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Rule based Semantic Reasoning for Personalized Recommendation in Indoor O2O e-commerce

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Abstract

O2O, as abbreviation for Online 2 Offline or Offline 2 Online, is a newly developed e-commerce mode that has been successfully drawn much attention in practice for its ability to bring opportunity for business. Offline 2 online 2 offline (O2O2O) is an extension to offline 2 online, it means that offline customer, especially for customer inside a shopping mall, is enticed by offline marketing and therefore purchase digital goods or services online via mobile application, eventually finish consumption in physical stores. However, two issues remain as obstacles that impede the implementation of O2O2O for real application. One is recognized as personalized recommendation problem that concerns what content is appropriate or interest enough to be recommended to the customer to prompt the purchase action. The other is the lack of effective communication way for information exchange between customers with stores nearby. A novel method that adopts rule based semantic reasoning is present in this paper. Examples demonstrate that the proposed method can easily and rapidly generate a practical solution for personalized recommendation problem. A recommendation system is subsequently constructed to create a linkage between customers and stores for providing seamless information exchange.

Keywords

Personalized recommendation, semantic web, ontology, business rule, O2O e-commerce.

1. Introduction

Under the context of popularity of smartphone devices, social communities, and mobile internet, applications of O2O e-commerce, where O2O abbreviates for Online to Offline or Offline to Online, have been increasingly growing in recent years. O2O e-commerce generally includes online and offline parts, which represent the virtual and physical world respectively, the general idea of O2O is that merchants provide service or information online to eventually enhance customer offline experience in real stores. O2O e-commerce as a newly developed business mode has successfully demonstrated its ability to bring business opportunity for merchants by means of maximizing the use of online or offline resource to achieve a merchant-customer win-win situation.

For typical O2O applications, like Yelp, Groupon, Uber, AmazonFresh, DianPing, MeiTuan, Qunar etc, they represent elaborately selected information to induce customer to generate a transaction that starts with online payment for digital coupon and finishes with customer picking up product or service at offline store. Therefore, one of keys to the success of these O2O applications is recognized as personalized recommendation that concerns the problem of how to tailor information to be recommended to the customer. The activity which is the most important part of a customer profile and is considered as the historical record to be used for generating high quality recommendation.

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Since O2O e-commerce services can be any composition of bricks-and-mortar, e-commerce, social commerce, location based service, and mobile commerce[1]. The channel that virtually connects the virtual and physical parts is necessary. Thus, the other key to the success of the O2O is to have an effective channel for tight interaction between stores and customers for both online and offline.

Considering a following scenario for business, customers who are currently inside a shopping mall, are attracted by interest information provided by nearby stores via offline advertising like brochure, post, or building broadcasting, and subsequently go online to purchase respective digital coupon, ultimately complete consumption at store nearby. This particular scenario describes an application of Offline 2 Online 2 Offline (O2O2O) which is an extension of traditional Offline 2 Online business mode, it is also called as indoor or in-store O2O.

The activity of a customer in indoor O2O not only deals with customer's online browser behavior and offline transaction record, but also concerns the actual movement of customer inside building. Therefore, the aforementioned two issues for a success of O2O are more challenging in indoor O2O application. First of all, additional information is required for personalized recommendation because the activity of a customer inside building may vary in time. Additional information such as physical location, time stamp, which is important to describe the activity that should be constantly tracked and timely added into customer's user profile.

Furthermore, compare to traditional O2O application that interactivity between stores and customers can be easily realized by customer browser online using mobile app, the system to realize interconnection between customer and store needs to be able to capture the physical location of customer, to gather with other necessary information to make personalized recommendation.

This paper targets on indoor O2O, and proposes solutions for above-mentioned two issues for implementation of indoor O2O application. It adopts ontology to conceptualize domain knowledge of store and customer and perform semantic reasoning for personalized recommendation based on business rule and ontology. A system framework which consists of indoor positioning engine and recommendation engine is built for combining information of customer's physical location and user profile for recommendation, it also provides instant and seamless information exchange between customers and stores.

The remaining of paper is organized as follows: Section 2 gives literature review on related techniques in this study. Section 3 presents the semantic reasoning based approach for personalized recommendation. Section 4 describes a system framework for implementing personalized recommendation for indoor O2O e-commerce. Section 5 concludes this study.

2. Related Work

Related work on topics involved in this study is given as:

2.1 O2O e-commerce

Since introduced by Alex Rampell [2] in 2010, O2O e-commerce has been successfully attracted much attention on both industry and academic. O2O e-commerce refers to the use of online channel to drive offline sales and redemption, or "offline purchase propelled by the web"[3]. Tsai et al [1] gave a description of O2O as providing seamless shopping experience between online commerce and offline bricks-and-mortar with any connected device. Groupon, Yelp, Uber, AmazonFresh, Walmart to Go, IKEA, Starbucks, Meituan, Dianping, 58.com, Qunar, etc demonstrate the success of O2O application in practice. According to a report provided by iResearch [4], the O2O e-commerce market reached 27.3 trillion Yuan (approximate to 3.9 trillion US dollar) in 2018 in china. An analysis of O2O model's development problems and trend was given in [5]. The research in [6] investigated how retail businesses may promote their products online to induce offline sales via social media enabled online to offline commerce, and their findings gave important insights for retail businesses seeking to leverage O2O commerce. Xiao proposed a system that can provide O2O e-commerce participants with offline merchants historical and predictive reputation information for managing reputation of

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offline merchants in O2O e-commerce[7]. A group buying of online to offline mode model using generalized stochastic Petri Nets was proposed in [8]. Zhang et al. proposed a method for evaluating performance of O2O model using generalized stochastic Petri Net. Chen conducted a back propagation neural network for precise recommendation in O2O[9]. Pan et al proposed a O2O service recommendation method based on multidimensional similarity measurements [10].

2.2 Personalized Recommendation System

The representative definitions of personalization as, "the ability to provide content and services tailored to individuals based on knowledge about their preferences and behavior" or "the use of technology and customer information to tailor electronic commerce interactions between a business and each individual customer", was given in [11]. A recommendation system is a computer-based system that uses profiles built from past usage behavior to provide relevant recommendations [12]. A recommendation system aims to provide users with personalized online product or service recommendations to handle the increasing online information overload problem and improve customer relationship management [13]. The interest of the recommendation system has dramatically increased within the age of e-commerce. The traditional service recommendation system can be summarized into three categories, content based filtering, collaborative filtering, knowledge based, and hybrid technique which normally combines different recommendation techniques in order to gain better system optimization [13,14].

2.3 Semantic Web and Ontology

The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation. The ultimate goal of Semantic Web is to make the machine to understand the Internet data. To enable the encoding of semantics with the data, well-known technologies are RDF(Resource Description Framework) and OWL(Web Ontology Language). Semantic web techniques are often applied in the recommendation system to present user preferences, or to enhance the quality of recommendation. Wang [15] proposed a semantic enhanced approach that extracted semantic information of object to support recommendation process. Yang [16] built a semantic web based personalized recommendation system for curriculum resources recommendation.

Ontology could be defined as a formal representation of knowledge "set of concepts within a domain, using a shared vocabulary to denote the types, properties and interrelationships of those concepts". The OWL (Web Ontology Language) is one of the most recent and popular ontology languages. It is the semantic web standard for formally specifying knowledge on the web. OWL is a markup language for publishing and sharing data using ontologies on the Internet [17]. As a formal knowledge representation method to represent the domain concepts and the relationships between those concepts, ontology has been used to express domain knowledge in recommender systems[18].

Study on [17] built an ontology based framework for tourism recommendation services. Yu et al. [19] adopted ontology to model and represent knowledge about learner and content, and proposed an ontology based semantic recommendation for context-aware e-learning. User's profile ontology based semantic framework for personalized food and nutrition recommendation was presented in [20]. Ontology based semantic similarity measure to improve the quality of recommendation was given in [21].

3. Semantic Reasoning based Personalized Recommendation

Store's profile and customer's profile are indispensable information for delivering a qualified recommendation. There are three steps to generate a tailored recommendation for customer. Firstly, information about customer and stores should be transferred into knowledge that is modeled using ontology to be further used for reasoning. Secondly, business rule is determined according to a predetermined marketing strategy. Finally, the rule is coded and loaded to ontology reasoner to perform reasoning for recommendation.

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This study assumes there is a four floors mall, which consists of four types of store as restaurant, shop, cinema, karaoke. Store profiles are tabulated in Table 1.

Table 1. Store's profiles

Name	Location	Type	OpenTime	Rating	Average Bill	Coupon
StoreA	3F	Restaurant	11AM-0AM	2	Low	30% Off
StoreB	3F	Restaurant	11AM-8PM	4	Moderate	-20 reduction
StoreC	3F	Restaurant	5PM-9PM	5	High	-
StoreD	4F	Cinema	0AM-12PM	4	Low	-20 reduction
StoreE	4F	Karaoke	11AM-3AM	3	Moderate	-10% off
StoreF	1F	Shop	10AM-9PM	4	Moderate	-10% off
StoreG	2F	Shop	11AM-8PM	5	High	--

The first line in Table 1 describes that there is a restaurant named StoreA located at 3 floor of mall, it opens during 11 to 24 o'clock, it gets 2 stars of rating, it provides 30% off coupon and average bill for consumption is normally low.

Moreover, assuming there is a customer named CustomerA who has visited the mall and made consumption. Since customer constantly moved inside building, the customer's activities were accordingly changed during the stay. A series of typical activities of CustomerA is shown in Table 2:

Table 2. A series of CustomerA's activity

Activity	Time	Location	Type	Average Bill	Duration
Act1	10:30	1F	Walk in mall		
Act2	10:40	1F StoreF	Shopping	High	30min
Act3	11:20	3F StoreB	Meal	Moderate	120min
Act4	14:00	4F StoreD	Movie	Low	150min
Act5	17:00	3F StoreC	Meal	High	120min
Act6	19:30	1F	Left mall		

As shown in Table 2, this series of activity describes that CustomerA walked into mall at 10:30, started shopping at StoreF on 1floor of mall, spent 120min for lunch at StoreB, went to see movie in the afternoon, had dinner at 17:00 at StoreC on 3 floor, finally left mall at 19:30.

These activities are part of information that is recorded in customer's profile as shown in Table 3. For simplicity, this study currently does not take customer's preference into account.

Table 3. Customer's profile

Name	Sex	Age	Activity
CustomerA	Female	20	Act1, Act2,Act3,Act4,Act5,Act6

3.1 Ontology

This paper adopts Protégé 5 [22] to build ontology to represent the knowledge among store and customer. The classes as known as objects in ontology are illustrated in Figure 1. There are seven major classes, literally represent the respective objects.

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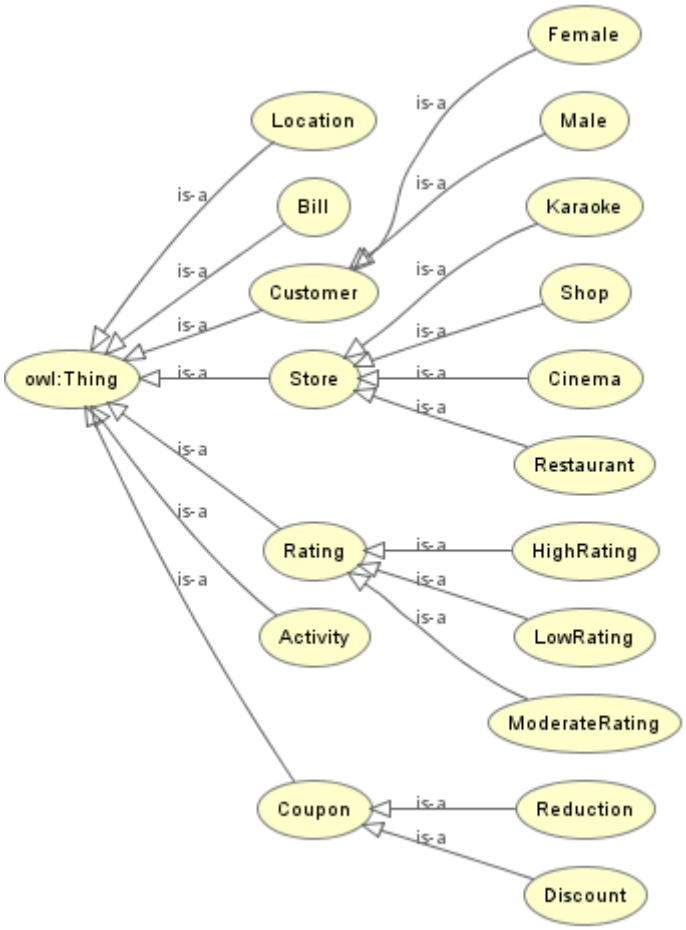

Figure 1. Proposed ontology

The store's profile along with customer's profile are coded as properties in ontology. The object property represents the relationship between objects, *e.g.*, property of *hasCoupon* means a store provides a coupon that may be presented as a reduction or discount. Property of *hasActivity* means a customer has an activity that may indicate the customer visited or completed a consumption at a store. The data property is the attribute that a class owns, *e.g.*, properties of *Activity:Time* and *Activity: Duration* record the time stamp and duration of an activity.

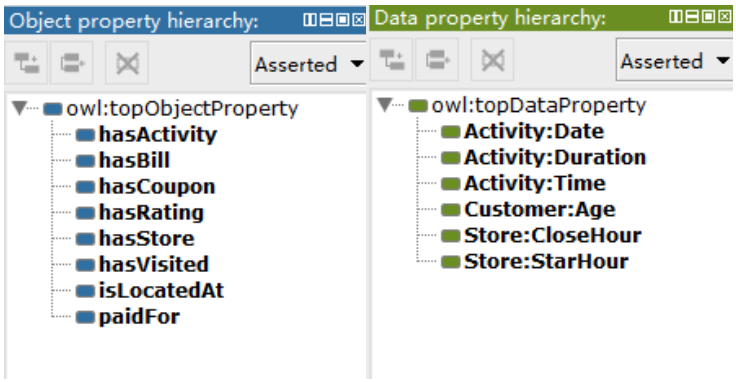

Figure 2. Properties

Using these properties, profile of StoreA, as given in first line of under Table 1 and as explicated under table, is modeled in ontology as shown in Figure 3. Figure 4 shows two activities of Act2 and Act3 of CustomerA modeled in ontology.

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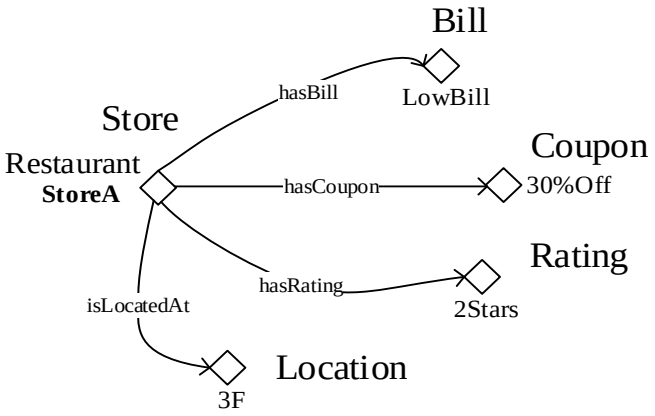

Figure 3. Profile of StoreA represented in ontology

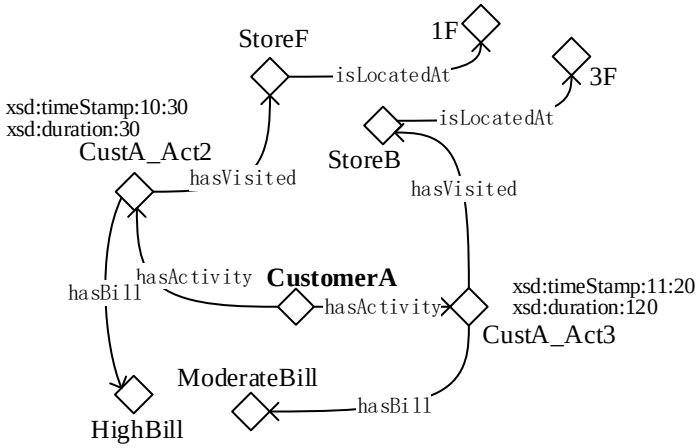

Figure 4. Two activities of CustomerA represented in ontology

3.2 Business Rule

A business rule usually represents a particular marketing strategy in Customer Relationship Management (CRM). For example, “storeRating > 3 stars” is a basic rule that contains one condition which means to select a store that has rating larger than 3 stars.

Using ∧ and ∨ operators, basic rules can be easily orchestrated into a complex rule. There are four operations that are used to composite complex rules are given in Table 4.

Table 4. Operations for generating complex rule

No	Operation
1	rule←rule1 ∧ rule2
2	rule←rule1 ∨ rule2
3	rule←rule1 ∧ (rule2 ∨ rule3)
4	rule←rule1 ∨ (rule2 ∧ rule3)

3.3 Semantic Reasoning

After ontology and rules are defined, personalized recommendation can be easily delivered. Two scenarios are studied in this study.

3.3.1 Cold start recommendation

Cold start problem commonly exists in recommendation. It refers to a situation when almost nothing is known about customer preferences[23]. Since it is a recommendation for a new customer, a possible

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marketing strategy may be to recommend a store that provides coupon and has moderate rating. The strategy transfer to business rule can be easily defined as:

Store ∧ Coupon ∧ Moderate rating

The rule coded in Protégéas query, and execute reasoning, the recommendations given by reasoner in Protégéare shown in Query results in **Figure 5**.

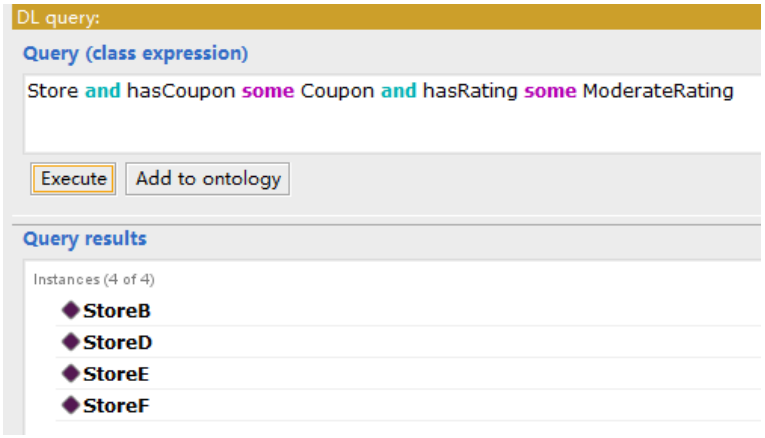

Figure 5. Query results for cold start

In above case, all qualified stores in Table 1 are recommended because there is no restriction on store type. In case of time stamp around 11 o'clock, which assumes that customer may seek for launch, hence changing condition to recommend a restaurant with low bill, the respective rule is:

Restaurant ∧ Coupon ∧ LowBill

The recommendation given by reasoner is StoreA, which is a restaurant located at 3F and it provides 30% off discount of coupon and its bill is low as shown in Table 1.

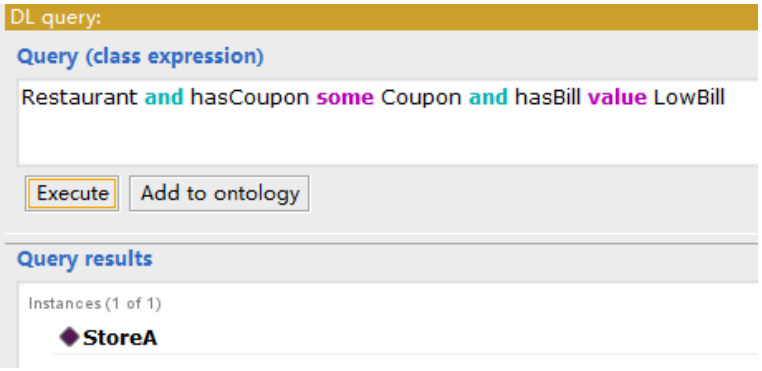

Figure 6. Recommend a restaurant for cold start

3.3.2 Personalized recommendation

For recommendation for regular customer like CustomerA. The rule for generating recommendation needs to be carefully figured to improve customer's satisfaction. Considering a scenario that CustomerA just finished shopping at 1F at 14:00. Since records in CustomerA's profile show that CustomerA used to watch movie in afternoon and have dinner afterwards, and also show that CustomerA is not sensitive with bill, a tailored rule for recommendation is given as:

Cinema ∨ (Restaurant ∧ HighBill ∧ (ModerateRating ∨ HighRating))

This rule indicates that to recommend a cinema because there is only one cinema in mall, and a restaurant, which have high bill and at least moderate rating. The results returned by Protégéis given in Figure 7.

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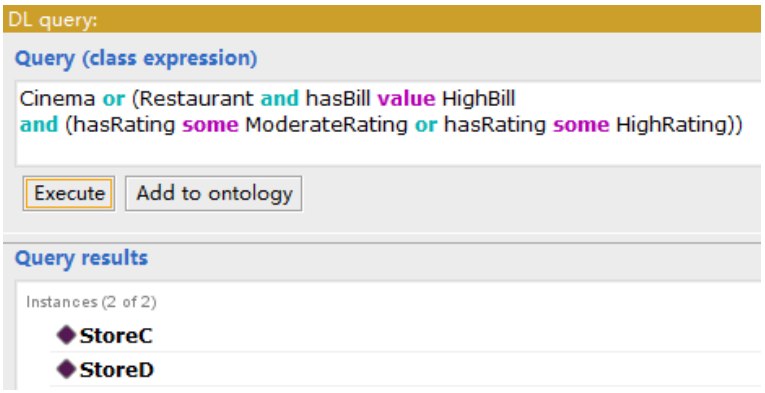

Figure 7. Personalized recommendation for CustomerA

4. Personalized Recommendation System for Indoor O2O e-commerce

4.1 System Framework

The framework for conducting a recommendation system of proposed method is given in Figure 8. The system consists of offline and online parts. The customer inside building and the physical stores around are associated with the offline part. The customer can connect to the system simply using apps on a mobile device. The stores are requested to frequently log into the system to maintain their goods or service data using any kind of terminals, such as mobile device, or computer.

The key components of system are indoor positioning engine and recommender. These two components are corresponding to functionalities of acquiring location information and generating personalized recommendation respectively. Customer's profile and goods or service data warehouse are databases which need to be regularly maintained and instantly updated in case of necessity.

The online part of the system can be built on cloud computing environment and following service oriented architecture standards to facilitate the deployment of the system. The functionalities are defined as web services based on WSDL (Web Services Description Languages). SOAP (Simple Object Access Protocol) is adopted for communications among web services. Web services can be dynamically orchestrated and generate new business rule according to BPEL (Business Process Execution Language).

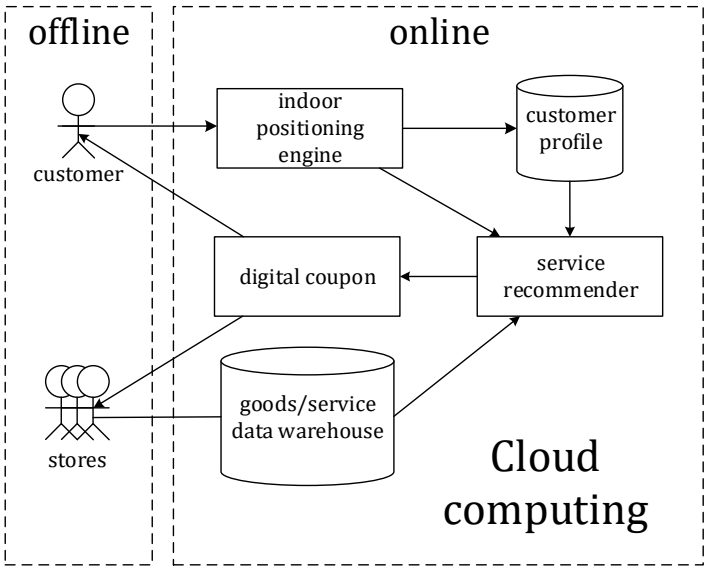

Figure 8. System framework for recommendation system

4.2 Recommendation Process

The interactions between objects of the proposed system for personalized recommendation are modeled using a sequence diagram as illustrated in Figure 9. The stores are response to maintain

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goods or service data warehouse, *e.g.*, adding a new item, or update change of current item. When a customer walks into the building, the apps on mobile device automatically initiates a request for a personalized recommendation.

The physical location of the mobile device as well as the customer's location in building can be captured by the indoor positioning engine of system using wifi based positioning technique. After the physical location is acquired, the recommender will query data warehouse for available goods or service of nearby stores. Meanwhile, the customer's preference will be extracted according to historical records from customer profile database and the information passed from the customer's mobile device. The recommender will try to find a match between customer's preference and goods or service from data warehouse. If a match can be found which means the personalized recommendation can be made, and the result of match will be substantiated in form of digital coupon whose information will be dispatched to the customer and the relative stores respectively. Otherwise, the recommender will consider the request as a new cold-start problem for recommendation, and the system will follow a predefined procedure to deal with it.

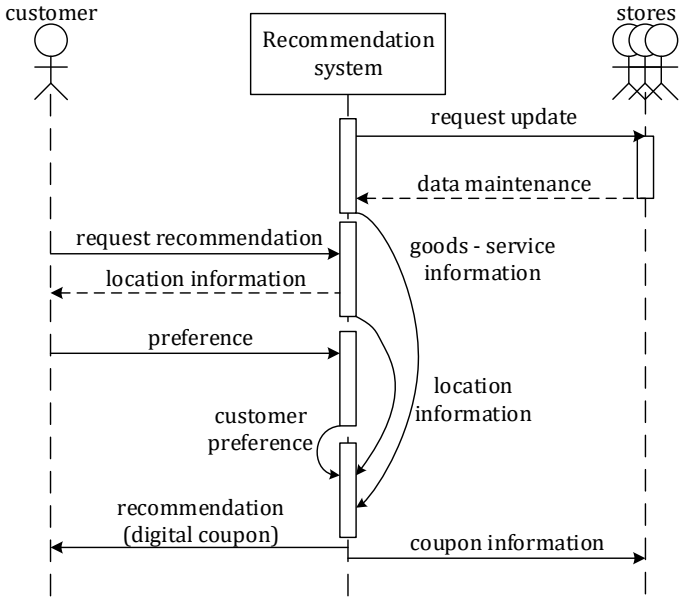

Figure 9. Sequence diagram of recommendation system

5. Conclusion

This paper presents a novel method for personalized recommendation for indoor O2O or so called O2O2O e-commerce. It conceptualizes the domain knowledge of recommendation between stores and customers into ontology, and generates business rule according to predefined marketing strategy. Personalized recommendation is given by sematic reasoning using Protégé based on business rule and ontology. A system framework consists of a recommendation engine and indoor positioning engine is constructed for deployment of the proposed recommendation system.

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