Productpedia – A Collaborative Electronic Product Catalog for Ecommerce 3.0

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Abstract. Despite the advancements made in ecommerce technologies over the past years, the inability to define and exchange semantically rich and accurate product information among ecommerce websites/applications has continued to intrigue researchers. This problem has taken on greater urgency because it impedes the realization of the full benefits of Ecommerce 3.0. The present research conceptualizes, designs and implements a cloud computing-based platform that enables global merchants to maintain a collaborative Electronic Product Catalog (EPC) known as Productpedia. This collaborative EPC platform addresses numerous shortcomings of prior researches by (1) maintaining a single centralized EPC database; (2) negating the need to synchronize and convert data; (3) creating an integrated meta-model ontology for merchants to define previously unclassified product information without the involvement of domain experts; and (4) enabling an Open Application Programming Interface based on RESTful web services to facilitate direct modification of the EPC database by even third-party applications.

Keywords: Electronic product catalog · Ecommerce · Web 3.0 · Web service · Design science

1 Introduction

An enduring and intriguing problem in ecommerce is the defining and exchanging of semantically rich and accurate product information [1–4]. Specifically, unstructured product information (e.g., product categories, descriptions, attributes and attribute values) that are readily understandable by human buyers and sellers cannot be automatically processed by ecommerce websites and applications easily [3]. Even when structured product information is available, it is at best an arduous if not impossible endeavor to exchange them among different ecommerce websites and applications [4]. For instance, even though major ecommerce websites such as Amazon.com and CNET Shopper have their own structured product information catalogs, these are closed catalogs that cannot be shared and modified outside of the respective website.

The lack of common and sharable structured product information impedes the development of ecommerce in the Web 3.0 era of semantic web, which is characterized by automated software agents that are capable of performing tasks on behalf of users using structured sharable data. This problem requires urgent attention as proponents of

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Ecommerce 3.0, a loose term for describing the third generation of ecommerce in the Web 3.0 era, have noted its huge potential. For instances, Ecommerce 3.0 is expected to enable data-driven interactions across multiple devices and touch points [5], and extensible ecommerce web services [6].

This research applies the design science framework and guidelines put forth by Hevner and his colleagues [7] to conceptualize, design and implement a cloud computing-based platform that enables global merchants to maintain a collaborative Electronic Product Catalog (EPC) known as Productpedia. Whereas a standard EPC caters only to a single standalone ecommerce application, the envisioned collaborative EPC potentially allows the merchants of a large number of ecommerce applications on a global scale to contribute product information with a common ontology for describing products and services as well as facilitating ecommerce sales transaction. The choice of a cloud computing-based architecture allows the collaborative EPC platform to be dynamically scalable and highly reliable [8]. In gist, Productpedia possesses the ability to help ecommerce merchants and service providers to realize the full potential of Ecommerce 3.0.

2 Theoretical Background

2.1 Ecommerce and Structured Product Information

The late 1990 s to early 2000 saw the rise of the integrative ecommerce web-era [1]. This era was characterized by an emphasis towards integration and interoperability of various electronic business processes such as electronic supply chain management and electronic customer relationship management among different websites. The integrative web-era is only possible if information can be shared among ecommerce websites [1]. To achieve information sharing, it is necessary to have a standardized way of representing information, e.g., Extensible Markup Language (XML), such that it may be readily extracted, used and reused. In particular, XML-based web services hold the promise towards enabling online business processes that facilitate sharing and reuse of information among websites. The proposed collaborative EPC platform, i.e., Productpedia, will primarily consist of a shared database of product information constructed using a XML-based data standard. A set of RESTful web service-based Open Application Programming Interface (API) will be provided by the collaborative EPC platform for developers to build new tools around it, i.e., any ecommerce applications or websites, such that anyone can easily contribute to the collaborative EPC.

The typical functionalities provided in an ecommerce website may be classified into seven categories [9]. Several of these functionalities may be directly or indirectly supported by an EPC. Content management from a seller's perspective involves managing information about the product items that are sold on an ecommerce website. This is the key focus of Productpedia, which not only includes a standardized ontology for describing products but also how the product information will be stored and assessed via the cloud, and reused by sellers across multiple ecommerce websites/applications. From the buyers' perspective, content management may refer to the browsing of product information and aggregating information from multiple sources

for comparison. In a standard EPC context, a buyer may only browse the product offerings in an EPC of a particular ecommerce website but is not aware of other similar offerings from other websites. A structured and sharable collaborative EPC allows service providers adopting Productpedia to provide recommendation agents that will help consumers to search for product information across multiple websites [10]. Merchandising refers to the placement of online advertisements, launching of up-sell or cross-sell promotions, and making product recommendations to consumers. Productpedia provides an avenue for sellers to implement multiple forms of negotiation across multiple websites using a single set of product information obtained from Productpedia.

2.2 Prior Works on Collaborative Electronic Product Catalog

The concept of a collaborative EPC such as Productpedia has been explored by prior researchers to varying extent. Schubert put forth the idea of a Participatory Electronic Product Catalog (PEP) to transform standard EPCs into trust-building entities that allow different stakeholders to leverage the social benefits in a virtual community of transaction [3]. The core component in Schubert's PEP architecture consists of a mediating EPC that is capable of combining different single merchant catalogs into one integrated EPC [3]. The PEP thus contains the aggregated product information of multiple merchants, which can then be utilized to provide value-added services to customers of these merchants. Collectively, the merchants, other service providers and customers form the virtual community of transaction.

Within this virtual community of transaction, the PEP architecture facilitates the provision of sophisticated value-added services such as enhanced recommendation service that returns aggregated results from different websites when customers search for desired items matching certain criteria. These advanced features are made possible by the mediating EPC of the PEP architecture, which provides an integrated source of structured sharable product information aggregated from multiple merchants.

However, Schubert's PEP architecture suffers from several problems [3]. First, the PEP architecture relies on an intermediate software component to integrate product information from multiple sources into the mediating EPC. This process requires continuous periodic synchronization between the single merchant catalogs and the mediating EPC. Second, the structured product information is not truly sharable because each merchant that wants to utilize production information from the mediating EPC must perform two-way conversion between its internal data format and the mediating EPC's data format. Third, the PEP architecture does not cater to the direct definition and modification of product information thus hampering the collaborative construction of the mediating EPC. Fourth, the PEP architecture is a conceptual one that lacks implementation details.

Yoo and Kim proposed a concrete web-based knowledge management system for sharing product information among application systems within a design and production environment [4]. The authors based their work on the notion that product information inherently possess complex semantics and thus are difficult to share among application systems [11]. Consequently, the authors defined product information carefully as three different types of knowledge – namely metadata, ontology and mapping relationships.

A knowledge base system using software agents is then created to share the knowledge using XML-based technologies. This approach enables effective search of product information, and automatic translation and reuse of product information. For instance, product information encoded in one data format, e.g., STEP, may be converted into business data encoded in another data format, e.g., EDIFACT, for use in electronic data interchange.

Although Yoo and Kim's approach provides a viable solution for sharing structured product information, it involves highly specialized data formats, software technologies and business processes that are not suitable for adoption in a general ecommerce environment [4]. The present research on Productpedia adopts an approach that is similar to Yoo and Kim's but one that is more lightweight and can be readily adopted in any ecommerce environment.

Lee and his colleagues also observed that even though having a database of well-defined products and services is essential for collaborative ecommerce processes, scant research has focused on developing and deploying a workable technology in a real-world commercial environment [2]. The authors proposed and developed an ontology-based EPC system that adopts a multi-layered software architecture consisting of (1) an EPC database; (2) the ontology-based EPC system itself; as well as (3) interoperability with different external ecommerce websites that can download and synchronize updated product information automatically. The most noteworthy feature of the entire platform is the use of meta-modeling approach for capturing the product ontology, which enables a highly extensible and flexible product ontology model [12, 13]. A meta-model product ontology does not predefine the actual categories, relationships among categories or the attributes describing product items in the same category. Rather, it specifies the notion of product categories and attributes and how instances of categories and attributes may be created and associated with each other.

The ontology-based EPC system does not rely on specialized data formats and enable interfacing with external websites. However, it is essentially a closed catalog that is maintained by internal domain experts and cannot be modified by external stakeholders. In this regard, it is not suitable for a generic ecommerce environment characterized by heterogeneous marketplace participants. Productpedia builds upon the works done by prior researchers [2–4] but addresses their limitations.

3 Requirements Analysis and Design of Productpedia

3.1 Collaborative Electronic Product Catalog Architecture

Schubert's PEP architecture is largely based on a mediating EPC that integrates different single merchant catalogs together [3]. The Productpedia collaborative EPC differs significantly from the PEP architecture. In the case of Productpedia, there exists only a single EPC that contains the original definitions of all product information directly contributed by different stakeholders in a collaborative manner. An overview of the proposed architecture of the Productpedia collaborative EPC is shown alongside the PEP architecture in Fig. 1. Productpedia's architecture addresses the shortcomings of the PEP architecture. In particular, structured product information is directly defined

in a single source using a common data standard and can be shared without any conversion. This approach resembles Yoo and Kim's knowledge base system architecture [4], and Lee and his colleagues' ontology-based EPC system architecture that both feature centralized metadata and ontology management [2].

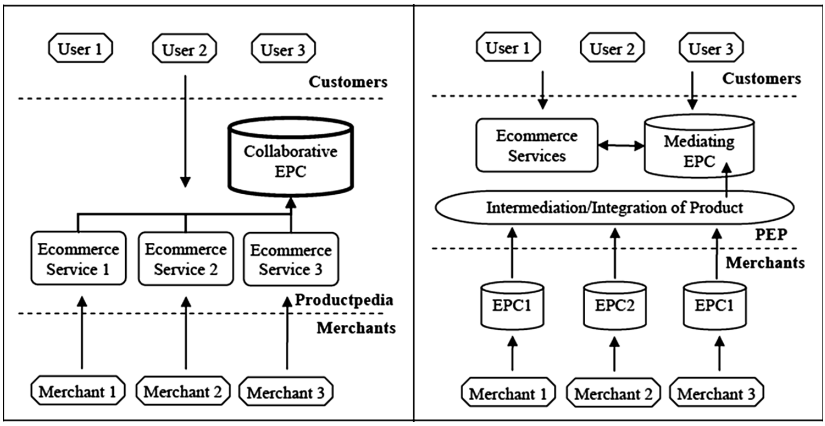

Fig. 1. Overview of the Productpedia collaborative EPC architecture (left) and Schubert's PEP architecture [3, p. 231] (right).

Productpedia's collaborative EPC will be exposed to external stakeholders via a multi-layered software architecture similar to Lee and his colleagues' ontology-based EPC system architecture [2]. A multi-layered software architecture is chosen because it enables greater flexibility, extensibility and scalability in adding new software components to provide new services in the future [14]. For instance, recommendation, collaborative filtering and data analytics components may be layered on top of the collaborative EPC to realize the full potential of Ecommerce 3.0 as envisioned by researchers and practitioners, e.g., [5, 6]. Specifically, Productpedia will follow a multi-layered web service architecture to provide a user-centered, interactive and collaborative EPC ecosystem. In addition, it adopts a semantic web approach to enable third-party software tools to be built around the structured product information residing in the cloud.

A complete architecture of the Productpedia collaborative EPC platform is shown in Fig. 2. At the core of the Productpedia platform are the meta-model ontology and the EPC database for describing the semantics of the product information and the actual product information using XML. The database is maintained by a core backend system. The core backend system handles critical functional logic and operations of the entire information system platform.

There are two non-trivial differences between Productpedia's architecture and those of prior researchers [2, 4]. First, Productpedia will be made open-source so that it may be maintained by all stakeholders in a collaborative fashion. A set of Open API based on RESTful web services, a type of software architecture for distributed systems using

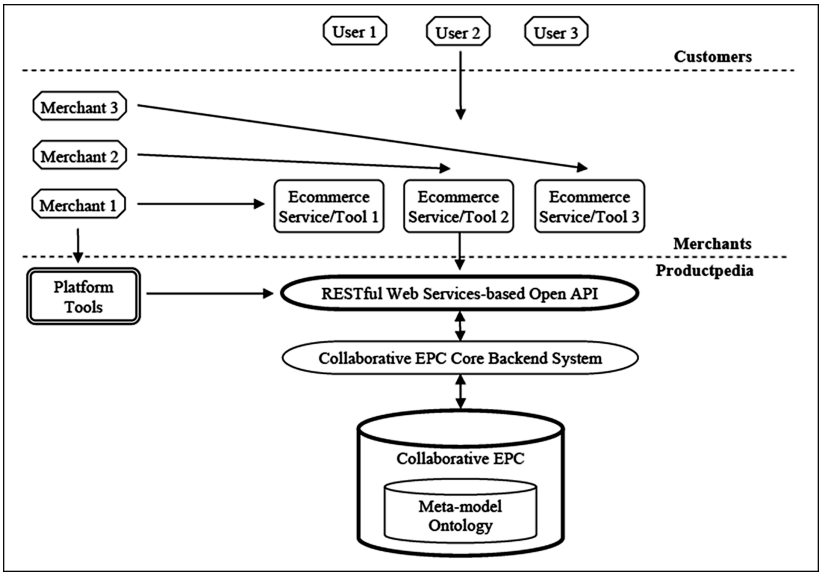

Fig. 2. Complete architecture of the Productpedia collaborative EPC platform

the Hypertext Transfer Protocol and the concept of representational state transfer, will be used to expose the meta-model ontology and EPC database to stakeholders. The Open API will contain a set of web service methods that enable websites and software tools to retrieve product schema and manipulate product information. Individual and organizational stakeholders can choose to interact with the collaborative EPC using a set of primary platform tools, or create their own software tools using the Open API. The latter approach allows the collaborative EPC to be seamlessly integrated into any new or existing ecommerce applications, including lightweight mobile devices, social networking applications and mashup applications.

Second, Productpedia's collaborative EPC includes an open meta-data ontology that allows any stakeholders to create and maintain the product ontology and relationships. The notion of internal domain expert does not exist and stakeholders operate collaboratively as peers to define the ontology. The differences between Productpedia' architecture and those of prior researches are summarized in Table 1.

3.2 Collaborative Electronic Product Catalog Design

Providing consumers with online tools to search and filter product information has long been highlighted as a critical success factor for ecommerce. Unfortunately, this is a non-trivial task because online merchants use vastly different product descriptions, albeit rich in information, and nonstandard formats to present these descriptions. Consequently, designing and implementing useful online tools to help consumers find products and services that meet certain attributes or for merchants to locate potential buyers of a particular trait has proven to be an elusive challenge [15].

Table 1. Comparison between Productpedia collaborative EPC platform and prior research

Dimension	Productpedia collaborative EPC	Schubert's PEP	Yoo and Kim's Web-based KM system	Lee et al.' Ontology-based EPC
Architecture	Concrete	Conceptual	Concrete	Concrete
Single centralized EPC	Yes	No	Yes	Yes
Data synchronization	No	Yes	No	Yes
Data conversion	No	Yes	Yes	No
Specialized data formats	No	No	Yes	No
Domain experts involvement	No	No	No	Yes
Single centralized ontology	Yes	No	Yes	Yes
Open platform supporting direct modification	Yes	No	No	No

Researchers acknowledging product information heterogeneity as a major impediment factor to business information exchange have proposed two general approaches to resolve this problem [16]. The first approach is standardization, which involves creating common vocabulary and protocol to be adopted by all parties involved in a business exchange. The United Nations Standard Product and Services Codes (UNSPSC) (http://www.unspsc.org) provide a global standard to classify products and services in a hierarchical fashion. However, it does not define the attributes for describing each commodity. eCl@ss (http://www.eclass.de) is a competing standard for product classification and description. Similar to UNSPSC, eCl@ss aims to facilitate information exchange between customers and their suppliers. eCl@ss is better because it attempts to provide a set of attributes to describe each product class. However, when compared to commercial shopping websites such as CNET Shopper.com (http://shopper.cnet.com), the predefined set of attributes is often less rich in details. The second approach is integration [16], which involves building mappings among product attributes from different product descriptions. In the context of integration, heterogeneity among different product schemas can be classified as either attribute naming conflicts or missing attributes. These problems are further complicated if the product schemas are multi-level trees [16].

Productpedia attempts to resolve the product information heterogeneity problem by adopting a standardized approach towards meta-model product ontology. A set of XML-based web service methods will be used by its community of stakeholders to define and maintain structured product information in an open and collaborative fashion similar to how articles on the Internet's largest free encyclopedia Wikipedia (http://www.wikipedia.org) is created and maintained. That is, to build upon the collective wisdom of Productpedia's community to create and maintain a useful

collaborative EPC just like how Wikipedia's volunteers have come together to maintain the hundreds of thousands of quality articles [17]. Neither domain experts nor a central authority is required to predefine the product categories, schemas and items. Productpedia's primary website as well as all third party websites and applications developed with its Open API will utilize this common set of XML-based product schemas to exchange product information. The added benefit of an open and collaborative approach is to allow the Productpedia community of stakeholders to create a rich set of attributes for each product category of interest to them, and presumably one in which they possess the relevant expertise. Ultimately, Productpedia collaborative EPC may become as comprehensive as global standards such as UNSPSC and eCl@ss, and as rich in details as private product schemas.

Productpedia's collaborative EPC ontology will be based on a single-level tree product schema model. Design provisions will be made to enable integration with users' existing product schemas or descriptions, if necessary, by making all attributes optional and allowing the definition of aliases for each attribute.

4 Design Science Artifacts of Productpedia

The design science research guidelines prescribed by Hevner, March, Park and Ram (HMPR) [7] have often been used by scholars to analyze and evaluate design science research [18]. In accordance with HMPR's design as an artifact guideline, "design science research must produce a viable artifact in the form of a construct, a model, a method or an instantiation" [7, p. 83]. Constructs are the concepts that form the research domain's vocabulary. Models are a set or propositions or statements expressing relationships among constructs. Methods are a set of steps used to perform a task. Instantiations are realized information systems built according to the specification of the three preceding artifacts.

Each higher-level artifact builds upon the lower level artifacts in an implied linear hierarchical manner [18]. In particular, the instantiation artifact involves a fully functional prototype of the Productpedia collaborative EPC platform together with the primary website that was developed with the Open API. Collectively, the instantiation artifact demonstrates the viability of Productpedia's community of stakeholders collaboratively maintaining the EPC, and also embodies all the lower level artifacts.

4.1 Construct

Ontology development is an approach commonly used in design science research that focuses on construct artifact [19, 20]. Ontology is a formal representation of knowledge as a set of related concepts within a domain. It is intended to facilitate interoperability among various information processing applications [21].

In our context, we attempt to define a meta-model ontology for a collaborative EPC platform. This is focused on the two major dimensions of ecommerce functionalities [9], namely content management and merchandising. The ontology is depicted in Fig. 3. A detailed vocabulary specification for the ontology has also been defined. For

instance, a product category "represents a classification of related product items exhibiting a common set of properties". This model follows the basic meta-model [2, 12, 13]. The inclusion of product category and product schema allows merchants to define new product items that are currently not categorized in the EPC.

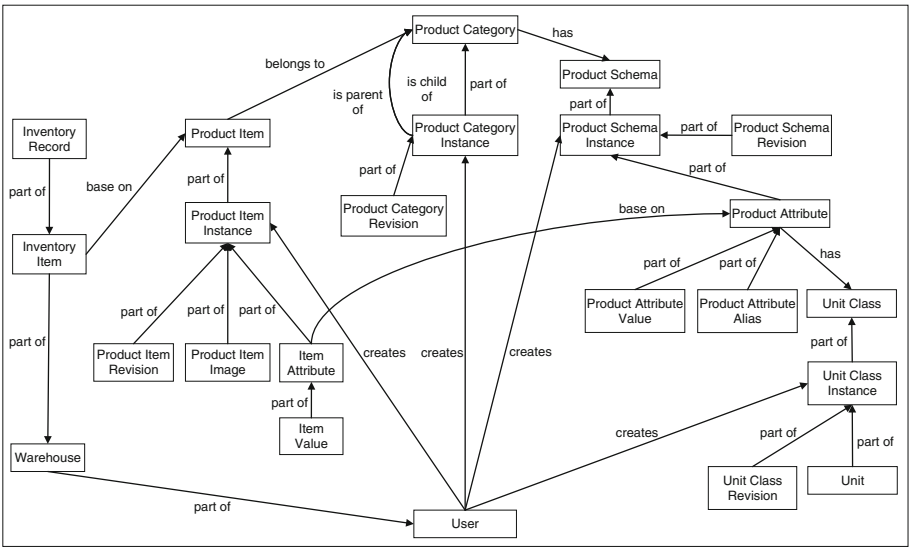

Fig. 3. Ontology for content management and merchandising ecommerce functionalities provided for by the Productpedia collaborative EPC platform.

4.2 Models

The ontology that has been described in the preceding sub-section forms the foundation to define the relationships among the constructs for a collaborative EPC. Unified Modeling Language (UML) is chosen to depict the models as it is the industry standard for object-oriented modeling [22]. UML class diagram is also more intuitive for depicting superclass and subclass concepts as compared to enhanced entity relationship diagram since it is (1) congruent with the objected-oriented programming paradigm; and (2) independent of the underlying data storage. Object-oriented programming itself is ideal for developing large and complex software system such as the platform proposed in this research.

The UML class diagrams represent both the solution to the information requirement analysis of the preceding chapter and the problem definition for the information system design task of the instantiation artifact. It essentially serves as reference logical data models for the development of the proposed platform. In accordance with the design characteristics discussed in the preceding section, the corresponding model for the subset of the ontology on product category shown in Fig. 3 is depicted in Fig. 4.

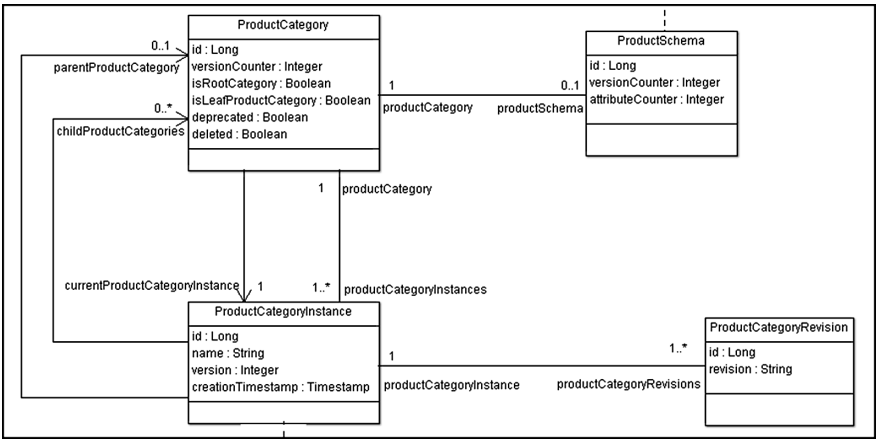

Fig. 4. Model for the product category ontology

4.3 Methods

The logical data models produced in the preceding sub-section form the basis for prescribing how various product information management tasks should be performed in the Productpedia collaborative EPC platform. Since the platform is based on an Open API architecture using RESTful web services, a series of API web service methods are carefully defined that allow an ecommerce application to interact with the collaborative EPC. This approach is similar to major commercial services such as eBay API (http://developer.ebay.com/common/api) and Amazon Marketplace Web Service (https://developer.amazonservices.com). In conjunction with the API methods, complementary processes are formulated to provide a reference implementation blueprint. Essentially, merchants contribute to the EPC by defining unit classes, product categories, product schemas for leaf product categories and product items. These components collectively constitute a shared EPC that community stakeholders can easily tap on to perform various ecommerce tasks such as creating a sales listing.

Since the collaborative EPC is a shared and distributed resource, the platform features several design characteristics to provide for an efficient and orderly management process. For example, each unique data record manifests as multiple instances and all revisions made to each instance of a unique data record are tracked and saved into the EPC database.

4.4 Instantiations

Instantiations operationalize the constructs, models and methods into the actual artifact that is used in the intended environment [7]. As part of this research, the constructs, models and methods defined in the preceding sub-sections were used to create a fully functional prototype of the proposed Productpedia collaborative EPC platform. It epitomizes the best practice recommended by design science scholars to the extent that

its design ideas have been implemented in concrete forms rather than exist as mere abstract entities [18]. A detailed technical discussion of Productpedia is beyond the scope of this paper. Briefly, the entire platform essentially manifests as a core backend system that is developed using Java Platform Enterprise Edition (Java EE) with component-based software engineering architecture for extensibility and scalability. This implementation approach is similar to how Lee and his colleagues' [2] had developed their ontology-based EPC. The prototype implements a total of 47 reference methods for managing unit classes, product categories, product schemas and product items in the collaborative EPC.

5 Conclusion

Researchers have for a long time highlighted an enduring problem with ecommerce, i.e., the ability to define and exchange semantically rich and accurate product information [1–4]. This research adopts a design science strategy to solve the problem by conceptualizing, designing and implementing a fully functional prototype of a collaborative EPC platform, i.e., Productpedia. This platform addresses the shortcomings of prior researches by (1) maintaining a single centralized EPC database; (2) negating the need to synchronize and convert data; (3) creating an integrated meta-model ontology for merchants to define previously unclassified product information without the involvement of domain experts; and (4) enabling an Open API based on RESTful web services to facilitate direct modification of the EPC database by even third-party applications. Productpedia holds the promise of empowering merchants to realize the full benefits of Ecommerce 3.0. For instance, its Open API is an example of an extensible ecommerce web service [6] that allows a merchant to define and share structured product information.

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