ (CnAObject ∪ CoreObject ∪ PoPObject)) ∪ (*consumes* ∃ CounterObject)) ∩ ((*grants* ∃ CnAObject) ∪ (*transfers* ∃ (CoreObject ∪ PoPObject))) ∩ (*isAuthorityOf* ∃ Regulator) ∩ (*bundles* ∀ (CnAObject ∪ CoreObject ∪ PoPObject)) ∩ (*consumes* ∀ CounterObject) ∩ (*grants* ∀ CnAObject) ∩ (*isAuthorityOf* ∀ Regulator) ∩ (*transfers* ∀ (CoreObject ∪ PoPObject))

Value objects are products or services of economic value, which are transformed by value activities and exchanged among business actors in a value network [3]. A value object can be assigned to one of four disjoint roles: (1) *core business object*, i.e., the main object of a consumer's desire; (2) *proof-of-performance object* (PoPObject), i.e., an evidence that a core object was produced according to a regulation; (3) *certification & accreditation object* (CnAObject), i.e., a permission granted by a regulator to assess core or proof objects; and (4) *counter-object*, i.e., an object given in exchange of any other type of object to ensure economic reciprocity [19]. Objects can be transformed by four types of activities assigned to the Agency roles, as formalized in the Table 2.

Table 2. Ontology axioms of object-role organization for *green value networks* modeling.

Class: CoreObject ≡ ValueObject
∩ ((*isBundledBy* ∃ (BackEndActivity ∪ ResourceActivity))
∪ (*isConsumedBy* ∃ FrontEndActivity))
∩ ((*isDistributedBy* ∃ ResourceActivity) ∪ (*isProducedBy* ∃ BackEndActivity))
∩ ((*isBundledBy* ∀ (BackEndActivity or ResourceActivity))
∪ (*isConsumedBy* ∀ FrontEndActivity))
∩ (¬ (*isBundledBy* ∃ FrontEndActivity)) ∩ (¬ (*isConsumedBy* ∃ BackEndActivity))
∩ (*isDistributedBy* ∀ ResourceActivity) ∩ (*isProducedBy* ∀ BackEndActivity)
∩ (*isTransferredBy* ∀ RegulatoryActivity)
Class: PoPObject ≡ ValueObject
∩ (¬ (*isConsumedBy* ∃ (BackEndActivity ∪ FrontEndActivity
∪ RegulatoryActivity ∪ ResourceActivity)))
∩ (¬ (*isProducedBy* ∃ BackEndActivity))
∩ (*isBundledBy* ∃ (FrontEndActivity ∪ RegulatoryActivity ∪ ResourceActivity))
∩ (*isGrantedBy* ∃ (BackEndActivity ∪ ResourceActivity))
∩ (*isBundledBy* ∀ (FrontEndActivity ∪ RegulatoryActivity ∪ ResourceActivity))
∩ (*isGrantedBy* ∀ (BackEndActivity ∪ ResourceActivity))
∩ (*isTransferredBy* ∀ RegulatoryActivity)
Class: CnAObject ≡ ValueObject
∩ ((*isGrantedBy* ∃ RegulatoryActivity) ∪ (*isTransferredBy* ∃ ResourceActivity))
∩ (*isBundledBy* ∃ (BackEndActivity ∪ FrontEndActivity ∪ ResourceActivity))
∩ (*isBundledBy* ∀ (BackEndActivity ∪ FrontEndActivity ∪ ResourceActivity))
∩ (*isGrantedBy* ∀ RegulatoryActivity) ∩ (*isTransferredBy* ∀ ResourceActivity)
Class: CounterObject ≡ ValueObject
∩ ((*isBundledBy* ∃ ResourceActivity)
∪ (*isConsumedBy* ∃ (BackEndActivity ∪ RegulatoryActivity ∪ ResourceActivity)))
∩ ((*isDistributedBy* ∃ ResourceActivity)
∪ (*isProducedBy* ∃ (BackEndActivity ∪ FrontEndActivity)))
∩ (*isBundledBy* ∀ ResourceActivity)
∩ (*isConsumedBy* ∀ (BackEndActivity ∪ RegulatoryActivity ∪ ResourceActivity))
∩ (*isDistributedBy* ∀ ResourceActivity) ∩ (*isPriceOf* ∀ ValueObject)
∩ (*isProducedBy* ∀ (BackEndActivity ∩ FrontEndActivity)

3.2 Defining Organizational Policies

The concept of *policy* used here refers to an organizational arrangement of roles played by actors, activities and objects in a value network settled to fill a consumer's need. In other words, a value network policy defines *who exchanges which types of objects with whom* and is inspired in the NIST Role-Based Access Control models proposed by Ferraiolo et al. (2001) [22]. In a *green value network* model, a policy specifies alternative value paths whereby certifications and proof objects are transformed by the intermediary actors to fill a consumer's need. A policy is configured by connecting actor-roles of Agency to activity-roles via OWL object properties of *authority*, *competence* or *responsibility*, and then, by connecting activity-roles to object-roles via OWL object properties of production acts. In this study, five candidate policy models were identified through Technical Action Research applied on the business case described in Sect. 4: *simple padlock*, *key holder*, *single key*, *padlock chain* and *key knot*. The names of the models suggest different value network arrangements to organize actor-roles, activity-roles and object-roles of a *green value network* model to fill a consumer's (principal) business need of products or services bundled with green certifications. For simplicity, only the specification of the *key holder* policy model is shown in Table 3.

Table 3. Description logics of the *KeyHolder* organizational policy model.

Class: KeyHolder ≡ Policy
∩ (*isComponencyBy* ∃ (Regulator
∩ (*hasAuthority* ∃ (RegulatoryActivity
∩ ((*grants* ∃ (CnAObject
∩ (*isBundledBy* ∃ (BackEndActivity
∩ (*isResponsabilityOf* ∃ (ThirdParty
∩ (*hasResponsability* ∃ (BackEndActivity
∩ (*grants* ∃ (PoPObject
∩ (*isBundledBy* ∃ (ResourceActivity
∩ (*isCompetenceOf* ∃Agent))))))))))))
∩ (*grants* ∃ (CnAObject
∩ (*isBundledBy* ∃ (ResourceActivity
∩ (*isCompetenceOf* ∃ (Agent
∩ (*hasCompetence* ∃ (ResourceActivity
∩ (*grants* ∃ (PoPObject
∩ (*isBundledBy* ∃ (FrontEndActivity
∩ (*isCompetenceOf* ∃Principal)))))))))))))
∩ (*grants* ∃ (CnAObject
∩ (*isBundledBy* ∃ (ResourceActivity
∩ (*isCompetenceOf* ∃ (Agent
∩ (*hasCompetence* ∃ (ResourceActivity
∩ (*grants* ∃ (PoPObject
∩ (*isBundledBy* ∃ (ResourceActivity
∩ (*isCompetenceOf* ∃Agent)))))))))))))))))))

4 Ontology Validation and Evaluation: A Case from the Agribusiness Sector in Brazil

According to Gómez-Pérez, Fernandez-Lopez and Corcho (2004), after an ontology is formally verified according to its consistency and correctness, it can be validated via proof-of-concept tool (i.e., technological validation), via confrontation with a "standard" theory or upper-level ontology (i.e., theoretical validation) or with a case study (i.e., practical validation) [10]. In this study, we validated the ontology proposed with Technical Action Research (TAR) applied to a real-world case. In TAR, a researcher validates the utility of an artifact of Information Systems by working in close cooperation with a real-world organization to extract elements of practice that will be used to refine the design of the artifact. According to Wieringa (2014), with TAR it is possible to predict how organizational problems could be solved if the artifact was implemented in real life [6]. TAR is a specific type of single case study, but different from an observational case study. In TAR, the researcher intervenes in the context where the artifact is applied with transfer of knowledge. However, in an observational case study, the researcher analyzes a case from a distance, with no direct intervention with the stakeholders of the organization that circumscribes the case study. Moreover, in TAR, while the researcher obtains knowledge to refine the IS artifact, the client organization acquires knowledge about how to solve its operational problems.

The behavior of an ontology can be characterized by its input data (i.e., individuals that will populate the classes, properties and restrictions of the ontology) and its output knowledge (i.e., the ontology models). In this study, the input data was collected directly from the owners of the selected company by following the TAR protocol suggested by Wieringa (2014) [6]. The input data concerned organizational information about how the company operates in national and international markets of fresh tropical fruit trade. The output data comprised knowledge generated by automatic inference on the ontology to produce alternative green value models. Therefore, the main *validation question* comprised *to assess if the ontology models would be economically effective in practice*. To facilitate the understanding of the models by business analysts, the ontology models were translated into *e^3value* models. Hence, the main evaluation question comprised *how the inferred ontology models leveraged our clients' understanding about current and future state of adopted strategies for green value networking*.

4.1 Ontology Validation – Practical Conformance Checking

The company that participated in this research was **Vita+**, part of the **Ecofertil Group**[7], with its main office located in the city of Mossoró, State of Rio Grande do Norte, in the northeastern and semi-arid region of Brazil. The company operates the agribusiness sector, producing and exporting *fresh tropical fruit* to European and American markets. Its main products for exportation are melon (e.g. *yellow*, *galia* and *toadskin*) and watermelon (*seedless*, specially). Structured interviews were applied to collect data about the current business network in which the company operates, including business actors, activities and objects of economic interest (including aimed green certifications). In TAR, there are three types of knowledge inference: *descriptive* (to explain causes for phenomena of interest), *analogic* (to identify architectural patterns) and *abductive* (to prospect how the IS artifact would change the context of the case), which was the type of inference applied in this study. Such changes can be classified as: *expected effect* (i.e. the difference between current and future models of

[7] http://ecofertil.com.br.

the case), *expected value returned* (i.e. economic effectiveness and efficiency) and *trade-off* (i.e., structural differences among the different models produced for the same case). After populating the ontology with the contextual data from the case, five *green value network* models were produced, which are framed according to the organizational *policies* introduced in Sect. 3 (fully formalized in the OWL model available online). The models are explained textually and illustrated with the *e*^{3}*value* notation as follows.

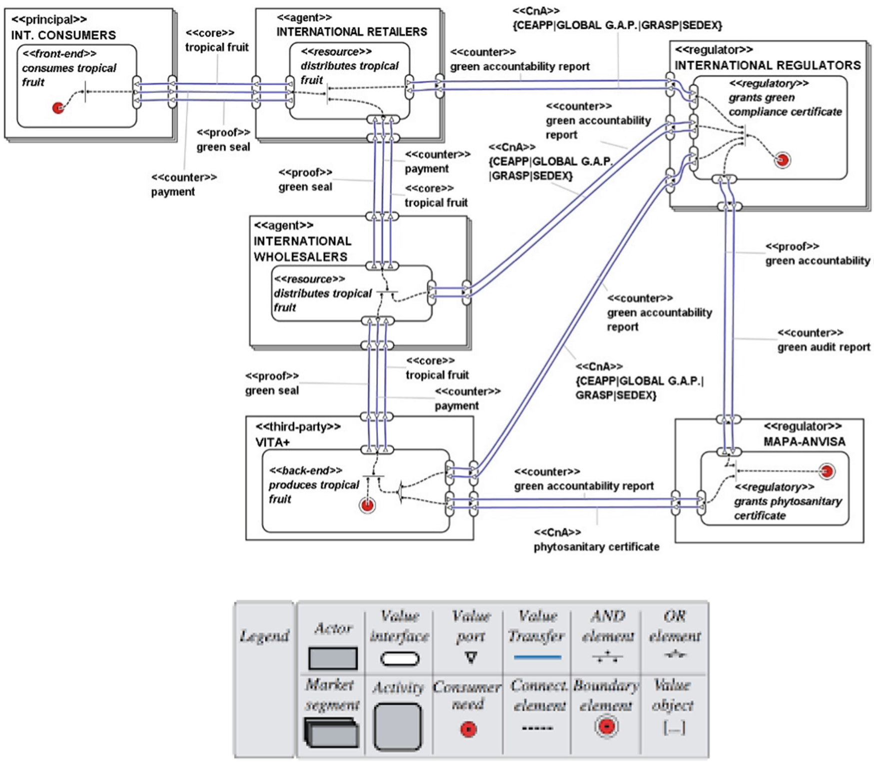

Fig. 2. **Padlock chain model:** compliance regulation shared between national and international regulators

Padlock chain model: in direct export via international wholesalers, the fruit produced by **Vita+** are checked by the Ministry of Agriculture Livestock and Food Supply (Ministério da Agricultura, Pecuária e Abastecimento – MAPA)[8], via the Brazilian Health Regulatory Agency (Agência Nacional de Vigilância Sanitária – ANVISA), which grants a phytosanitary document authenticated by a certified Agronomy engineer that releases a fruit container for exportation. As depicted in Fig. 2, the national regulator (MAPA-ANVISA) provides green accountability reports to foreign regulators in

8 http://www.agricultura.gov.br/.

exchange of audit reports to certify that the Brazilian company complies to internal regulations. **Vita+** currently has GLOBAL G.A.P.[9], SEDEX[10], GRASP[11] and CEAPP certifications, which allows for exporting tropical fruit to England, Italy, Spain, Portugal and The Netherlands. Its main wholesaler partners are Jaguar, QPI, Barbosa and VidaFresh, which distributes their products to international retailers. According to the model, the proof-of-performance object (green seal) is produced by the back-end activity and transferred through wholesalers and retailers to the final consumer. This model is currently implemented by **Vita+**.

Simple padlock chain model: a simplification of the previous model is depicted in Fig. 3, which illustrates the case of a direct export involving the producer and retailers. This model is *not currently implemented* by **Vita+** due to some restrictions, as fractionated distribution is not the core business of the company. However, the board of managers validated the model as currently implemented by market competitors.

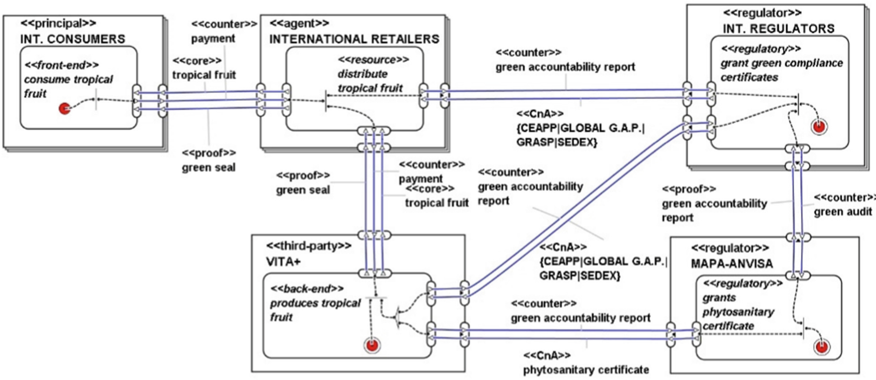

Fig. 3. **Simple padlock chain model:** direct exports to international retailers.

Key knot chain model: an extension of the first model is the specific case in which international wholesalers and retailers grant their own green certifications and standards, to which the products imported from foreign companies must comply (vide Fig. 4). In this case, retailers or wholesalers might operate as both agents and regulators. The final product has an aggregated value of green seals. As depicted in the model, the green seals flow originally from the producer, but each intermediary adds different seals to the products. **Vita+** currently implements this model.

Key holder model: to operate in the national market, **Vita+** needs to be granted by the only national regulator (MAPE-ANVISA), as depicted in Fig. 5. With this certification, the producer can sell fruit directly to the national wholesalers. **Vita+** cooperates with

[9] https://www.globalgap.org/uk_en/.

[10] https://www.sedexglobal.com/.

[11] https://www.globalgap.org/uk_en/for-producers/globalg.a.p.-add-on/grasp/.

many national wholesalers, such as Pilon, Casa da Uva, Benaci, Villalva and Canaã, which redistributes fruit to the local retailing supermarkets.

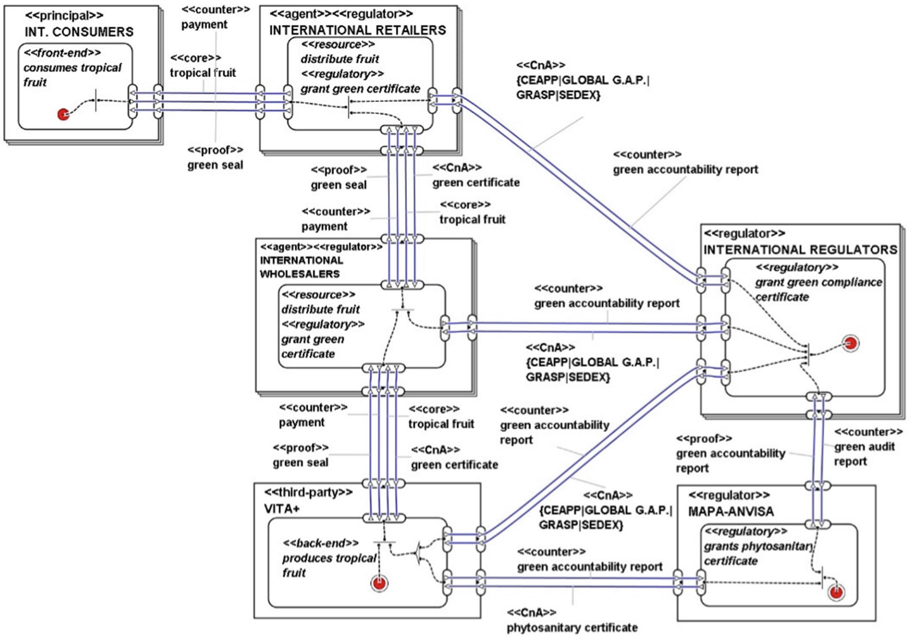

Fig. 4. Key knot chain model: international retailers and wholesalers demanding compliance to own green certifications from producers, in addition to global certifications.

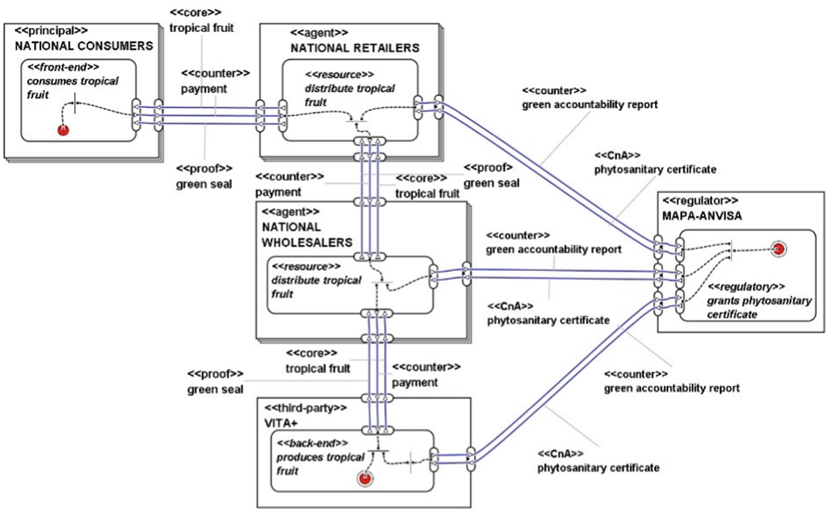

Fig. 5. Key holder model: national retailers and wholesalers obtain green certificates from a centralized national regulator.

Single key model: A simplification of the previous model is the case when the producer cooperates directly with national retailers (vide Fig. 6). **Vita+** does not implement this model currently, but validated the model as adopted by local competitors.

According to the owners of the company, all the five models produced by the ontology are *economically feasible*. **Vita+** implements currently variations of the *padlock chain model*, *key knot chain model* and *key holder model*. Such variations were referred to as containing critical elements of practice, which were not disclosed by the company for the sake of market competitivity. The *simple padlock chain model* and the *single key model* are not yet implemented by the company, as these models do not actually encompass core business competencies and strategies of the company. Nevertheless, the company recognized these two models as currently implemented by local competitors.

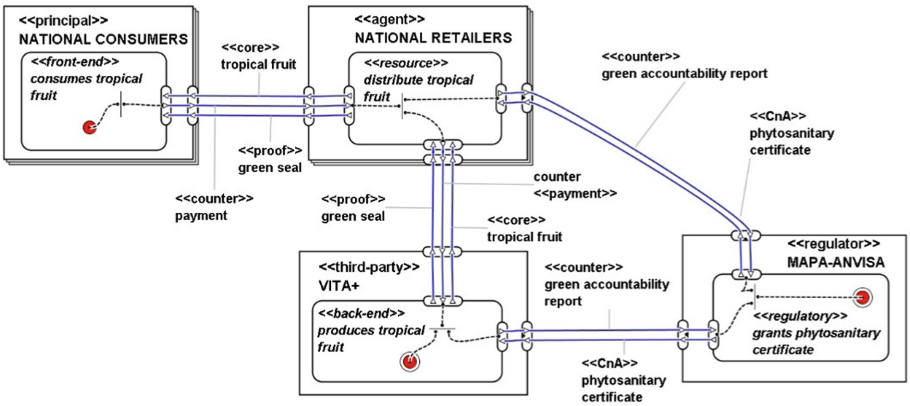

Fig. 6. Single key model: national retailers obtain the core object and the green certificate directly from the producer and national regulator, respectively.

4.2 Ontology Evaluation

Adams, Nelson and Todd (1992) proposes a framework to evaluate information technology in general, based on how the final user *accepts* a new technology and *perceives* its *usefulness* and *ease of use* [23]. These requirements are also considered in the evaluation phase of Ontological Engineering [10, 11]. As the ontology proposed by this study was expressed with properties based on the Speech Acts Theory of Searle (1969) [17], its original specification in OWL can be understood by IS scholars but may be difficult to be apprehended by business analysts. Therefore, as Technical Action Research normally demands business *expert opinion*, the ontology was evaluated based on the models generated by the ontology and expressed in the *e*^{3}*value* notation (already evaluated in related study as an effective tool to communicate business requirements) [3, 4, 13, 21]. From our best knowledge, there are no strict standards to evaluate usefulness, ease of use or acceptance of business ontologies. For this purpose, we have adapted the TAR protocol proposed by Wieringa (2014) [14] to elaborate a survey that was submitted to the owners of **Vita+** with the following questions:

(1) *Is it necessary for your company to have value network models defining explicit business strategies to obtain green certifications?*
(2) *Do the green value models describe how the transactions are arranged in the markets where your company operates?*
(3) *Would these models support decision making in your company?*
(4) *Do the organizational policies expressed in the models make practical business sense?*
(5) *Is the decision-making problem of attempting to satisfy a consumer's need of products bundled with green seals and certifications through different value paths clearly formulated?*
(6) *Does the visualization of the green value models help explaining and prospecting opportunities for sustainable business strategies?*
(7) *Do the models generated in this study reflect the current state of green business practice adopted by your company?*
(8) *Do the complementary explanations of the models (i.e., modeling sessions, e^3value models, case documentation and interview reports) add knowledge to decision-making in your company?*

The questions were answered according to a value partition scale as: (1) *extremely*; (2) *a lot*; (3) *partially*; (4) *a little*; and (5) *not at all*. **Questions 2 to 7** were answered with **level 2** (a lot) and **question 1** with **level 3** (partially). The cause explanation given by the owners of **Vita+** for **question 1** is that there are conditions of practice and subjective values currently affecting the cost of transactions made by the company that are not present in the models and will be kept undisclosed for the sake of market differentiation and competitivity of the company. Moreover, it was pointed by the owners of the company that corporate values such as *availability*, *loyalty* and *trust* involved in component transactions of the *green value network* models could be assessed prior to actual calculation of cost of transaction. If aggregated, the values of each component transactions can provide Key Performance Indicators (KPIs) to assess the economic efficiency of each value model produced.

5 Related Study

There is a progression of studies in Value Network Modeling addressing the configuration of value models for development of long-term business relationships. These studies include the seminal *e^3value* framework of Gordijn and Akkermans (2003) [2], refined latter by Gordijn and Akkermans (2018) [3]; the *e^3control* framework of Kartseva, Gordijn and Tan (2009) [21]; and the Value Monitoring Ontology of Silva (2013) [13], refined latter by Silva et al. (2017) [20].

The original *e^3value* framework proposed by Gordijn and Akkermans (2013) supports specification and analysis of networked business strategies that prelude business process modeling. One of the main strengths of the framework is its graphical notation, evaluated through several European business cases as "easy to understand", by business analysts. Nonetheless, in its original formulation, this framework does not support prospective analysis of opportunistic behavior that normally emerges in untrusted business networks. This limitation was treated latter with the *e³control* framework proposed by Kartseva, Gordijn and Tan (2009).

The *e3control* framework extends the original *e³value* with a set of design patterns and a methodology to configure preemptive controls against opportunistic behavior in value networks. Particularly, this framework allows the prospection of how value transactions of a value network could be negatively affected by contract violations, and which actors could be possibly involved in such violations. This study advances the current state of value network modeling with the consolidation of design patterns validated with multiple real-world case scenarios. Nevertheless, one limitation of this study is that its grounding ontology was not formally verified, and model inference is limited by the architectural *rigidity* of the design patterns expressed in the e³value notation.

The Value Monitoring Ontology proposed by Silva (2013) and corresponding design patterns described in Silva et al. (2013) elaborates on preemptive monitoring of fraudulent behavior in value networks. This study extends the original *e³value* ontology with concepts of Multiple Agency proposed by Eisenhardt (1989) [16], principles of Contract Theory, by Colton and Dewatripont (2004) [18], Dietz' Enterprise Ontology (2006) [15] and the linguistic framework of Speech Acts proposed by Searle (1969) [17]. The ontology was evaluated with real-world case scenarios in renewable energy markets in Europe, Intellectual Property Rights in the music industry and Customs Control in The Netherlands. However, as its preceding studies, this study does not address explicitly Green Computing requirements.

In general, the related study point to the importance of business *sustainability*, which demands expression of *social*, *economic* and *environmental* concerns. However, the treatment of monetary value was still dominant in these studies. In this research, we attempted to treat Green Computing requirements in the early design of value models in two ways: (1) by *extending* the concept of a *consumer's need* from a single core business object to a bundle of products, green certifications and proof-of-performance evidence; (2) *by proposing an organizational design* logic to configure value paths whereby green certified products will flow within a value network. The case in the Agribusiness sector in Brazil is only a starting point to raise elements of practice to develop and mature *green value network modeling*.

6 Conclusions and Future Research

This research was driven by a Design Science perspective, conforming to guidelines provided by Hevner and Chatterjee (2010) [5] and Wieringa (2014) [6], and thereby focused on treating problems of social relevance. We give account of the knowledge questions raised in Sect. 1 (Introduction) and Sect. 4 (Ontology validation) as follows.

(1) *What are green value network models?*
These models extend original value network models with concepts of environmental sustainability. The research agenda for Green Computing proposed by

Hevner and Chatterjee (2010) recommends leveraging Information Systems design to cope with issues of environmental conservation. This perspective demands the treatment of requirements such as disposal of electronic waste, end user satisfaction, energy use, management restructuring, regulatory compliance, return on investment (ROI), telecommuting, thin client solutions and virtualization of server resources. These requirements can be treated progressively, on different managerial layers. In this study, we extend the notion of a business need as the starting point of configuration of a value network model as a bundle of core business product and corresponding green certificates and proof of clean production.

(2) *What concepts ground these models?*
According to Gordijn and Akkermans (2003) [3] the grounding concepts of a value network model are: *business needs*, *actors*, *value activities* and *value objects*. In this study, actors, activities and objects are typified according to roles of Multiple Agency [16], organized in a communication model inspired in the Role-Based Access Control (RBAC) model [22] and connected by Speech Acts [17] – previously adapted to express business process models by Dietz (2006) [15].

(3) *How these concepts are related to consumers' needs of products that demand green certifications?*
The concept of a *policy* in a *green value network* model defines *who exchanges which type of object through which activity to whom*. This communication structure was translated as ontology properties to characterize *actor-roles*, *activity-roles* and *object-roles* within a *green value network* model. Each policy has a different economic efficiency, as green seals and corresponding certificates add value to the final product to be delivered to the final consumer. The *e*^{3}*value* framework already provides an internal mechanism to prospect distributed profit share among the actors willing to form value networks.

(4) *Would the green value models proposed in this research be economically effective if implemented in practice?*
According to the Technical Action Research protocol applied at **Vita+** company, all the green value models depicted in Sect. 4 were evaluated as *economically effective*. The *simple padlock chain model* (vide Fig. 3) and the *single key model* (vide Fig. 6) are not yet implemented by the company but were recognized as currently implemented by market competitors.

(5) *How the inferred ontology models leveraged our clients' understanding about current and future state of adopted strategies for green value networking?*
The *utility* of the ontology models was evaluated with **questions 1 to 4** of the questionnaire presented in Sect. 4, whereas its *ease of use* was evaluated with **questions 5 to 8.** The owners of **Vita+** indicated that the value network models are *useful* to support decision-making about the adoption of value paths necessary to obtain green certifications and are *easily communicated* and understood.

This study can be leveraged by at least three research directions: (1) to investigate if the organizational structures of the green value network models proposed in this study could be consolidated as design patterns, by application in multiple and similar case studies (i.e., for sensitivity analysis) or in related business domains (e.g., wind and solar energy trading companies); (2) to investigate how business values such as availability, loyalty and trust could be analyzed prior to the actual formation of transactions *in green value network* models; and (3) to extend the ontology with a taxonomy of *environmental resources* to classify and prospect the sustainability of the value activities to be included in a *green value network* model.

References

1. Normann, R., Ramirez, R.: From value chain to value constellation: designing interactive strategy. Harv. Bus. Rev. **71**(4), 65–77 (1993)
2. Peppard, J., Rylander, A.: From value chain to value network: insights for mobile operators. Eur. Manag. J. **24**(2–3), 128–141 (2006)
3. Gordijn, J., Akkermans, J.M.: Value-based requirements engineering: exploring innovative e- commerce ideas. Requir. Eng. **8**(2), 114–134 (2003)
4. Gordijn, J., Akkermans, H.: Value Webs, Understanding e-Business Innovation. The Value Engineers, B.V., Soest (2018)
5. Hevner, A., Chatterjee, S.: Design Research in Information Systems: Theory and Practice. Springer, Heidelberg (2010). https://doi.org/10.1007/978-1-4419-5653-8
6. Wieringa, R.J.: Design Science Methodology for Information Systems and Software Engineering. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-662-43839-8
7. Cameron, K.: Critical questions in assessing organizational effectiveness. Organ. Dyn. **9**(2), 66–80 (1980)
8. Lusch, R.F., Vargo, S.L., Tanniru, M.: Service, value networks and learning. J. Acad. Mark. Sci. **38**(1), 19–31 (2010)
9. Uschold, M., King, M.: Towards a methodology for building ontologies. In: Proceedings of Workshop on Basic Ontological Issues in Knowledge Sharing, held in conjunction with IJCAI-95, 13p. (1995)
10. Gómez-Pérez, A., Fernandez-Lopez, M., Corcho, O.: Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web. Springer, Berlin (2004). https://doi.org/10.1007/b97353
11. Vrandečić, D., Sure, Y.: How to design better ontology metrics. In: Franconi, E., Kifer, M., May, W. (eds.) ESWC 2007. LNCS, vol. 4519, pp. 311–325. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-72667-8_23
12. Ionita, D., Gordijn, J., Yesuf, A.S., Wieringa, R.: Value-driven risk analysis of coordination models. In: Horkoff, J., Jeusfeld, Manfred A., Persson, A. (eds.) PoEM 2016. LNBIP, vol. 267, pp. 102–116. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-48393-1_8
13. Silva, P.A.: Value Activity monitoring, Ph.D. thesis, Tilburg University (2013). https://pure.uvt.nl/ws/portalfiles/portal/1522768/PhD_Thesis__Patr_cio_de_Alencar_Silva_.pdf. Accessed 14 July 2019
14. Loucopoulos, P., Kavakli, V.: Enterprise knowledge management and conceptual modelling. In: Goos, G., et al. (eds.) Conceptual Modeling. LNCS, vol. 1565, pp. 123–143. Springer, Heidelberg (1999). https://doi.org/10.1007/3-540-48854-5_11
15. Dietz, J.: Enterprise Ontology: Theory and Methodology. Springer, Heidelberg (2006). https://doi.org/10.1007/3-540-33149-2
16. Eisenhardt, K.M.: Agency theory: an assessment and review. Acad. Manag. Rev. **14**(1), 57–74 (1989)

17. Searle, J.R.: Speech Acts: An Essay in the Philosophy of Language. Cambridge University Press, Cambridge (1969)
18. Bolton, P., Dewatripont, M.: Contract Theory. The MIT Press, Cambridge (2004)
19. Mankiw, N.G.: Principles of Macroeconomics, 6th edn. South-Western Cengage Learning, Mason (2014)
20. de Alencar Silva, P., Allah Bukhsh, F., da Silva Reis, J., de Castro, A.F.: Agency monitoring patterns for value networks. In: Pham, C., Altmann, J., Bañares, J.Á. (eds.) GECON 2017. LNCS, vol. 10537, pp. 81–93. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-68066-8_7
21. Kartseva, V., Gordijn, J., Tan, Y.-H.: Designing value-based inter-organizational controls using patterns. In: Lyytinen, K., Loucopoulos, P., Mylopoulos, J., Robinson, B. (eds.) Design Requirements Engineering: A Ten-Year Perspective. LNBIP, vol. 14, pp. 276–301. Springer, Heidelberg (2009). https://doi.org/10.1007/978-3-540-92966-6_16
22. Ferraiolo, D.F., Sandhu, R., Gavrila, S., Kuhn, D.R., Chandramouli, R.: Proposed NIST standard for role-based access control. ACM Trans. Inf. Syst. Secur. **4**(3), 224–274 (2001)
23. Adams, D.A., Nelson, R.R., Todd, P.A.: Perceived usefulness, ease of use, and usage of information technology: a replication. MIS Q. **16**(2), 227–247 (1992)