Chapter 5
Using Ontologies to Develop and Test a Certification and Inspection Data Infrastructure Building Block

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Abstract Global markets for information-intensive products contain sharp information asymmetries that lead to market inefficiencies resulting from consumer purchasing decisions that are based on incomplete information. Elimination or reduction of such information asymmetries has long been the goal of governments as well as various nongovernmental entities that recognize that addressing issues such as sustainable production, socially just labor practices, and reduction in energy needs and health expenditure is closely linked to consumers being fully aware of the economic, environmental, and social impacts of their purchasing decisions. This chapter reports on the creation of ontology-enabled interoperable data infrastructure based on semantic technologies that would enable information sharing in traditionally information-restricted markets. The main technical result is a proof-of-concept set of data standards built on semantic technology applications and the functionalities of formal ontology of certification and inspection processes. The current proof of concept focuses specifically on certified fair-trade coffee, and while its applicability is currently limited, it has the potential to become universally applicable to any certification

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and inspection process for any product and service. In addition to producing a number of artifacts relevant to the expandability of the work, such as domain ontologies, the research indicates that while big data systems are necessary, they are not sufficient to create high levels of consumer trust. By testing the criteria using both hand-generated and automated queries, we are able to demonstrate that CIDIBB (Certification and Inspection Data Infrastructure Building Block) is not only able to test the trustworthiness of certification schemes but also that our ontology generates consistent results.

Keywords Ontology • Virtual certificates • Certificates • Semantic applications • Ontology validation • Certification ontology

5.1 Introduction

Economic theory tells us that a market clears when the upward sloping supply curve and the downward sloping demand curve cross—it is the basis for the bold assertion that free markets are the best way to distribute the factors of production to create a globally efficient production and distribution system. But hidden behind the theory of markets are assumptions about perfect information—both sellers and buyers must have access to the same perfect information about the state of the market. As we all know, these assumptions about information in free markets are often not true. When we choose (purchase) surgeon's services, we are often ignorant of how successful she has been in past surgeries. When we purchase a health insurance policy, we most likely do not know or understand what important features or services are not covered. When we buy a pair of running shoes, we do not know if they were

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manufactured in a sweat shop using child labor. When we purchase a pound of coffee, we do not know if it was grown in a way that exploited farm workers or damaged some distant ecology or even used unhealthy pesticides. Each of these market transactions points to the problems of information asymmetry that pervade many contemporary global marketplaces.

Current trends in consumer markets involve a growing number of ethical consumers who are increasingly paying attention to information about where, when, how, and by whom our food, consumer, and durable goods are produced (Bray, Johns, & Kilburn, 2011; Goleman, 2009; Watts & Wyner, 2011). For instance, organic market penetration for fresh produce has grown to 12 % in the United States since the adoption of USDA organic standards (Dimitri & Greene, 2002); fair-trade markets have grown 20 % in Europe and 40 % annually in the United States and the Pacific Rim (Kim, Lee, & Park, 2010). Yet information needed by ethical consumers during the buying process is still rarely available (Graham & Haarstad, 2011). Moreover, market premiums for organic, fair-trade, or environmentally friendly products offer an incentive to "greenwash" products by adding product labeling that promises low to no environmental impact with the sole aim of increasing profitability for the manufacturer or retailer and introducing additional sources for information asymmetries into the market. As a measure of the problem, a 2010 survey by TerraChoice conducted in 24 stores in the United States and Canada claimed that more than 95 % of the 5300 products being observed commit at least one instance of greenwashing (Makower, 2010; TerraChoice, 2010).

To reduce information asymmetry in this particular area, governments, NGOs, and private organizations have created a third-party certification and labeling industry. The numbers of third-party labeling initiatives have expanded rapidly since the 1990s (Albersmeier, Schulze, Jahn, & Spiller, 2009; Jahn, Schramm, & Spiller, 2005). The rapid proliferation of labeling obstructs the ability of consumers to observe the meaning behind labels, making their warranty of trusted information no longer adequate (Jarman et al., 2011).

This chapter describes the design and development of a semantic web-based prototype that could help correct information asymmetries in free markets. We are seeking to build an information infrastructure that can promote what we refer to as Full Information Product Pricing (FIPP) systems. FIPP systems are characterized by features that allow a surgeon an insurance company or a coffee producer to charge a premium (a FIPP price) for a product or service because consumers trust the information provided to them in regard to the key attributes of these products and services and these attributes align with consumers' values.

The rest of the chapter is organized in six sections following this introduction. Section two provides a vision of the ways in which CIDIBB can help in the creation of virtual certificates to promote FIPP systems. Section three describes previous research and some basic concepts about ontologies. Section four includes a brief description of the main components of CIDIBB as a set of three ontologies, CerTIN, FLO, and CiTruST. Section five presents an empirical evaluation of CIDIBB. In this section, we show ways in which CiTruST can be used to automatically classify certification systems in terms of their trustworthiness. Finally, section six includes a discussion, concluding remarks, and future work to fully develop CIDIBB.

5.2 Creating Virtual Certificates to Correct for Information Asymmetries in Markets

Our approach to producing FIPP systems involves the creation of a certification ecosystem. Certifying organizations will set explicit measurable standards for all types of products and services. Then third-party certifiers will send representatives to inspect facilities, processes, and outcomes to certify that they indeed meet the publicly available standards. Finally, a certificate will be attached to the product or service that gives consumers, or consumer advocates operating as agents of the consumers, all the trusted information that they need, i.e., perfect information without asymmetric bias.

Such systems already exist but only in partial form. Some organizations already produce certificates that are physically attached to products or services that we purchase. Examples of such physical certificates include Fair Trade and USDA Organic certificates that are printed on food products or the certificate issued by the local department of health of a clean and healthy kitchen hanging in many restaurants. Our scheme proposes that certificates, rather than being physically attached to products or services, become virtual certificates. Virtual certificates will be broadcasted on the internet and can be attached as an extended package of information to a unique product identifier such as a UPC product codes.

The challenge of making such virtual certificates a reality lies mainly in making the vast amounts of disparate data shareable and understandable across certification and inspection processes in a way that will be trusted by consumers. A key technical component that is necessary but missing is a combination of data standards and procedures that allow data to be shared seamlessly among the various and potential users of that data. We refer to this component as the "data infrastructure building block."[1] The Certification and Inspection Data Infrastructure Building Block (CIDIBB), whose creation is described in detail in this chapter, is a set of data standards in the form of a formal ontology of the certification and inspection process that would allow the creation of a data ecosystem for certification processes.

From a technical point of view, CIDIBB consists of four interlocking components that all operate in a semantic web environment. Three of the key components of CIDIBB consist of linked ontologies that model the domain of inspection and certification of consumer products with the certification and inspection of fair-trade coffee taken as a specific exemplar. The fourth component is a 28 question use case scenario that serves as a normative definition of what constitutes a trusted inspection virtual certificate (see Appendix).

At a high level, Fig. 5.1 shows the main components of the ecosystem created around CIDIBB. Such an ecosystem may include at least four classes of key

[1]The name "Data Infrastructure Building Block" derives from the National Science Foundation Data Infrastructure Building Block program which aims to "foster cross-community infrastructure development that solves common problems, while building blocks of data infrastructure that can support and provide data solutions to a broader range of scientific disciplines while reducing duplicative efforts." (http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504776)

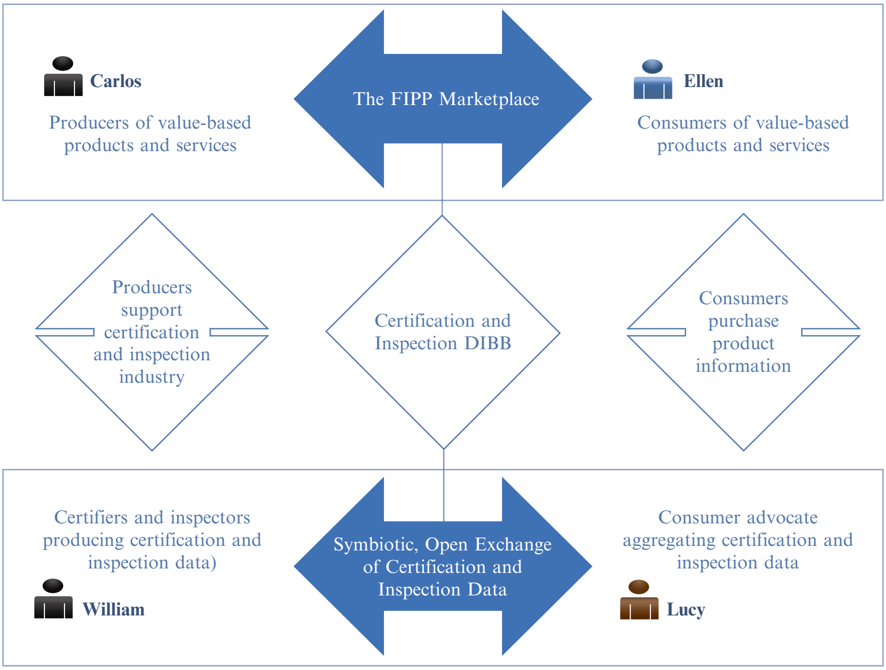

Fig. 5.1 Certification and Inspection Data Infrastructure Building Block (CIDIBB)

stakeholders that we represent by an idealized individual shown in each of the four corners of the figure.

Ellen, shown in the upper right-hand quadrant, represents consumers who will scan a product bar code to view its consumer rating and help them make a purchasing decision. Lucy, in the lower right-hand quadrant, represents a new consumer advocate industry that analyzes the full information package of consumer products and then sells that information to consumers such as Ellen. Lucy relies on William, a member of the inspection and certification industry, who uses CIDIBB to broadcast information about how, when, where, and by whom consumer products are created. The marketplace will drive what virtual certificates William is creating depending on what issues consumers are concerned with. For example, if consumers are concerned about the environmental impacts of the products they buy, then William's virtual certificates would focus on, for example, the carbon footprint created in producing and delivering the product to the final consumer Ellen. Carlos represents producers of value-based products and services. Carlos is cooperating with William to certify his production processes and to document unobservable attributes of his products because he understands that Ellen is willing to pay a price premium for products produced using methods that are congruent with her values. However, Carlos can continue to charge a price premium, and Lucy and William can stay in business only as long as Ellen continues to trust the information about virtual certificates that are being introduced into this newly formed Full Information Product Pricing (FIPP) ecosystem.

5.3 Previous Research

5.3.1 FIPP Systems and Trust

Our previous research has shown that trust plays a key role in all FIPP relationships (Luna-Reyes et al., 2013). In fact, trust is considered as an alternative governance mechanism in most collaborative relations (Powell, 1996). Higher trust levels lead to lowering of costs that result from the need to protect against opportunism (Shapiro, Sheppard, & Cheraskin, 1992). Moreover, the literature points out the importance of trust in these market transactions, particularly in the case of unobservable product attributes (Arora, 2006).

Researchers have identified several mechanisms for "trust production," which include calculative, relational, and institutional mechanisms (Rousseau, Sitkin, Burt, & Camerer, 1998). Institutional trust refers to the existence of an institutional framework that regulates the relationship between the main actors in the collaboration. Calculative trust refers to an estimation of the risks and payoffs intertwined in the interaction, and relational trust is associated with emotional bonds, shared values or objectives between the actors, or recognition of the trustworthiness of other participants in a repeated relationship. Research has found that institutional trust is particularly relevant for systems such as the proposed CIDIBB and that some features of information systems and information technologies contribute to building of institutional trust (Gefen et al., 2006; Luna-Reyes et al., 2013). Some of these features include peer feedback, online testimonials, affiliation links, guarantees, or system quality. The development of trust was central to designing the various components of CIDIBB, which are described in Sect. 5.4.

5.3.2 Ontologies and the Semantic Web

In the field of information and computer science, ontologies refer to explicit specifications of terms and their relationships within a domain of interest (Gruber, 1993). Such specifications provide a number of benefits, the most basic of which is enabling a computer to reason over the terms and properties of data (Uschold & Gruninger, 1996). Semantic web applications or services require that data be published in a format that makes use of these specifications as proposed in ontologies relevant to the domain of interest to which the data belongs (Berners-Lee, Hendler, & Lassila, 2001). Data published following such specifications may be called "linked data," and such data serve as building blocks for the semantic web (Berners-Lee, 2006). Creating data this way allows for more precise results from searches in the web and the automation of inferences over contents of the data (Bizer, Heath, & Berners-Lee, 2009). Specifically, using ontologies for the semantic web involves publishing data in the Resource Description Framework (RDF) file structure (W3C specification) in which subjects, predicates, and objects (or RDF triples) within components of the data are explicitly identified.

As semantic web technologies make use of specifications established in domain ontologies, they make it possible for data from different organizations and with different terminology—within a particular domain (e.g., certification and inspection processes) and using semantically equivalent concepts—to be integrated and classified in a structured way to improve searchability and the use of automated reasoning. For example, when a certification or inspection organization provides data where the "field inspector" is labeled as an "auditor," definitions in the ontology may indicate that these terms refer to the same concept, although they are labeled differently from one organization or one dataset to another. A software application can then use the ontology to determine that two attributes in two different datasets are equivalent. Applications can also use inference tools to make determinations about items and properties included in the dataset, such as "Is there an auditor?" or "Is the date of inspection before the date of certificate?"

The use of these tools and approaches makes it possible to adopt a framework that supports integration, data reuse, and automated reasoning. Therefore, these technologies are used in this research as the framework for our efforts to design, build, and test the concept of a Certification and Inspection Data Infrastructure Building Block (CIDIBB).

5.4 Key Technical Components of CIDIBB: Ontology-Based Data Standards and Evaluation System

CIDIBB is an abstract architecture for data storage, retrieval, and automated reasoning of certification and inspection data, based on semantic web principles. We developed three ontologies, CerTIN, FLO, and CiTruST (See Fig. 5.2). These three ontologies together form the fundamental base of the proposed Certification and Inspection Data Infrastructure Building Block (CIDIBB). CerTIN ontology defines the high-level abstraction of concepts, which we refer to as the global ontology. FLO ontology and CiTruST are called local ontologies. They inherit and expand high-level concepts defined in the global ontology. For more elaborate description about these ontologies and their development process, please refer to Sayogo et al. (Forthcoming).

CerTIN defines the most important and basic concepts of a certification system at a high level, meaning that CerTIN only provides the higher-level definition of a certification system that serves as an overarching architecture to connect multiple, more detailed ontologies for each certification and labeling scheme. The CerTIN ontology used standard definitions of class and property that are available from existing ontology literature. In addition, CerTIN has adopted classes and properties from three ontologies recommended by the W3C (World Wide Web Consortium).

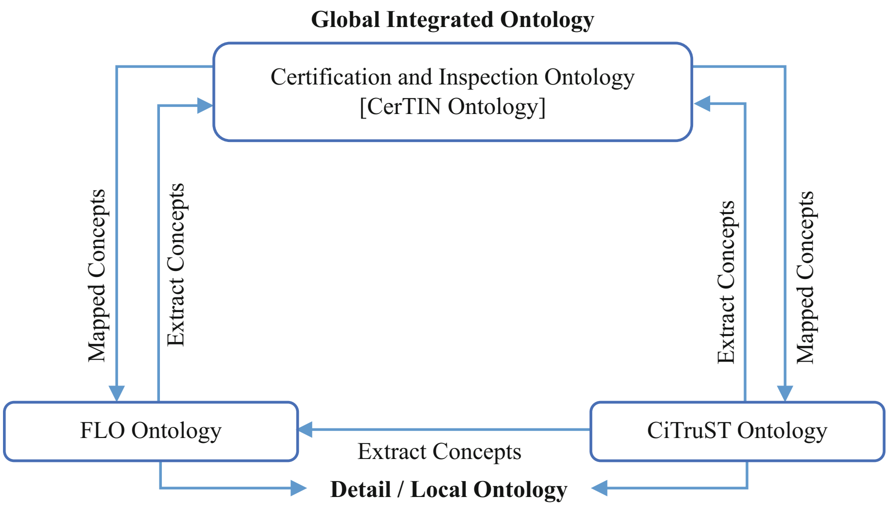

Fig. 5.2 The proposed ontologies and their relationships (Source: Sayogo et al. (Forthcoming))

These three include Dublin Core,[2] FoaF[3], and Good Relation[4] (Sayogo et al., Forthcoming).

CiTruST ontology was created to further demonstrate the scalability and expanded functionality of CerTIN ontology as an integrated global ontology. Thus, this ontology uses the classes and properties from CerTIN to define the quality of a certification process. CiTruST enables the determination of a "good" or "poor" certification process. We started with the basic structure of a certificate to find indicators for the quality of certification. Some components of the basic structure of a reliable certification process are accreditation body, certification body, standard setter, and monitoring process (Albersmeier et al., 2009; Deaton, 2004; Jahn et al., 2005; Tanner, 2000). The document analysis and interviews further indicated the importance of independence and monitoring processes that combine both document and field inspection as an indicator of reliable certification.

We thus posited that existence or nonexistence of particular components in the structure of certification indicates the degree of reliability of the certification scheme. The level of trustworthiness refers to the degree of certification trustworthiness derived from the conformance or nonconformance to the object of trustworthiness. The object of trustworthiness refers to the classes specified in CerTIN ontology. CiTruST ontology proposes four levels of certification process reliability, namely, level A to level D of certification trustworthiness. The assignment of the

[2] http://dublincore.org/2008/01/14/dcterms.rdf

[3] http://xmlns.com/foaf/spec/

[4] http://www.heppnetz.de/projects/goodrelations/

level depends on the existence of the criteria in the object of trustworthiness. The properties of level A of trustworthiness from CiTrusT ontology are shown below.

<'Level A of Trustworthiness'	*conformsTo*	***Some***	*Standard>*
<'Level A of Trustworthiness'	*certifiedBy*	***Only***	*'Third Party Certifier'>*
<'Level A of Trustworthiness'	*hasCertifyingOfficer*	***min 1***	*CertifyingOfficer>*
<'Level A of Trustworthiness'	*hasCompleted*	***Some***	*DocumentInspection>*
<'Level A of Trustworthiness'	*hasCompleted*	***Some***	*FieldInspection>*
<'Level A of Trustworthiness'	*hasEvaluationDecision*	***Some***	*CorrectiveMeasure>*
<'Level A of Trustworthiness'	*hasEvaluationDecision*	***Some***	*NonConformity>*
<'Level A of Trustworthiness'	*hasEvaluation Decision*	***Some***	*ObjectiveEvidence>*
<'Level A of Trustworthiness'	*hasStandardSetter*	***Exactly 1***	*StandardSetter>*
<'Level A of Trustworthiness'	*inspectedBy*	***min 1***	*Inspector>*
<'Level A of Trustworthiness'	*Authorize*	***min 1***	*Certificate>*

FLO ontology is an example of a local ontology that we created to further demonstrate how CerTIN ontology can be mapped to specific certification and inspection schemes. The ability of CerTIN to map into a local ontology such as FLO enables users (consumer advocates) to extract consistent and detailed information for assessing the trustworthiness of a certification scheme.

The most important elements of FLO ontology are the detailed classifications of compliance criteria into their properties. A compliance criterion is constructed with several restrictions, as defined in the FLO standard, by specific timeline, criteria types, measurement of the criteria, and organization applicability. These restrictions represent the properties of the criterion. Conformance to these properties affects the evaluation decision for certification, and it is also argued that conformance to these properties defines the level of trustworthiness of the certification schemes.

5.5 Empirical Testing of the Proof of Concept

After we created the basic building blocks of the CIDIBB, we devised a set of empirically based steps to test the resulting proof-of-concept system: (1) we generated a sample dataset drawn from the domain of Fair Trade certification of coffee grown in Mexico, (2) we used the ontology-based standards to publish this dataset in the form of an RDF triple store, (3) we generated SPARQL queries to determine if we could retrieve the answers to the 28 use case questions from the online published data (and if not, why not), (4) we summarized our results in terms of how many of the 28 use case questions could be answered with what level of assuredness and accuracy, and (5) we tested some limited reasoning capabilities to see if an inference-based system could distinguish between several datasets with known differences in quality and trustworthiness.

The testing process has been run against four datasets stored using the CIDIBB architecture: an Ideal Benchmark certification and inspection dataset and three certification schemes including FLO, Dave and Nic, and Nonviolent Dove. "Ideal Benchmark" certificate characterizes a hypothetical virtual certificate that could answer 100 % of the questions posed by the use case. FLO certificate dataset represents a high-quality virtual certificate. "Dave and Nic" and "Nonviolent Dove" are two synthetic certificates that represent degrees of greenwashed data. We created these two levels of greenwashed data by eliminating some key inspection data, not specifying criteria, or taking other shortcuts in the full certification and inspection process.

Answers to the 28 use case questions for each of the four datasets produced a unique distribution across the three classified levels (see Fig. 5.3). Differences in the level of difficulty required to retrieve the answers to these 28 questions can be used to assess the relative trustworthiness of various certification and inspection processes. Our test results clearly differentiate trustworthy virtual certificate datasets and datasets that yield less trustworthy virtual certificates.

Our results clearly distinguish between high-quality FLO data and data from the other virtual certificates that were missing answers to many of the detailed questions in the use case (See Fig. 5.3). We added an "Ideal Benchmark" certificate to characterize a hypothetical virtual certificate that could answer 100 % of the questions posed by the use case.

Tautologically, the Ideal Benchmark provides answers to all 28 questions in the use case, whereas the FLO certificate answers 19 of the questions; the lightly greenwashed certificate ("Dave and Nic") answers ten of the questions, and the heavily greenwashed certificate answers only seven of the detailed questions in the use case. Because the ontology contains an elaborated and semantically meaningful description of what a normatively defined good certification and inspection system should contain and because the use case questions do probe into some detail, greenwashed systems cannot "hide" the fact that their certificates are based on shortcuts and less than rigorous methods. Notice especially the sharp decline in questions that can be answered directly by SPARQL queries. By testing the criteria using both SPARQL and DL queries, we are able to demonstrate that not only is CIDIBB able to test the trustworthiness of certification schemes but also that our ontology generates consistent results.

Our empirical results show that the structure of CIDIBB provides a framework to evaluate the trustworthiness of different certification schemes. The CIDIBB architecture can support a system that integrates and exchanges massive amounts of

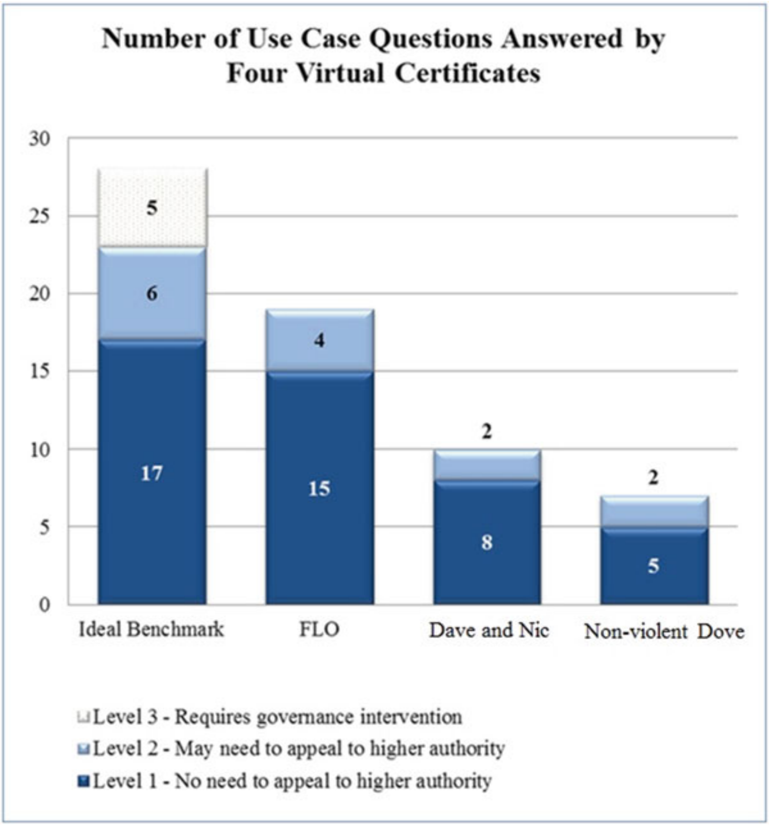

Fig. 5.3 The result of empirical testing of the certification schemes into the CIDIBB benchmark for trustworthiness

dispersed data about product certification and inspection schemes using semantically structured triple stores and allows consumer advocates, such as Lucy, to directly query such data for answers to the 28 use case questions and to use those answers to inform consumers, such as Ellen, about the trustworthiness of the certificates on the products and services she plans to purchase.

As discussed immediately above, a skilled human user of our CIDIBB can exhaustively query the existing data for multiple certification schemes, paying close attention to all 28 use case questions to arrive at the results presented in Fig. 5.3. Because of the use of semantic technologies, the manual process described above can be automated to classify a certification scheme as of four types (A through D) where an "A" classification is compatible with highly trusted data (again as defined by the 28 use case questions) and "D" classification is compatible with heavily greenwashed certification processes. Table 5.1 presents the results of our automatic classification of trustworthiness for the four datasets.

Table 5.1 The automated trustworthiness ranking of three certification schemes using the CiTruST ontology and reasoning

No	Certification scheme	Trustworthiness rating
1	FLO Labeling International (Flo-Cert)	A
2	Dave and Nic Certification	C
3	Nonviolent Dove Certification	D

5.6 Discussion: Vignettes Illustrating How a Certification and Inspection Data Infrastructure Building Block (CIDIBB) Might Be Used to Create Virtual Certificates

The components described above create a whole that is greater than the sum of its parts. These components constitute a "Certification and Inspection Data Infrastructure Building Block" (CIDIBB) that can be used to support the sharing of diverse datasets to meet multiple needs in the supply chain that feeds the consumer marketplace. We support this claim with four vignettes, illustrating how such a platform, based on semantic web technologies, might enhance the efficiency of the consumer marketplace.

5.6.1 Vignette #1: A Certifying Organization Uses CIDIBB to Create a New Virtual Certificate

William is the cofounder of CyberJustTrade (CJT), a start-up certification agency. As someone who is well trained in both sustainable marketing and economics, and who is knowledgeable about information systems, William understands the importance of differentiation strategy. Thus, he envisioned the creation of first-ever virtual sustainable certification scheme as the company's lever to compete against other much bigger certification agencies. His extensive observations and research on current certification schemes lead to an understanding of the lack of transparency in the current system. Based on this, he and his cofounder plan to enrich end consumers' purchasing experiences by providing a sustainable certification label that has three distinct functionalities: (a) enables instant traceability of certification information, (b) enables comparison against other certification schemes, and (c) provides increased transparency on certification information. William and his cofounder soon confronted three major challenges to their efforts: (a) the ownership of certification information is in the hands of the applicant and not the certification agency, (b) commercial privacy related to certification data for each firm in a supply chain, and (c) provision of instant traceability and comparability requires the availability of standardized data across supply chain firms and other certification schemes.

Upon discovering CIDIBB, William realizes it can help his certification agency in overcoming the abovementioned challenges. By requiring the applicant to store their data in CIDIBB compliant format, it will enable CJT to extract consistent and standardized information across the entire supply chain. Since CIDIBB is based on CerTIN global ontology, CJT could set up the level of abstraction of the data that needs to be extracted from the supply chain. By setting the level of abstraction to a higher level, CJT could evade the problem of commercial privacy. Since CIDIBB as a framework is equipped with well-established collaborative governance, the use of CIDIBB also solves the data ownership issue. The ability of CIDIBB to facilitate retrieval of consistent and standardized data supported with a trustworthiness ontology enables the CJT to easily compare the trustworthiness of different certification schemes against CJT certification and then to sell the comparison information.

5.6.2 Vignette #2: A Consumer Advocate Uses CIDIBB to Create a New Product or Service Rating System

Lucy is the CEO of a well-established product rating firm. Lucy's firm is an information aggregator that harvests information about sustainable consumer products and publishes proprietary product ratings (organized by UPC code). The firm has created a number of apps that allow consumers to access the product ratings, while they are shopping either in a physical store or online. Their business model is to sell a low cost-subscription to their service to individual consumers. One of the early entrants into their market niche was the GoodGuide product rating system.[5]

Figure 5.4 shows the architecture Lucy can use to build a CIDIBB-based product rating system. Consumer values are expressed as concerns and questions, which can be translated into machine-understandable queries. These queries are executed against standardized data and semantically enriched by CIDIBB ontology. For example, some consumers may be concerned if child labor was used during production processes (see Sect. 5.3). This concern can be translated into a machine-understandable query as presented below:

*If<NoEmployementOfChildrenUnderAgeOf15 hasEvaluationDecision**some**'EvaluationDecision'>and*
*<NoEmployementOfChildrenUnderAgeOf15 hasCriteriaType**value**"Core Criteria">and*
*<NoEmployementOfChildrenUnderAgeOf15 hasTimeline**value**"Initial Audit">and*
*<NoEmployementOfChildrenUnderAgeOf15 hasApplicability**value**"Members of Organization">and*
*<NoEmployementOfChildrenUnderAgeOf15 hasIndicator**value**"There are no Children under the age of 15 years employed">*

[5] GoodGuide is an actual product rating service that provides consumers with information about the health, environmental, and social performance of products and companies. http://www.goodguide.com

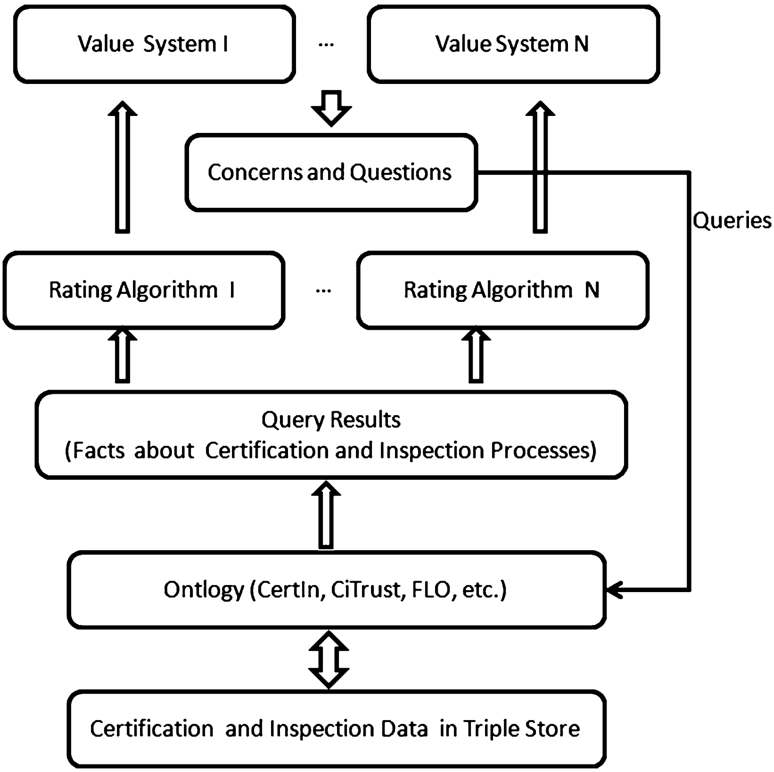

Fig. 5.4 CIDIBB-based product or service rating system

If the returned query result is true, then it means that no child labor was used in the production of the good. Query results are then fed into the rating algorithm. The output of the algorithm is one or more ratings that reflect the value of the good or service according to a particular value system.

5.6.3 Vignette #3: A Producer Featuring Sustainable Products or Services Creates Databases that Are CIDIBB Compliant

Carlos intends to reorient his mango producing farm in Central America to a farm that produces products that can be exported to premium consumer markets in the United States, Canada, and the EU.

Carlos recognizes that having multiple virtual certificates attached to his mangoes is key to the success of his export business. He wants his mangoes to be Fair

Trade certified, USDA organic certified, Shade Grown Certified, as well as being certified with a number of new virtual certificates that have emerged in the past several years (see Vignette #1 above). Carlos intends to manage all aspects of his business so that details of his operations, all of which are being inspected by multiple certification and inspection organizations, will all be as open as possible to anyone and everyone who is interested in buying his products. As Carlos contemplates setting up his business and its information systems, he recognizes that broadcasting the certification information of his mangoes to the internet using the CIDIBB will be key to his ability to charge a premium price.

In order to broadcast this information, Carlos has two options, (1) he can reconstruct his databases to make them CIDIBB compliant, or (2) he can retrieve the certification and inspection data from existing databases, further improve the retrieved data, and make them CIDIBB compliant. Choosing either option, Carlos will be facing some technical challenges.

5.6.4 Vignette #4: TallMart Creates a Two-Sided Market Platform to Produce and Distribute Sustainable Products and Services

The strategic planning unit of TallMart corporation, a major retailer in the United States and the EU, has realized that about 14 % of its base market consists of "green consumers," individuals who are willing to pay a premium for products that they can trust have been produced in conditions that are consistent with their values.[6] TallMart recognizes the potential of the CIDIBB to bring trusted information into the consumer marketplace as well as the commercial potential of creating a "two-sided" marketing platform wherein retail consumers pay a premium for products that can be sold with CIDIBB-certified virtual certificates, while at the same time producers of sustainable products are willing to pay a fee to have information about their products distributed on TallMart's platform using the CIDIBB standard, as shown in Fig. 5.5.

5.7 Concluding Remarks

Global markets for information-intensive products contain sharp information asymmetries that lead to market inefficiencies, resulting in consumer purchasing decisions that are based on incomplete information. Unintended side effects of these

[6] Walmart has been working with suppliers on various sustainability initiatives. In 2009 they introduced a sustainable measurement system that tracks the environmental impact of products. See especially: http://corporate.walmart.com/our-story/ or http://corporate.walmart.com/global-responsibility/

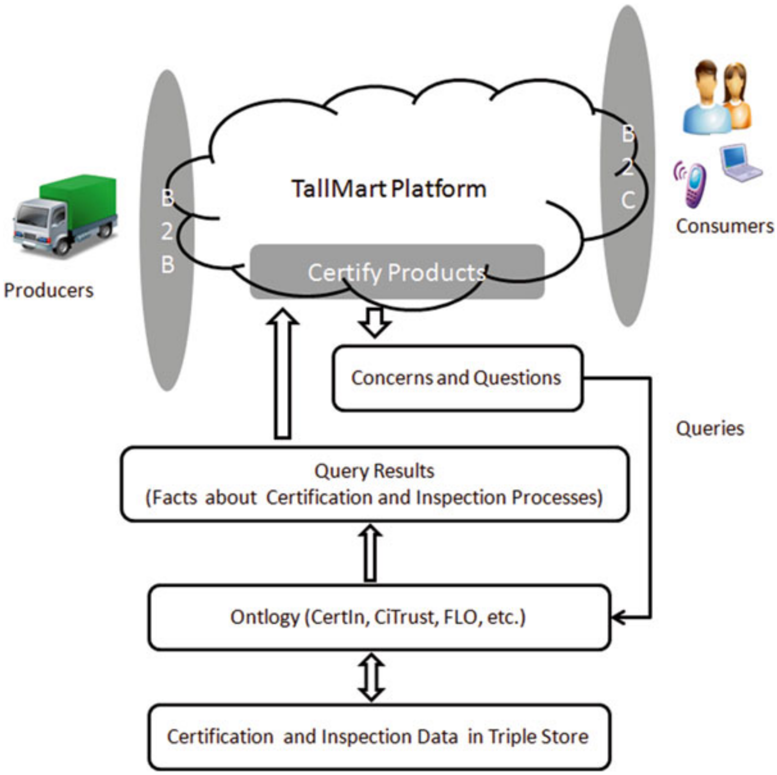

Fig. 5.5 TallMart platform

information asymmetries vary depending on the markets in question, ranging from negative externalities such as environmental degradation in the case of unsustainable production practices for agricultural products, loss of human capital in the case of exploitative labor practices, or unfavorable patient outcomes in the case of incomplete information about the quality of care provided in different healthcare settings. Elimination or reduction of such information asymmetries has long been the goal of governments as well as various nongovernmental entities that recognize that addressing issues such as sustainable production, socially just labor practices, and reduction in energy needs and health expenditure is closely linked to consumers who are fully aware of the economic, environmental, and social impacts of their purchasing decisions.

Our current research explored creation of ontology-enabled interoperable data infrastructure, based on the semantic web that would enable information sharing in traditionally information-restricted markets. Throughout the 3-year project, we explored the feasibility of tagging and broadcasting a diverse and dispersed set of data from product certification and inspection processes to allow for assessment of their accuracy and trustworthiness. The main technical result of our project is a proof-of-concept Certification and Inspection Data Infrastructure Building Block (CIDIBB), which is a set of data standards built on semantic web applications and the functionalities of a formal ontology of the certification and inspection process. While the current proof of concept focuses narrowly on certified fair-trade coffee and its functionality is limited, it has the potential for becoming universally applicable to any certification and inspection process for any product and service.

Achieving universal applicability of the CIDIBB, however, requires a series of steps aimed at refinement and broadening of our existing proof of concept and gradually increasing the scope of products and services. The first step is to further refine and test a full prototype in the original area of its focus, namely, certified fair-trade coffee. Such refinement and testing requires access to real-world certification and inspection data. The second step is the application of the refined CIDIBB to other certifications surrounding coffee, such as organic, to test the applicability of our Certification and Inspection Ontology (CerTIN) to other certification schemes. The continual focus on coffee takes advantage of our domain expertise and allows us to test CIDIBB's ability to address comparability of different certification schemes. If such buildup is successful, the next step toward testing for universal applicability is to incorporate other agricultural products that might require different inspection processes. Finally, the last step toward universal application is to use the existing CIDIBB for nonagricultural domains.

Making CIDIBB a reality requires integration of data and information that is under the ownership and stewardship of public and private entities. In this way, many nontechnical requirements also need to be met. While information quality and integrity have always been an issue of concern even in situations with a single information source, it will be an even more complex problem in the case of a platform that is designed to integrate information from multiple disparate sources. Thus, creating technical and process mechanisms to ensure information integrity and security is essential for the data to be trustworthy. Moreover, designing information policy that balances the need for supply chain transparency and ability of businesses to remain competitive is key. Establishing a governance structure is crucial for all large system development projects, but perhaps especially so for the development of platforms dealing with the complex determinants of sustainability such as CIDIBB. The key to this process is establishing a basis for "principled engagement"—a common understanding of the ways in which different stakeholders use central concepts and terms (Emerson, Nabatchi, & Balogh, 2012).

By making our proof-of-concept CIDIBB operational, we would provide, for the first time, a way for end users to reduce sharp information asymmetries in consumer markets through access to certification and inspection information in areas as widely dispersed as the performance of a healthcare provider, energy consumption patterns, or the safety of products we use each day in our daily routines.

References

Albersmeier, F., Schulze, H., Jahn, G., & Spiller, A. (2009). The reliability of third-party certification in the food chain: From checklists to risk-oriented auditing. *Food Control, 20*(10), 927–935.

Arora, R. (2006). Product positioning based on search, experience and credence attributes using conjoint analysis. *Journal of Product & Brand Management, 15*(4/5), 285–292. http://doi.org/10.1108/10610420610685695.

Berners-Lee, T. (2006, July 27). *Linked data*. Retrieved from Berners-Lee, T. (2006). *Linked data*. Retrieved from http://www.w3.org/DesignIssues/LinkedData.html

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic web. *Scientific American, 284*(5), 34.

Bizer, C., Heath, T., & Berners-Lee, T. (2009). *Linked Data – The Story So Far: International Journal on Semantic Web and Information Systems, 5*(3), 1–22. http://doi.org/10.4018/jswis.2009081901.

Bray, J., Johns, N., & Kilburn, D. (2011). An Exploratory Study into the Factors Impeding Ethical Consumption. *Journal of Business Ethics, 98*(4), 597–608. http://doi.org/10.1007/s10551-010-0640-9.

Deaton, B. J. (2004). A theoretical framework for examining the role of third-party certifiers. *Food Control, 15*(8), 615–619. http://doi.org/10.1016/j.foodcont.2003.09.007.

Dimitri, C., & Greene, C. (2002). *Recent growth patterns in the U.S. organic food markets. Economic Research Service* (No. #AIB-777). Washington, DC 20036: US Department of Agriculture (USDA). Retrieved from http://www.ers.usda.gov/media/255720/aib777fm_1_.pdf

Emerson, K., Nabatchi, T., & Balogh, S. (2012). An integrative framework for collaborative governance. *Journal of Public Administration Research and Theory, 22*(1), 1–29. http://doi.org/10.1093/jopart/mur011.

Gefen, D., Pavlou, P. A., Benbastat, I., McKnight, H., Stewart, K., & Straub, D. W. (2006). ICIS panel summary should institutional trust matter in information systems research? *Communications of the AIS, 17*, 205–222.

Goleman, D. (2009). *Ecological intelligence: How knowing the hidden impacts of what we buy can change everything* (1st ed.). New York: Broadway Books.

Graham, M., & Haarstad, H. (2011). Transparency and development: Ethical consumption through web 2.0 and the internet of things. *Nformation Technologies & International Development, 7*(1), 1–18.

Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition, 5*(2), 199–220. http://doi.org/10.1006/knac.1993.1008.

Jahn, G., Schramm, M., & Spiller, A. (2005). The reliability of certification: Quality labels as a consumer policy tool. *Journal of Consumer Policy, 28*(1), 53–73.

Jarman, H., et al. (2011). *I-choose: Consumer choice, digital government, and sustainability in North America*. Presented at the APPAM Fall Research Conference. Washington, DC.

Kim, G.-S., Lee, G. Y., & Park, K. (2010). A cross-national investigation on how ethical consumers build loyalty toward fair trade brands. *Journal of Business Ethics, 96*(4), 589–611. http://doi.org/10.1007/s10551-010-0486-1.

Luna-Reyes, L. F., Zhang, J., Roy, R., Andersen, D. F., Whitmore, A., & Andersen, D. L. (2013). Information strategies to support full information product pricing: The role of trust. *Information Polity: The International Journal of Government & Democracy in the Information Age, 18*(1), 75–91.

Makower, J. (2010, November 1). *Is TerraChoice Greenwashing?* Retrieved from http://www.greenbiz.com/blog/2010/11/01/terrachoice-greenwashing

Powell, W. (1996). Trust-based forms of governance. In T. Tyler & R. M. Kramer (Eds.), *Trust in organizations: Frontiers of theory and research* (pp. 51–67). Thousand Oaks, CA: Sage Publications.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Review, 23*(3), 393–404. http://doi.org/10.5465/AMR.1998.926617.

Sayogo, D. S., et al. (Forthcoming). Ontological modeling of certification and inspection process to support smart disclosure of product information. *International Journal of Public Administration in the Digital Age*.

Shapiro, D. L., Sheppard, B. H., & Cheraskin, L. (1992). Business on a handshake. *Negotiation Journal, 8*(4), 365–377.

Tanner, B. (2000). Independent assessment by third-party certification bodies. *Food Control, 11*(5), 415–417. http://doi.org/10.1016/S0956-7135(99)00055-9.

TerraChoice. (2010). *Greenwashing Report 2010*. Retrieved from http://sinsofgreenwashing.org/findings/greenwashing-report-2010/index.html

Uschold, M., & Gruninger, M. (1996). Ontologies: Principles, methods and applications. *Knowledge Engineering Review, 11*(2), 93–136.

Watts, S., & Wyner, G. (2011). Designing and theorizing the adoption of mobile technology-mediated ethical consumption tools. *Information Technology & People, 24*(3), 257–280. http://doi.org/10.1108/09593841111158374.