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An Indoor Personalized Service Recommendation System for Offline 2 Online E-commerce

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Abstract

The O2O e-commerce as a promising business becomes popular in recent years has been successfully attracted much attention in the real world. O2O stands for both Online to Offline and Offline to Online, however most O2O practitioners interest in Online 2 Offline, which provides online information to enhance offline customer experience. The Offline to online commerce is less focused due to the lack of an efficient way for seamless interaction between customers and stores. This paper presents a system to perform indoor personalized service recommendation for the implementation of offline to online commerce. It adopts indoor positioning technique to acquire physical location of the customer in a building and then gives personalized service recommendation accordingly using semantic enhanced approach. It aims to bring business opportunities by tailored recommendations for stores from nearby customers. The proposed system is designed to be built on cloud computing environment and following service oriented architecture standards to facilitate the deployment. The validity of the proposed system is examined using the Petri net and the results are satisfactory.

Keywords

O2O e-commerce; Offline to Online; Indoor positioning; Personalized service recommendation; Petri net.

1. INTRODUCTION

Since introduced by Alex Rampell in 2010 [1], O2O electronic commerce as a new e-commercial business mode becomes popular in recent years with the rapid growth of mobile internet. The general idea of O2O commerce is that companies provide service or information online to eventually enhance customer offline experience in real stores. In other words, O2O commerce integrates the virtual and the real worlds together. The success of O2O business shows that O2O can help companies gain more revenue, or increase brand affinity and keep customer loyalty using tailored marketing strategies. Tsai [2] pointed out that O2O commerce services can be any composition of bricks-and-mortar, e-commerce, social commerce, location based service, and mobile commerce, it can be defined as providing seamless shopping experience between online commerce and offline bricks-and-mortar with any connected device. Thus, the key to success of O2O is to have an effective channel for tight interaction between stores and customers for both online and offline.

O2O stands for Online to Offline or Offline to Online, however most practitioners like Groupon, Yelp, MeiTuan, DianPing, etc, interest in online to offline, which intends to induce customer make online payment for discount and then finish consumption offline. In this case, the interactivity between stores and customers can be easily achieved through customer's online

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browsing on their mobile device. On the other hand, consider a following scenario, people who are inside a shopping mall, can they get useful or valuable information that may lead to consumption without advertisement brochure, post, or broadcasting, etc. This scenario presents a typical application of offline to online mode. Unfortunately, it is not easy to implement offline to online, because there is the lack of effective channel for instant communication between offline customers and stores.

This paper proposes an indoor personalized service recommendation system to solve the problem in the above-mentioned scenario to realize the instant and seamless information exchange between customers and stores for the success of offline to online commerce. The idea is to firstly use indoor positioning technique to obtain customer's physical location in the building, and then personalized service recommendations by semantic enhanced approach are made and sent back to induce the customer to go to a nearby store to finish consumption. Hence, there are two pivotal parts in the proposed system, which are indoor positioning engine that provides location information inside building, and service recommendation engine as known as recommender that adopts user preferences to deliver tailored recommendation.

The remaining of paper is organized as follows: Section 2 introduces related techniques in this study. Section 3 presents the architecture for constructing the proposed system for Offline to Online e-commerce. Section 4 uses Petri Net tool to model the proposed system and the model's validity is testified. Section 5 concludes this study.

2. RELATED TECHNIQUES

The brief introduction of main techniques involved in this study is given as:

2.1. Indoor Positioning Technique

Rich studies were conducted on indoor positioning in both industry and academia. Wifi, Bluetooth, RFID, Ultra Wide Band, Radio, Cellular are the most popular techniques used in indoor positioning systems, and their accuracy was testified respectively on [3]. Wifi-based positioning approaches have been one of the 'best practices' in both outdoor and indoor environments due to its lower price and wider coverage [4]. Li et al [5] proposed a kriging based method for yielding a database of location fingerprints in Wifi positioning, results showed that it can not only achieve better accuracy, but also greatly reduce the workload and save training time. Yang and Shao [6] proposed a novel method for Wifi-based indoor positioning that can improve the localization performance in terms of time of arrival measurement and angle of arrival estimation.

In 2013, Apple spent $20M on acquiring WiFiSlam which developed techniques on mobile apps to detect the phone user's location in a building using Wifi signals [7]. Apple also started to deploy iBeacon location-aware transmitters at all of its U.S. retail stores since Dec 2013. Google uses publicly broadcast Wi-Fi and GPS, cell tower, and sensor data to estimate the location of a device [8].

2.2. Semantic Enhanced Personalized Service Recommendation System

Study on [9] gave 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". The interest of the recommendation system has dramatically increased within the age of e-commerce. A recommendation system is a computer-based system that uses profiles built from past usage behavior to provide relevant recommendations [10].

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The traditional service recommendation system can be summarized into three categories, content based filtering, collaborative filtering, and hybrid technique which normally featured by combining previous two techniques together. Semantic approaches are often applied in the recommendation system to present user preferences, or to enhance quality of recommendation. Wang [11] proposed a semantic enhanced approach that extracted semantic information of object to support recommendation process. Studies of [12, 13] adopted ontology based semantic similarity measure to improve the quality of recommendation.

2.3. Petri Net

Petri nets are a graphical and mathematical modeling tool for describing and studying information processing systems that are characterized as being concurrent, asynchronous, distributed, parallel, nondeterministic, or stochastic [14]. Since Petri net was originally proposed by Dr.Carl Admin Petri, it has been widely applied in the fields of business process modeling, workflow management system, software design, discrete process control, etc.

A Petri net is notated as a five tuple: PN=(P, T, F, W, M0) [14], where:

P = {p1, p2,...,pm} is a finite set of places,

T = {t1, t2,...,tn} is a finite set of transitions,

F$\subseteq$ $(P \times T) \cup (T \times P)$ is a set of arcs (flow relation),

W: F $\rightarrow \{1, 2, 3, \cdots\}$ is a weight function,

M0: P$\rightarrow \{0, 1, 2, 3, \cdots\}$ is the initial marking,

P $\cap$T = Φ and P $\cup$T $\neq$ Φ.

Hou [15] adopted generalized stochastic Petri net to model group buying of online to offline e-commerce, and time efficiency and performance analysis were conducted. Generalized stochastic Petri net was used to model and evaluate the performance of one kind of O2O model called buy online and pick up at store in [16]. Petri net also was applied to analyze and optimize a furniture O2O logistics process in [17].

3. DESIGN OF INDOOR PERSONALIZED SERVICE RECOMMENDATION SYSTEM FOR O2O E-COMMERCE

3.1. Proposed System

The architecture of the proposed indoor personalized service recommendation system is given in Figure 1. 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 major components of it are indoor positioning engine and service recommender. These two components are corresponding to functionalities of acquiring location information and generating personalized service recommendation respectively. Customer 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).

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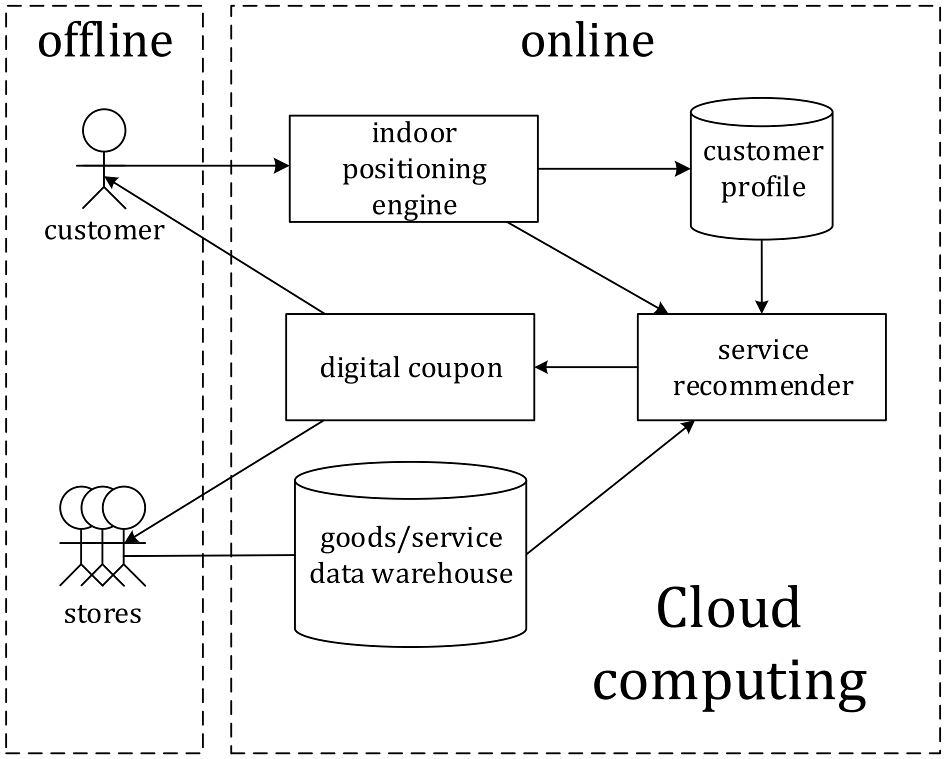

Figure 1. Architecture of recommendation system

3.2. Sequences of Recommendation Process

The interactions between objects of the proposed system for personalized service recommendation are modeled using a sequence diagram as illustrated in Figure 2. The stores are response to maintain 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 personalized service 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 history 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.

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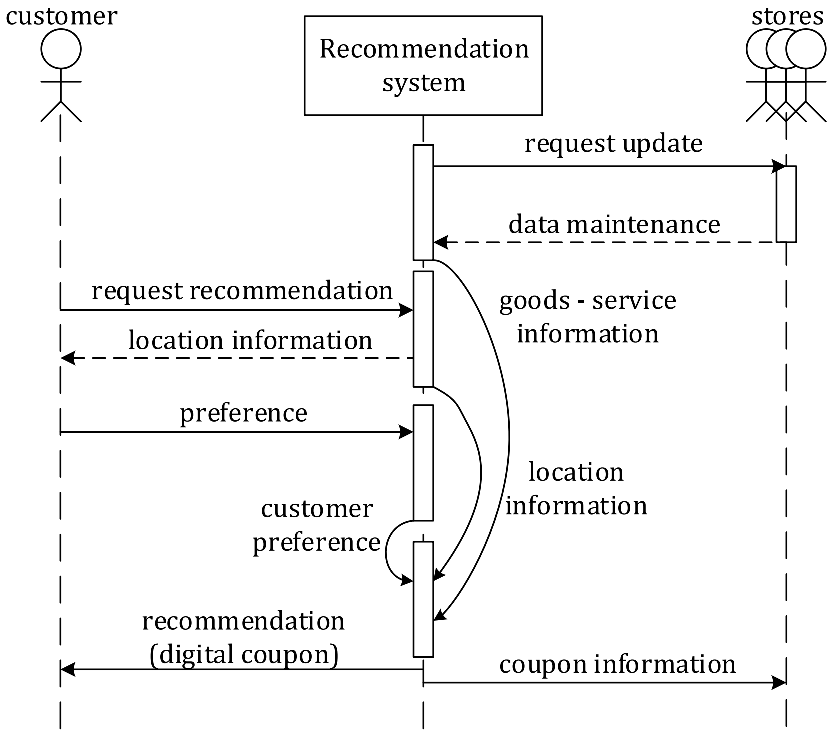

Figure 2. Sequence diagram of recommendation system

4. SYSTEM MODELLING USING PETRI NET

4.1. Petri Net Model

Petri net is applied to model the proposed system as presented in Figure 3. The model in Figure 3 is conducted by PIPE, a famous tool for creating and analyzing Petri nets [18].

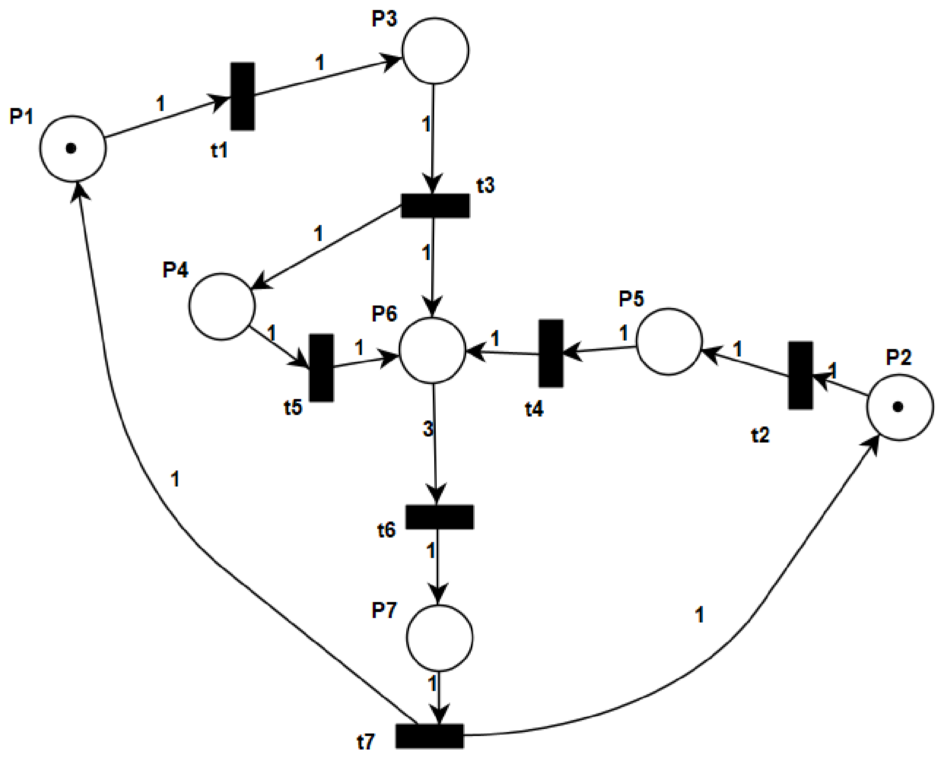

Figure 3. Petri Net model

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The model contains 7 places and 7 transitions. The meanings of symbols are listed in Table 1.

Table 1. Meaning of symbols

Symbol	Place	Symbol	Transition
P1	customer in building	**t1**	trigger request
P2	stores in building	**t2**	maintain data
P3	indoor positioning engine	**t3**	acquire location
P4	customer profile	**t4**	send goods data
P5	goods data warehouse	**t5**	extract preference
P6	recommender	**t6**	generate recommendation
P7	digital coupon	**t7**	send information of digital coupon

4.2. Model Analysis

a. Incidence matrix

The incidence matrix is the matrix whose rows correspond to places and whose columns correspond to transitions. The incident matrix of net is calculated as:

$$\begin{array}{c} \\ P1 \\ P2 \\ P3 \\ P4 \\ P5 \\ P6 \\ P7 \end{array} \begin{array}{c} \begin{array}{ccccccc} t1 & t2 & t3 & t4 & t5 & t6 & t7 \end{array} \\ \begin{pmatrix} -1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & -1 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & -3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & -1 \end{pmatrix} \end{array}$$

a. Reachability graph

The reachability graph represents all the reachable states of a Petri net. The reachability graph of the net is constructed and shown in Figure 4:

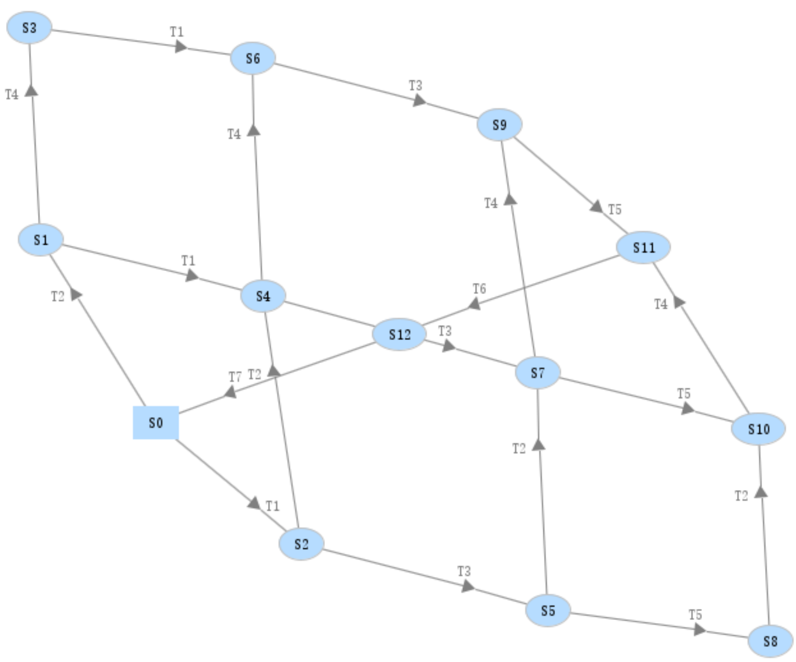

Figure 4. Reachability graph

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S0 in rectangle shape denotes the initial state of the net. The marking of S0 is {1, 1, 0, 0, 0, 0, 0}. All the markings of state are tabulated as follows:

Table 2. States of net

State	Marking	Edges from	Edges to
S0	{1, 1, 0, 0, 0, 0, 0}	S12(t7)	S1(t2), S2(t1)
S1	{1, 0, 0, 0, 1, 0, 0}	S0(t2)	S3(t4), S4(t1)
S2	{0, 1, 1, 0, 0, 0, 0}	S0(t1)	S5(t3), S4(t2)
S3	{1, 0, 0, 0, 0, 1, 0}	S1(t4)	S6(t1)
S4	{0, 0, 1, 0, 1, 0, 0}	S1(t1), S2(t2)	S6(t4), S7(t3)
S5	{0, 1, 0, 1, 0, 1, 0}	S2(t3)	S8(t5), S7(t2)
S6	{0, 0, 1, 0, 0, 1, 0}	S3(t1), S4(t4)	S9(t3)
S7	{0, 0, 0, 1, 1, 1, 0}	S4(t3), S5(t2)	S10(t5), S9(t4)
S8	{0, 1, 0, 0, 0, 2, 0}	S5(t5)	S10(t2)
S9	{0, 0, 0, 1, 0, 2, 0}	S6(t3), S7(t4)	S11(t5)
S10	{0, 0, 0, 0, 1, 2, 0}	S7(t5), S8(t2)	S11(t4)
S11	{0, 0, 0, 0, 0, 3, 0}	S9(t5), S10(t4)	S12(t6)
S12	{0, 0, 0, 0, 0, 0, 1}	S11(t6)	S0(t7)

b. Invariant analysis

Invariant analysis is often utilized to test the boundedness and liveness of a Petri net. The T-invariants and the P-invariants of the net illustrated in Figure 3 are calculated as shown in Table 3 and Table 4 respectively.

Table 3. T-invariants

t1	t2	t3	t4	t5	t6	t7
3	3	3	3	3	3	3

Table 4. P-invariants

P1	P2	P3	P4	P5	P6	P7
2	1	2	1	1	1	3

The P-invariant equation is:

$$2M\ (P1) + M\ (P2) + 2M\ (P3) + M\ (P4) + M\ (P5) + M\ (P6) + 3M\ (P7) = 3.$$

The results show that the net is covered by positive T-invariants and P-invariants, therefore the net is bounded and live.

5. CONCLUSION

This paper presents an indoor personalized service recommender system that aims to create a connection between the offline customer and the stores around for implementing offline to online e-commerce. The proposed system is modeled by a Petri net. The structural analysis of reachability graph and incidence matrix are carried out to prove the correctness of the model. The invariant analysis shows that the model is bounded and live. However, this paper mainly

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studies the recommendation process, the detail of indoor positioning and semantic enhanced recommendation are not discussed, these will be interesting topics for future research.

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