Towards a Framework for Knowledge-based Pricing Services Improving Operational Agility in the Retail Industry

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Abstract

Marketing research has identified several benefits of dynamic pricing models. For example, dynamic pricing in terms of inventory considerations and time horizons, bundling or personalized offerings has been found to increase sales volume, customer satisfaction and to skim reservation prices. However, today's retailers lack the capability to apply dynamic pricing models because of missing services that realize them and technologies such as smart product infrastructures that deliver the resulting prices to customers. Moreover, dynamic pricing models rely on various price parameters provided by several stakeholders such as retailers (e.g., inventory data), suppliers (e.g., recommended sales price), customers (e.g., buying history or products in the shopping basket), or the government (e.g., taxes). In this sense, interoperability between the price parameters of these stakeholders is required and can be addressed with the help of semantic technologies. Because unprecedented, our objectives are therefore to model, implement and evaluate a framework for pricing services that rely on explicit semantic descriptions and rules. We call them knowledge-based pricing services (KPS). In contrast to dynamic pricing models that are solely based on historical data about prices and customers, the knowledge-based approach uses logical statements to individualize a price. In the current work, we propose a conceptual model for KPS and exemplify its use for a personalized pricing scenario within an in-store shopping situation. Furthermore, we draw implications for business models in the retail industry to motivate the adoption of KPS. And finally, existing tools (e.g., ODRL-Services, SPDO or the Tip 'n Tell smart product infrastructure), which may play a major role for the implementation of KPS, are discussed in order to guide future work. This paper is therefore a first step towards the application of dynamic pricing strategies in retail stores that are based on explicit semantics and which have the potential to improve operational agility in the retail industry through an improved availability and quality of price information. Thus, KPS may foster the evolution of a new business ecosystem around pricing services.

Keywords: Pricing Service, Knowledge-based Framework, Retailing

1. Introduction

Today's retailers lack the capability of applying sales strategies that rely on an instant pricing of products. For example, dynamic pricing in terms of inventory considerations and time horizons (Elmaghraby and Keskinocak 2003, Gallego and van Ryzin 1994, Su 2007), bundling (Bitran and Ferrer 2007, Gaeth et al. 1991) or personalized offerings (Choudhary et al. 2005, Liu and Zhang 2006) have been found to increase sales volume, customer satisfaction and to skim reservation prices and should therefore be highly relevant to retailers; but time and costs limit frequent updates of price tags. Thus, pricing of products and bundles is rather static in retail stores today. Especially, personalized pricing is not feasible at all[1] and can only be indirectly applied with loyalty cards that promise discounts after or at the purchase. In this sense, retailers' operational agility, i.e., the ability to accomplish speed, accuracy, and cost economy in the exploitation of pricing strategies is strongly restricted (Sambamurthy et al. 2003, Kowatsch et al. 2008).

To address this challenge, a price delivery infrastructure and pricing services must be available. On the one hand, smart products could support the presentation of dynamic prices as they incorporate information technology for business purposes (Konana and Ray 2007, Maass and Varshney 2008). In contrast to Electronic Shelf Labelling Systems (Southwell 2002), the concept of smart products is more flexible because products can directly be identified through the attached barcode or RFID tag in order to request price information. Accordingly, smart product infrastructures (e.g., Tip 'n Tell, Maass and Filler 2007) and dynamic product interfaces (Janzen and Maass 2008a, Maass and Janzen 2007) can be used to present price information instantly to customers in retail stores. The adoption of these technologies by consumers is also promising as shown by recent studies (Kowatsch et al. 2008, Kowatsch et al. 2009, Maass and Kowatsch 2008).

However, on the other hand, the application of dynamic pricing models does not only require a delivery infrastructure but also a service platform for the management and configuration of pricing models. In particular, dynamic pricing models rely on various price parameters provided by different stakeholders such as retailers (e.g., inventory data), suppliers (e.g., recommended sales price), customers (e.g., buying history or products in the shopping basket), or the government (e.g., taxes). Thus, the evolution of a new retail ecosystem around pricing services is most likely if early adopters apply them. And similar to IT-based ecosystems like the App Store with Apple being the keystone (Iansiti and Levien 2004), also developers and providers of pricing services would be part of this new retail ecosystem (Tian et al. 2008). Figure 1 exemplifies a pricing service ecosystem in the retail industry.

Having a delivery infrastructure and a pricing service platform, retailers and their suppliers would be able to promote dynamic price information to their customers with all the benefits identified by marketing research (see above). This also implies an enhancement of operational agility in terms of improved availability and quality of price information in the retail industry. But bearing in mind many different stakeholders as shown in Figure 1, it is obvious that interoperability is a key challenge for a successful application of pricing services as it has been in IT for over two decades (Legner and Lebreton 2007). To address this challenge, the use of semantic technologies might be a solution as they enable an automated exchange and integration of semantically rich information (Maass and Lampe 2007). Correspondingly, there are three primary advantages for using semantics-based services: "they promote reuse and interoperability among independently created and managed services; ontology-supported representations based on formal and explicit representation lead to more automation; and explicit modeling of the entities and their relationships between them allows performing deep and insightful analysis" (Sheth et al. 2006, p. 56).

[1] This does not apply to high-cost or high-complex products such as individual software or cars. In this case, sales representatives begin negotiations with customers leading to personalized prices.

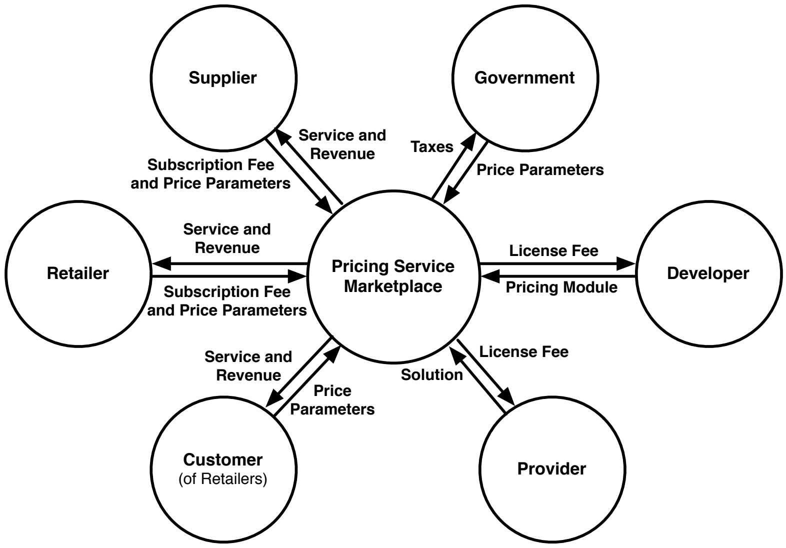

Figure 1. Example of an ecosystem for pricing services in the retail industry.
Note: The figure is partly adapted from Tian et al. (2008).

Because unprecedented, our objectives are therefore to model, implement and evaluate a framework for pricing services that rely on semantic descriptions and rules and that we call knowledge-based pricing services (KPS). The contribution of the current work is limited to the first step only. Therefore, we propose a conceptual framework for KPS and exemplify its use in the next section. Then, implications of KPS are drawn for business models in the retail industry to motivate their adoption. Afterwards, existing tools for the implementation of KPS are discussed in order to guide future work. Finally, we conclude this paper with a short summary.

2. A Framework for Knowledge-based Pricing Services

Our framework for knowledge-based pricing services (KPS) is based on the work of Spohrer et al. (2007), which discusses steps towards a theory of service systems. They claim that components of a service system are “people, technology, internal and external service systems connected by value propositions, and shared information” (ibid. p. 73). Consistently, our framework also comprises four components (cf. Figure 2). But no recursive definition of *service system* is used for ease of presentation and which is also consistent with the Ambient Media Framework (AMF). AMF is a recent model proposed by Maass and Varshney (2009) that can be used to design service-based IS environments.

According to Spohrer et al. and AMF, our framework consists of a Social System, a Service System, an Infosphere and a Physical Realization System. The Social System describes roles and objects in a shopping environment, e.g., people such as retailers, suppliers and customers or smart products. These roles and objects interact and communicate according to implicit or explicit pricing rules and protocols. Thus, the social system is strongly related to the concept of people as described by Spohrer et al. For their interactions and communications, role-taking actors and objects make use of pricing services provided by the Service System, which covers both internal as well as external service systems (see Spohrer et al. for further details). The Infosphere provides the semantics that are associated to entities of both the Social System and the Service System, whereas these entities are realized by appropriate Physical Realization Systems, e.g., a semantic web service for pricing bundles. Consistent with Spohrer et al., the Infosphere represents shared information of all entities within a service system whereas the Physical Realization System requires adequate implementation technologies.

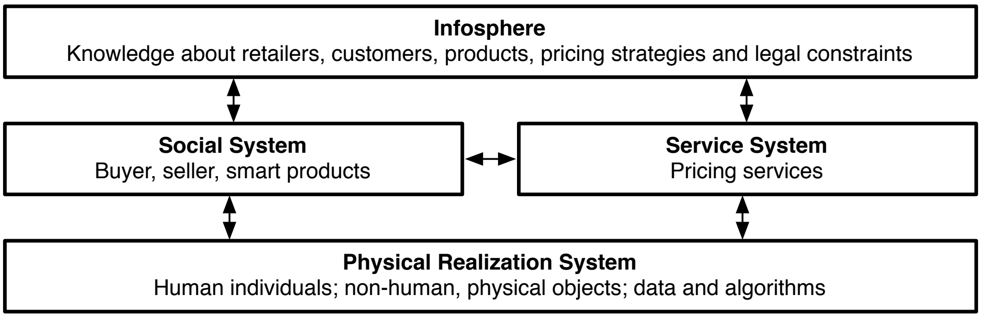

Figure 2. Framework for knowledge-based pricing services in the retail industry

Because it addresses the challenge of interoperability within a heterogeneous ecosystem as depicted in Figure 1, the main advantage of our framework lies in the semantics-based component, i.e., the Infosphere. This component is used to describe KPS and their interactions with people and smart products with explicit semantic descriptions and rules. In contrast to dynamic pricing models that are solely based on historical data about prices and customers (e.g., airlines pricing passenger seats), the knowledge-based approach relies on logical statements to determine a price. A literature review on pricing models reveals five domains of knowledge, which are relevant for a Pricing Infosphere. These domains cover knowledge about retailers, customers, products, legal constraints and pricing strategies. An overview of the domains with exemplary pricing aspects and supporting literature is given in Table 1. We briefly discuss each of these domains:

- *Knowledge about the retailer:* first, knowledge about the retailer covers pricing parameters that address his or her inventory management, individual terms and conditions for volume discounts or product bundles to name a few. Thus, these pricing parameters describe general requirements and constraints that are derived from the retailer's strategic goals.

- *Knowledge about the (individual) customer:* second, knowledge about an individual customer is predominantly required to implement personalized pricing strategies and thus relevant for KPS. For example, a retailer needs to know the buying frequency or sales volume of a customer to provide a discount if a loyalty programme belongs to the retailer's strategic goals. In contrast to knowledge about the retailer, which may also include information about customer segments, i.e., retailers' assumptions of customer segments, this domain focuses solely on information that is related to an individual customer.

- *Knowledge about the product:* the third knowledge domain addresses all information related to products a retailer offers, such as the product description or the recommended sales price as determined by the supplier or producer. But the information provided here can also be derived from other sources, e.g., review portals like DooYoo.co.uk, eOpinions.com, Ask.com or Amazon.com, which may influence the pricing of a product as well.

- *Knowledge about legal constraint:* this knowledge domain covers all aspects that are specific to a country and their policies related to pricing. For example, the information of value added taxes or customs duty belongs to this knowledge domain.

- *Knowledge about pricing strategies:* finally, without knowledge of pricing strategies in general, i.e., the required pricing parameters, effects on sales, fit with strategic goals of retailers, suppliers or producers, the implementation and application of pricing strategies would fail because they build a parenthesis for the other four domains. Correspondingly, the basic entity in a pricing marketplace will be services in the form of instances of these pricing strategies tailored for different retail industries.

All in all, each of these knowledge domains must be made explicit for interoperability reasons, such that the configuration and application of a specific pricing service reduces time and effort for all stakeholders shown in Figure 1, which would in turn increase operational agility in the retail industry.

Table 1. Five domains of knowledge, examples of their pricing aspects and supporting literature relevant for the implementation of knowledge-based pricing services

Domain of pricing knowledge	Examples of pricing aspects	Supporting Literature
Knowledge about the retailer	Terms and conditions, contract, stores, inventory, configuration of pricing strategies, assumptions about customer segments, sales observations	Aviv and Pazgal 2005, Bichler and Kalagnanam 2006, Chinthalapti et al. 2006, Choudhary et al. 2005, Elmaghraby and Keskinocak 2003, Gallego and van Ryzin 1994, Kelkar et al. 2002, Su 2007, Zhiqiang and Xiong 2008,
Knowledge about the (individual) customer	Reservation price, shopping frequency, products in the shopping cart, age, gender, price sensitivity, price aversion	Baydar 2002, Baydar 2003, Bichler and Kalagnanam 2006, Chinthalapti et al. 2006, Choudhary et al. 2005, Dewan et al. 1999, Hardestya et al. 2007, Gaeth et al. 1991, Kelkar et al. 2002, Liu and Zhang 2006, Tellis and Gaeth 1990, Zhiqiang and Xiong 2008
Knowledge about the product	Product description and specification, product costs, recommended sales price and its validity time period	Aviv and Pazgal 2005, Bichler and Kalagnanam 2006, Chinthalapti et al. 2006, Choudhary et al. 2005, Elmaghraby and Keskinocak 2003, Gallego and van Ryzin 1994, Kelkar et al. 2002, Zhiqiang and Xiong 2008
Knowledge about legal constraints	Delivery region, currency, laws, policies, time, taxes, logistic costs	Aviv and Pazgal 2005, Kelkar et al. 2002, Gallego and van Ryzin 1994, Stremersch and Tellis 2002, Su 2007
Knowledge about pricing strategies	Contract, currency, price, price type, bundling, personalized pricing, dynamic pricing, inventory, price aversion	Aviv and Pazgal 2005, Bitran and Ferrer 2007, Bichler and Kalagnanam 2006, Chinthalapati et al. 2006, Choudhary et al. 2005, Elmaghraby and Keskinocak 2003, Hardestya et al. 2007, Gaeth et al. 1991, Gallego and van Ryzin 1994, Kelkar et al. 2002, Karpowicz and Szajowski 2007, Liu and Zhang 2006, Stigler 1963, Stremersch and Tellis 2002, Su 2007, Tellis and Gaeth 1990, Zhiqiang and Xiong 2008

2.1 Application of the Framework

After we have introduced the basic components of our framework for KPS, we exemplify its use in this section. We chose a personalized pricing scenario in the retail industry of Greece as shown in Figure 3. In this scenario, the personalized pricing service is an *implemented* instance of a personalized pricing strategy, which is likewise a pricing strategy according to a given ontology. Furthermore, existing digital instances of retailer Smith, customer Mayer and the smart product (here a digital camera) all provide the parameters for the personalized pricing service. Due to legal constraints in Greece, each transaction requires a value added tax to be added to the product's price. Thus, a mandatory value added tax service, i.e., an external service, is added to the personalized pricing service. Both pricing services are realized with adequate semantic web service technology. In this purchase situation, the customer would request the price of the digital camera with the help of a mobile device, such as a personal digital assistant. Within the domain of fashion products, a corresponding video clip (see http://www.youtube.com/watch?v=tEWrfU9O44o) shows this procedure in detail for the smart product infrastructure Tip'n Tell (Maass and Filler 2007). The following high-level rules show an example for this knowledge-based pricing scenario:

a) Personalized pricing rule: *If the customer is a student and has made a sales volume of 100 Euro in this month, then reduce the recommended sales price by 5 percent.*

b) Value added tax rule: *If a product is bought by a customer, then the price is increased by the value added tax of the country the product is bought / shipped to.*

In summary, the framework can be used to model particular purchase situations that are relevant for retailers, suppliers or producers of products in finding new opportunities to apply dynamic pricing models. Correspondingly, this framework helps to identify the required knowledge-domains, services and technologies, i.e., components that are based upon explicit semantics.

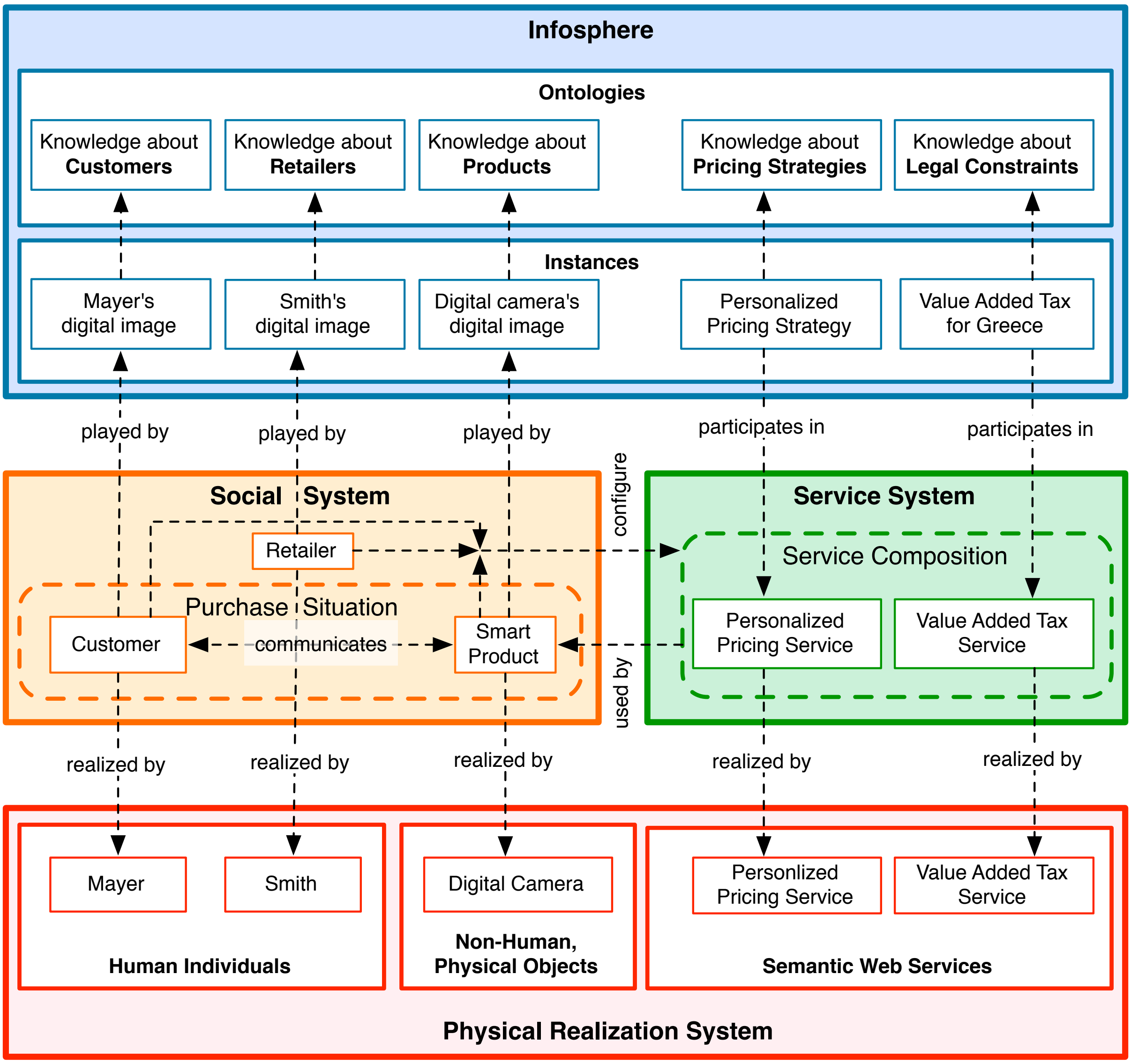

Figure 3. Design of a knowledge-based pricing scenario in the retail industry based upon the framework of the current work.

3. Implications for Business Models

In this section, we draw implications of the use of knowledge-based pricing services (KPS) for corresponding business models in the retail industry to motivate their adoption. One should note that the following discussion assumes that a smart product infrastructure and mobile devices are available through which prices can be presented on demand to customers, who stand in front of products. The following implications cover dynamic pricing models in terms of personalized offerings, bundling, inventory considerations and time horizons, because these aspects have been shown to be relevant for the retail industry (see Bitran and Ferrer 2007, Choudhary et al. 2005, Elmaghraby and Keskinocak 2003, Gaeth et al. 1991, Gallego and van Ryzin 1994, Liu and Zhang 2006, Su 2007).

- *Personalized pricing:* personalized pricing services allow the application of first degree price discrimination strategies according to Pigou (1920). Their main objective is to skim consumer surplus and therefore to increase the retailer's sales volume. With the exception of individual negotiations for high-cost or complex products such as individual software products or cars, the application of personalized pricing strategies in in-store shopping situations is currently restricted to loyalty cards, that promise a discount after the consumer has made enough purchases. Smart product shopping scenarios would change these kinds of business models. For example, if the digital instance of a consumer provides information that is relevant to the retailer (e.g., whether he is a student or an employee), the latter may provide an individual price and present it on demand through the channel of smart products. Furthermore, retailers have the potential to deeply listen into their customers' interests and pricing needs if they capture the shopping interactions and buying behaviour. This kind of 'listening in' might also lead to new personalized pricing models (Urban and Hauser 2004). In addition, also suppliers or producers might price their products according to the input of individual consumers. For example, to increase customer retention a producer may give a discount on his product because the customer already owns another product of that producer. In this sense, business models related to personalized pricing might also foster the cooperation between retailers, suppliers, producers and the end-consumer.
- *Product bundling:* A KPS for product bundles would enable retailers and suppliers[2] of complementary products (e.g., digital cameras and memory cards) to negotiate a discount for a product bundle instantly by semantic reasoning mechanisms at that point of time, when a customer is interested in those products. This would not only make the product bundle more attractive to the customer but would also increase sales volume and profit of the retailer and its suppliers, if the customer buys two products instead of one. These kinds of scenarios would foster the cooperation between retailers and suppliers of complementary products in terms of price negotiations, whereby the tie-in product (here, the memory card) would generate less profit through a higher discount, because it was tied-in by the digital camera (see Gaeth et al. 1991). In addition to recommended sales prices, corresponding business models should therefore consider pricing parameters and constraints for ad hoc price negotiations of product bundles, too.
- *Pricing that considers the retailer's inventory:* IT-based inventory management tools such as collaborative planning, forecasting and replenishment, quick response or vendor managed inventory have improved the availability of stock information for both retail and online stores (Elmaghraby and Keskinocak 2003). Based on this information, knowledge-based pricing services can be parameterized such that they calculate prices according the current status of the inventory. For example, the retailer might dynamically reduce the price of products that sell slow to increase their attractiveness, whereas fast-selling articles of which only a small amount

[2] Here, retailers might also cooperate directly with the producers of products.

is still available might be priced higher in order to reorder them timely. In this sense, knowledge-based pricing services might change existing business models due to stock information that is instantly available at that time a consumer is interested in a product. Accordingly, the question will arise how to use this stock information in order to improve both availability and sale of products by adaptive pricing mechanisms.

- *Pricing that considers time horizons:* by having a finite time horizon for selling products (e.g., for seasonal products), the objective of retailers is to maximize expected revenues until the end of a selling season by pricing products adequately (Aviv and Pazgal 2005, Su 2007). For example, new swimsuits will be priced higher at the beginning of a summer season than at the end. Current business models consider a more static approach in changing prices over a finite time horizon due to high operational costs (Elmaghraby and Keskinocak 2003). In this case, products are priced usually two times over a selling season. With the use of KPS, new business models may therefore apply dynamic pricing strategies on a far more granular level. Higher prices in times of high-demand at the end of a week or a day would be one example. Pricing non-durable goods such as groceries in relation to their life cycle would be another. Hence, the concept of time and product life cycle considerations may play a major role in the design of future business models in the retail industry.

In addition to these implications, it must be considered that each of the pricing scenarios discussed could have a negative impact on consumer behaviour and the image of a retailer, supplier or producer. Correspondingly, two of the most important topics that must be addressed by all business models are security aspects and price transparency. The first one is important according to the framework presented in the last section, because there exist various knowledge domains and explicit descriptions about customers, retailers and products for which access models must be defined to prevent fraudulent use. By contrast, the second aspect is crucial in terms of consumers' negative attitudes towards prices, that vary from day to day or from one friend to another. Thus, it must be always made transparent how a particular price is calculated to make the price traceable for the consumer. Otherwise, consumers would rather avoid retail stores that offer dynamic prices without the rationale behind it.

4. Existing Tools Guiding Future Work

In this section, existing tools for E-Commerce transactions are briefly described, which can be used to implement knowledge-based pricing services (KPS). First of all, we start with adequate delivery infrastructures into which KPS can be embedded. Because there exist many potential infrastructures and related systems such as electronic shelf labelling systems, we briefly describe three of them, which are particularly related to the concept of smart products. Then, front-ends for KPS are provided, before we finally list standards for pricing services and semantic data models.

4.1 Delivery Infrastructures

First of all, the smart product infrastructure Tip‘n Tell (Maass and Filler 2007) represents an adequate delivery platform for KPS as it uses a semantic framework and reasoning mechanisms to provide information about products. Within a Tip'n Tell shopping scenario, physical products are equipped with RFID tags to identify them and to start human product interaction through a mobile shopping assistant. Then, if a product's RFID tag was scanned by a consumer, the mobile shopping assistant informs the Tip 'n Tell web service (Java & Axis2) about this product. The server components manage the semantic data pool using the semantic framework Jena2 to allow the user to request the price information of a product. Currently, we are developing a new version of Tip‘n Tell, which allows to plug-in external OSGi modules such as pricing services. A second infrastructure is Fosstrak (previously Accada, Floerkemeier et al. 2007). Although it is an open source RFID middleware platform that mainly focuses on monitoring activities within supply chains, it can be used in combination with the concept of smart products as these products also embed RFID technology. For example, e-commerce transactions can be conducted with the help Fosstrak and tangible user interfaces in the form of smart products (Maass and Kowatsch 2009). And finally, Construct represents also a potential delivery platform for KPS (Dobson et al. 2007). It is an open source platform for pervasive environments (e.g., in-store shopping environments with smart products), which uses RDF as its data exchange model and which supports a knowledge-centric model for interactions. In this sense, Construct fits well to the knowledge-based framework as presented in the current work, too.

4.2 Front-ends

In addition to backend infrastructures, price information of products must be presented to customers in in-store shopping situations. In contrast to electronic shelf labelling systems (e.g., Southwell 2002), mobile devices are more flexible with regard to the concept of smart products. Correspondingly, first applications are being developed for consumers to communicate with physical products (Maass and Varshney 2008). Examples are Shoppers Eye (Fano 1998), Impulse (Youll et al. 2000), MyGrocer (Kourouthanassis and Roussos 2003), MASSI (Metro AG), the Tip 'n Tell mobile client (Maass and Filler 2007), the Mobile Prosumer (Resatsch et al. 2008), Easishop (Keegan et al. 2008) or APriori (von Reischach et al. 2009). All of them allow consumers to request product information directly at the point of sale and thus are potential candidates to provide front-ends for knowledge-based pricing services.

4.3 Standards for Pricing Services and Semantic Data Models

The last building block for the implementation of KPS is related to standards for price descriptions and semantic data models. The latter are useful, because they can integrate standardized and non-standardized product information (Maass and Lampe 2007). In order to store and maintain price information of products, there exist several standards. Consistent with our knowledge-based approach and explicit product descriptions, Kelkar et al. (2002) reviewed existing standards for electronic product catalogues that are based on XML and which can be used to model and define prices. In detail, they evaluated the following standards: cXML, xCBL, BMEcat, EAN.UCC, OAGIS, RosettaNet. As a result of their theoretical and empirical analysis, Kelkar et al. proposed a new general price model, because the evaluated standards cover real world price models in a limited way.

Furthermore, contracts and prices can be modelled with the Smart Product Description Object (SPDO, Janzen and Maass 2008b). SPDO is a semantic data model for products and works hand in hand with the Tip‘n Tell infrastructure (see above). The SPDO consists of five facets of which the product description and business description are used to model the corresponding price and contract information of a product. GoodRelations is another example of a semantic data model for products (Hepp 2008), which is also relevant for future work related to KPS. In addition, semantic data models can be complemented with the use of rule languages (e.g., SWRL) and reasoning mechanisms in order to request or calculate prices in a knowledge-based fashion.

And finally, because laws and contracts are required to deploy and maintain sophisticated and complex services (Spohrer et al. 2007), the licensing of pricing services could be managed with the ODRL Services (ODRL-S) profile (Gangadharan et al. 2008). This profile is based on XML and fits therefore to our framework for KPS.

In summary, all of these tools, i.e., delivery infrastructures, consumer front-ends, pricing standards and semantic data models are starting points for our future work that will predominately address the implementation and evaluation of KPS.

5. Summary

In the current work, we proposed a framework for knowledge-based pricing services (KPS) that rely on explicit semantic descriptions and rules. In combination with adequate delivery infrastructures such as the smart product infrastructure Tip'n Tell, they have the potential to increase operational agility in the retail industry, because they enable retailers to implement dynamic pricing models in terms of inventory considerations, time horizons, bundling and personalized offerings, i.e., all kinds of price models, which cannot be applied dynamically with static price tags as of today. KPS use logic statements to derive prices and therefore extend dynamic pricing models that are solely based on historical data. In order to motivate the adoption of KPS, we have also drawn implications for corresponding business models in the retail industry. Finally, a brief overview of existing tools was given that will be helpful for a reference implementation of KPS we aim to develop and evaluate in future work.

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