MODEL FOR PERSONALIZATION OF SALES PROMOTIONS BASED ON BEACON TECHNOLOGY

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Abstract:

Companies are making great efforts to develop personalized offers for customers. However, many customers consider that it is inappropriate to receive offers that they are not interested in, to receive an excessive number of simultaneous sales promotions, or receive them frequently, or even to receive promotions in an untimely manner. Although online shopping is constantly on the rise, when it comes to retail sales, the number of online purchases is still significantly lower compared to the number of in-store purchases. In this paper, we present a model of a smart retail environment that tracks customer activity inside the store and sends them personalized promotions while they are still at the store. The smart environment is based on the use of beacon technology and an appropriate relational database. The main benefits of this approach are increasing the company profits by sending personalized promotions to customers at the right time, increasing customer satisfaction, and collecting data on customer behaviour in the store for future analysis. For the purposes of experimental verification of the model, a test database was created, and the paper shows a number of queries executed in it.

Keywords:

Beacons, Smart Retailing, SQL Database, Personalized Promotions.

INTRODUCTION

The development of IoT (*Internet of Things*) technology, as well as the constant increase in the number of applications that use the information on user's location, lead to the increasing popularity of location-based services. The main employment of location services is the navigation service, and also, the services of monitoring and surveillance, geomarketing and advertising, or mapping. The location services are used in sports, medicine, video games, social networks, business, and commercial applications as well. Combining the information on the location together with other information relevant to the user opens up the possibility for numerous applications of these services. The beacon technology is being increasingly implemented for location, navigation, and tracking services in indoor venues such as museums, theatres, cinemas, airports, shopping malls, stores, etc.

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DOI: 10.15308/Sinteza-2023-206-213

Although online shopping is constantly on the rise, when it comes to retail sales, the number of online purchases is still significantly lower compared to the number of in-store purchases. According to [1], in 2022, in Great Britain, the percentage of online retail sales accounted for about 27% of total retail sales. For textiles, clothing, and footwear, this percentage is even lower coming in at about 23% for the month of December 2022 [1]. This data points to the need to create a smart in-store environment and personalized promotions for customers that would be presented to them while they are shopping in that particular store. Thanks to a number of benefits, such as high energy efficiency, precise positioning, low cost, and simple implementation, the beacon technology is being increasingly used to create a smart environment in stores. The implementation of location services in the majority of applications used on a daily basis indicates that users agree to disclose information about their location because they benefit from it. Weather apps, social networking apps, apps like Viber and WhatsApp, as well as various delivery and traffic tracking apps, all use location information nowadays. Numerous researches on customer acceptance of beacon technology, and on the influence of this technology on business, have been conducted. Recent studies [2] – [6] show a positive customer response to beacon technology, as well as an increase in customer satisfaction. The research [3] addresses the acceptance of beacon-triggered promotions in smart retail, having examined the markets of Serbia, Croatia, and Bulgaria.

In this paper, we present a model of a smart retail environment that tracks customer activity inside the store and then sends them personalized promotions while they are still in the store location. The smart environment is based on the use of beacon technology and an appropriate relational database.

The main benefits of this approach are an increase in company profits when personalized promotions are sent to customers at the right time, an increase in customer satisfaction, and the collection of data on customer behaviour in the store which can be used to increase business efficiency in the future. The paper is organised as follows. A brief overview of beacon technology is presented in Section 2. In Section 3, the concept of a smart environment and the corresponding *SQL* database are presented. The process of creating a test *SQL* database is also described. Subsequently, an overview of the most significant results that indicate the advantages and possibilities of the system described in this paper is presented in Section 4. And ultimately, conclusions and a direction for future studies are provided at the end of the paper.

2. BEACON TECHNOLOGY

Beacon technology was introduced by Apple in 2013. The global beacon market size was USD 1.36 billion in 2018 and is projected to reach USD 31.61 billion by 2026 [7]. Beacon devices are small devices that use battery power and BLE (*Bluetooth Low Energy*) technology to broadcast radio signals to nearby smart devices that have the proper application installed and Bluetooth enabled. Beacon devices emit a UUID (*Universally Unique IDentifier*), a major and a minor number that uniquely identify the beacon device [8]. Based on this information and the Received Signal Strength, it is possible to determine the location of a smart device which is then used to initiate the appropriate action, such as sending notifications to the smart device. Figure 1 illustrates the basic operation of beacon technology in smart retail.

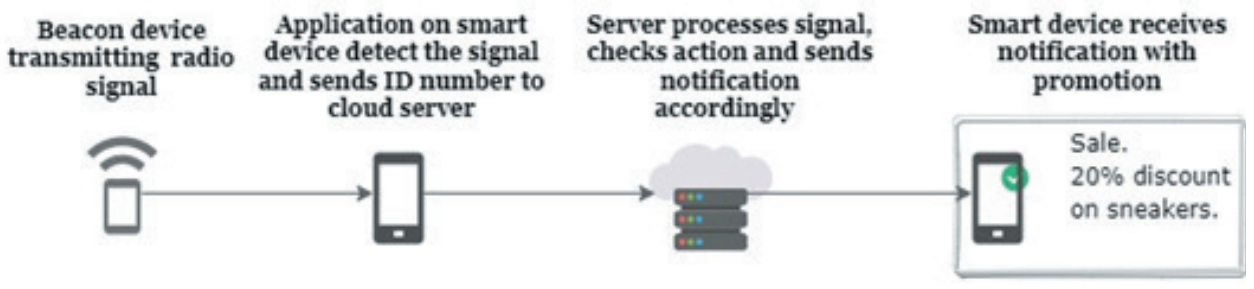

Figure 1 - Functional process of beacon technology in smart retail.

The concern of the companies about the number of customers who would have their Bluetooth enabled and store apps installed on their phones is unfounded [4]. Due to the increasing popularity of smartwatches and wireless headphones, most mobile users have Wi-Fi and Bluetooth enabled at all times [4]. When it comes to the store application, there are also alternative solutions, such as using the application of the shopping centre where the store is located. However, companies have not yet understood all of the benefits of introducing beacon technology into retail.

There are numerous scientific research papers that deal with beacon sensor networks for various purposes. In [9] architecture for museums, location-based content delivery using augmented reality and beacons was proposed. A smart airport system based on beacon technology is developed in [10]. Beacon technology was widely used during the pandemic caused by the Covid-19 virus to develop a system for monitoring risky contacts [11].

3. SMART RETAIL MODEL

3.1. BASIC ASSUMPTIONS

The general idea is to deploy enough beacon devices in the retail store so that each article is within range of at least one of them. If the store has a fitting-room, then the beacon devices must be installed in it. Based on the customer's movement around the store, the type of article the customer is interested in can be predicted.

On the other hand, depending on the time spent in various areas of the store, it is possible to anticipate whether or not the customer will make a purchase. The acquired data can be used to determine whether or not to send a promotional message to the customer via the application. If a message about a promotion is to be sent to the customer, it is necessary to determine which promotion should be sent to the customer, i.e., what type of article is the discount granted for.

3.2. DATABASE STRUCTURE

All necessary information for the smart environment is expected to be stored in a relational database. In reality, authorised personnel of companies and stores should enter a number of data points (e.g., data on companies, stores, articles, etc.); the next data set is obtained from the mobile application installed on the customer's phone (customer data); and the third data set is obtained from the beacon device (UUID, major, minor, battery, etc.). The relational database was built with *Microsoft SQL Server*. *SQL* has been chosen as the industry standard for data in almost all computing applications [12]. The created database consists of 13 tables. Table 1 summarises the properties of each table and the relationships between the tables. In the second column (Table attributes) the primary key of the table is highlighted, while the foreign key is listed in parentheses in the third column, relationships. Companies, stores, beacon devices, customers, articles, transactions, and promotions are the key entities in the database.

3.3. GENERATING A TEST DATABASE

In order to fill in the dataset tables with the data required to evaluate the suggested approach, a random data generator, *Excel*, and *SQL* scripts were employed. In the absence of large real-world data sets, this method of filling in the database was required. The test database stores data from 300 beacon devices installed in 30 stores. In addition, data on 1.181 clients and nearly 3.000 articles were captured. There are currently 121 active promotions. The promotion was sent to 682 customers, and the total number of transactions recorded in the system is 684. Initially, the use of a random data generator was intended to fill in all the tables of the test database. It was not possible to use the random data generator for all database tables due to a number of criteria that had to be met to obtain consistent data. The random data generator was used when generating data for the company, store, beacon, customer, people_counter data tables, as well as for a part of the article data table. All the data on the customers, which they made available through the app setting, is placed in the customer table. The people_counter table is designed to obtain information on the number of customers who do not use the system described in this paper. The beacon table's key attributes are the UUID, major, and minor numbers that allow identification of the beacon device. The UUID is used to identify the network to which the beacon belongs, in this case, the company itself. The major number is associated with a smaller set of beacons at a given location, i.e., a specific store. The minor number corresponds to the specific beacon device in the shop, i.e., the articles in the coverage zone of the beacon device. The beacon table also contains other technical data, such as the status of the beacon device and its battery, which are required to keep the system operating.

Table 1 - Database structure overview.

Table name	Table attributes	Relationships
company	**id,** name, address, tin, email, contact, status	article (company_id) promotion (company_id) store (company_id)
store	**id**, company_id, name, address, contact	beacon (store_id) people_counter (store_id) company (company_id)
beacon	**uuid, major, minor**, store_id, format, rssi, power_tx, interval_ms, range, battery, status	store (store_id) beacon_customer (uuid, major, minor) beacon_article (uuid, major, minor)
beacon_customer	**id**, uuid, major, minor, customer_id, in_zone, out_zone	beacon (uuid, major, minor) customer (customer_id)
customer	**id**, name, last_name, email, birth_date, gender, address	beacon_customer (customer_id) transaction (customer_id) customer_promotion (customer_id)
article	**id**, company_id, name, price, class	company (company_id) beacon_article (article_id) transaction_article (article_id)
beacon_article	**id**, uuid, major, minor, article_id	article (article_id) beacon (uuid, major, minor)
transaction	**id**, customer_id, promotion_id, date, amount, amount_after_ promotion	customer (customer_id) promotion (promotion_id) transaction_article (transaction_id)
transaction_article	**id**, transaction_id, article_id, quantity	transaction (transaction_id) article (article_id)
promotion	**id**, company_id, promotion_start, promotion_stop, article_class, sale	transaction (promotion_id) company (company_id) customer_promotion (promotion_id) promotion_criterion (promotion_id)
customer_ promotion	**id**, customer_id, promotion_id, promotion_code	customer (customer_id) promotion (promotion_id)
promotion_criterion	**id**, promotion_id, criterion, threshold, promotion_type	promotion (promotion_id)
people_counter	**id**, store_id, date, people_number	store (store_id)

Scripts written in *SQL* were used to generate data for the beacon_customer, beacon_article, customer_ promotion, transaction, and transaction_article tables, as well as for a portion of the articles table. The majority of the tables listed above have a significant number of complex criteria that had to be met, which was not achievable through the generation of random data. The created scripts simulate the movement of the customers around the store, interaction with beacon devices and objects in the store, and the purchasing process. The created scripts allow for different collections of data each time they are performed.

The time of entry and exit of the customer from the beacon device zone is stored in the beacon_customer table for all beacon devices in the system. This information is critical in determining the type of article the consumer is interested in and deciding whether or not to send a promotional message to that customer. For data generation, an *SQL* script using a cursor that simulates the customer's movement around the store and interaction with beacon devices was written. At a predetermined interval, the script creates a random customer entry and exit time for a specific store. The moment of entering the store corresponds to the in_zone attribute, which is increased by a random time interval, resulting in the value of the out_zone attribute for the observed beacon. The out_zone value of one beacon device represents the value of the in_zone attribute of another randomly selected beacon device. This procedure is repeated until the customer exits the store.

In the article table, name, price, article id, and company were generated using a random data generator. For the class attribute, no random data generator was used. Following that, the article class data is constructed using the *SQL* script in such a way that it can take one of the 19 predefined values: jacket, coat, trench coat, suit jacket, overalls, dress, skirt, shorts, pants, jeans, shirt, t-shirt, sweatshirt, bag, accessories, sneakers, shoes, sandals, boots. Articles from a minimum of one and a maximum of three classes are assigned to beacon devices.

After the generation of the beacon_article table, the data on the class of articles is also placed in the article table.

In the customer_promotion database, promotions are assigned exclusively to those customers who meet the criteria for sending the promotion. An *SQL* script was also created for data generation. The script uses a cursor to determine the total amount of time spent in the store, the amount of time spent in the fitting-room, and the amount of time spent with a specific class of articles for each customer. The customers who meet the criteria given in both the promotion and the promotion_criterion tables are then verified. An *SQL* script is used to get 30% of randomly selected customers from the customer_promotion table and create a transaction for them, where the purchased article class matches the article class of the sent promotion. It is assumed that some of the customers who received the promotion will not use it for the transaction. The script also randomly selects 10% of customers from the customer_promotion table and creates transactions without promotion for them. In addition, the script generates transactions for unidentified customers, that is, consumers who do not use the technology described in this work, so 60% of total transactions are non-promotional and non-customer id transactions.

The promotion and the promotion_criterion tables were manually created in *Excel* before being imported into *Microsoft SQL Server*. The reason for this is an attempt to meet as many real criteria for different types of articles as possible.

For example, most clothing promotions are based on time spent with the article and time spent in the fitting-room, as it is anticipated that customers would want to try on certain pieces of clothing they are interested in. In the case of footwear, the criteria for sending a promotion are the amount of time spent with the article and the total amount of time spent in the store.

4. RESULTS AND ANALYSIS OF RESULTS

The proposed smart environment, which is based on beacon technology and a relational database, can provide numerous benefits to potential users, primarily companies and stores. After the creation and filling in of the test database, a series of queries were executed, obtaining useful derived information that showed interesting patterns in the data.

The information on unused promotions can be quite valuable to companies. A large percentage of unused promotions for a specific article class may indicate that the criteria used to deliver the promotion should be changed. Figure 2 shows a graphic representation of the total number of unused promotions, sorted by article class. From Figure 2, it can be seen that the largest number of customers, 41, did not use promotions for sneakers, while only 8 customers did not use promotions for accessories.

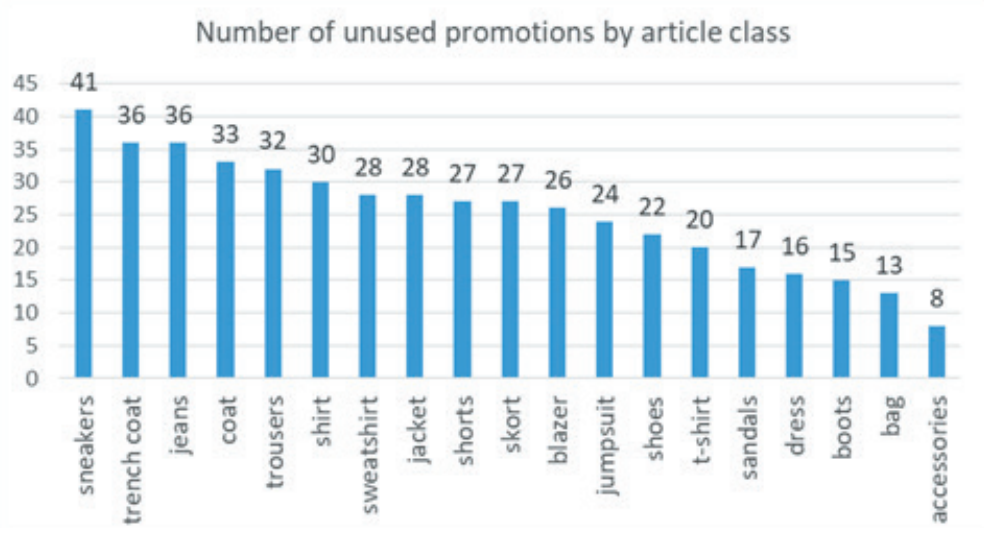

Figure 2 - Number of unused promotions by article class.

It is necessary to focus on transactions where customers did not use promotions even though they were sent to them. Table 2 shows the purchased article class and the promotional article class for the selected category of transactions. From Table 2 it can be observed that customers to whom a promotion for shorts and sweatshirts was sent often decide to buy an article from another class. Furthermore, as shown in Figure 2, the total number of unused promotions for shorts and sweatshirts is large, indicating the necessity of verifying the criteria for delivering promotions for the stated article classes.

When the customer receives a message with a promotion, it can influence not only the decision whether to make a purchase or not, but also the precise article to purchase. Table 3 provides an overview of the average sum of transactions with promotion, without promotion, as well as the average sum of transactions for customers outside the beacon system. From Table 3, it can be observed that the average number of transactions with promotions is greater than the average number of transactions without promotions for the majority of the dates listed. For example, on 25.12.2022 the price of transactions with promotion was even 59.95% higher than the price of transactions without promotion. According to the inquiry results, customers who use promotions purchase more expensive products.

In addition to data on unused promotions and the average price of different types of transactions, tracking the number of customers who do or do not use the beacon system can have an impact on the company's business. It is for this reason that the database contains the people_counter table. The total number of customers, as well as the specific number of customers inside and outside the system, can be easily obtained by query. An increase in the number of customers within the system would mean a positive response to the system by customers, as well as an increase in customer satisfaction and system popularity.

To ensure the smooth operation of a system with a large number of beacon devices, all beacon devices must work properly. If one of the beacon devices used to measure the time spent with a certain class of article, e.g. sneakers, is out of order, customers will not receive a sneaker discount promotion. On the other hand, a poor operation of a beacon device in the fitting-room affects a substantially larger number of promotions, that is, all of the promotions where the time spent in the fitting-room is one of the criteria. One of the disadvantages of the beacon system is its maintenance, as well as company concerns about the battery life of the beacon device [2]. As a result, the status and the battery attributes are presented in the beacon table. In this way, the battery life can be easily monitored, and the staff in charge of system maintenance can respond in a timely manner.

Table 2 - Class of the purchase article and promotion article for transactions with promotion that was sent but not used at the time of purchase.

Class of the purchased article	Promotion article class	Number of transactions
trench coat	shorts	4
sweatshirt	shorts	4
jeans	shorts	4
coat	sweatshirt	3
trousers	sweatshirt	3
jeans	jumpsuits	2
shirts	sweatshirt	2
trench coat	sweatshirt	2

Table 3 - Average price of different types of transactions.

Type of transaction	21.12.2022	22.12.2022	23.12.2022	24.12.2022	25.12.2022
average purchase price without promotion	20882.11	25357.04	18267.67	32759.64	15624.73
average purchase price with promotion	21646.20	27234.04	25972.03	31485.85	26061.01
average purchase price outside the system	22066.34	21279.49	28544.22	25409.51	27624.62

Table 4 - Part of dataset used to analyse how customer demographics affect the promotion utilisation.

gender	year of birth	promotion send	completed transaction	used promotion
male	1971	1	1	1
male	2000	1	1	0
female	1988	1	1	1

According to [12], analysts spend about 80% of their time preparing data for analysis and developing models with impure data, which is detrimental to the analysis and leads to bad results. An *SQL* gives the user the ability to extract, filter, update, sort, and manipulate data. Furthermore, *SQL* includes a vast number of different aggregate functions that allow detecting interesting patterns in data, in addition to the ordinary arithmetic operations, functions for working with character data and dates, and logical and set operators. A wide range of queries were executed during database testing in order to prepare the data for analysis.

Table 4 displays a portion of the query results used to examine how customer demographics influence promotion utilisation. The information on the gender and date of birth is available for 305 customers, 134 of whom received a promotion, and the dataset containing their records was used for the analysis. The transaction was carried out by 55 customers in the dataset, where a total of 43 promotions were applied. The majority of customers, 92 of them, are men. The birth years of the customers range from 1971 to 2003. For the purpose of the analysis, a decision tree model was created, Figure 3. The model testing took up 30% of the data. The model's accuracy is 75.61% (True Negative 70.73% and True Positive 4.88%). From Figure 3 it can be observed that promotions are most frequently used by customers of both genders born after the year 2000.

At the same time, the gini index for females reached 0, indicating that the node is perfectly homogeneous and there is no impurity or uncertainty in the node classification. On the other hand, the gini index of 0 could indicate overfitting of the model to the training data, so the result is not always desirable.

It is necessary to point out that the analysis of the impact of customer demographic variables on the use of a promotion was conducted on a small dataset with customer data generated completely random. A random data generator was used to create consumer data, and then a simulation of client movement and interaction with beacon devices and objects was performed. The analysis was carried out with the aim of demonstrating to the potential database users how the acquired data, along with machine learning, may be used to precisely identify the criteria for sending personalized promotions. One of the most significant tasks for the proper implementation of the system is determining the criteria on when to send personalized promotions. It is crucial to identify the critical moment when to deliver the promotion to the customer. The sending of the promotion can influence not only whether or not a consumer would buy, but also the specific selection and number of articles they buy. As a result, the company's profit and customer satisfaction can be increased, which is the system's main goal.

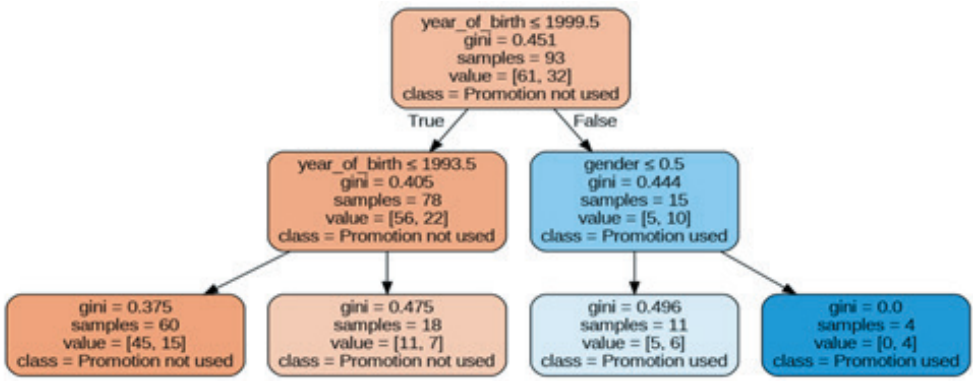

Figure 3 - A decision tree model used to evaluate the utilization of promotions based on customer demographics.

5. CONCLUSION

Beacon technology and relational databases are excellent solutions for creating a smart retail environment. The main benefits of this solution are: increasing the company's profits by sending personalized promotions to customers at the right time; increasing customer satisfaction; and collecting data on customer in-store behaviour that can be used to increase business efficiency in the future.

Within the system described in this paper, the criteria for sending promotions are determined subjectively due to the lack of real data. In the further course of the research, cooperation with real companies is planned in order to obtain real datasets about customers who visit their stores. The dataset should contain the data on customer retention for individual article classes, total time spent in the store, time spent in the fitting-room, data on customer gender and age, as well as the transaction data, including the information on whether a transaction was made and, if so, on the product class or the article that was purchased. Such a dataset would allow machine learning to be used to identify more precisely the criteria for providing personalized promotions, which would benefit both companies and customers.

6. ACKNOWLEDGEMENTS

This research was partially funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

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