The Decision of Building Location-Based Advertising Push Platform

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***Abstract*—Location-based advertising (LBA) service is a new form among current mobile service applications. Research on this latest service and the related adoption strategies and evaluation factors involving enterprises as well as consumers is essential for its further development and promotion. In this research, the Fuzzy AHP was applied to analyze the positive and negative evaluation factors of enterprises' adopting LBS advertising. The analysis result indicated that the top three factors that affect enterprises to build up a platform for push notification LBS advertising are increasing customer flow rate, App development and ads design cost, and improving business awareness and getting product exposure.**

Keywords—Location-based advertising, Analytic hierarchy process, Fuzzy theory, Multiple-Criteria Decision-Making

I. INTRODUCTION

Along with the evolution of information technology, the types of adverting can be roughly categorized into traditional printed flyers, radio adverting, television advertising, Internet adverting, and mobile advertising developed with the popularization of modern mobile devices. Following the current innovation and development of mobile technology and services, the form of mobile advertising has changed from short message service (SMS) advertising and multimedia messaging service (MMS) advertising to the current trend of providing advertisements through various applications (APPs) installed on the mobile devices. Since mobile devices are able to locate and track users' positions, this type of advertising has been applied to pushing advertisements to customers according to their locations and is called location-based advertising (LBA).

According to the definition of the Mobile Marketing Association in 2011, an LBA service is any service or activity that uses location information to convey marketing messages through an application.[1] It can be further categorized to GPS LBA, Wifi LBA, Bluetooth LBA, etc., based on the common build-in positioning components in a mobile device. As compared to the old-fashioned strategies that send advertisements randomly, any type of LBA, which sends messages to targeted customers based on where they are located, provides better publicity and customer acceptance of the advertisements. In recent years, due to the popularity of mobile applications, more and more users have installed applications that support positioning functions in order to obtain information related to their current locations [22]. By collecting the records obtained through the location-based service (LBS) applications, businesses can easily send relevant information through pushing advertising to customers based on their current location [25].

Some studies have shown that LBA service can effectively improve consumers' willingness to click and watch mobile advertisements. For businesses, increasing the exposure of products or services is undoubtedly one of the key factors in increasing their profitability and revenue. Therefore, both the industry and academic fields are currently paying high attention to the LBA service [1]. However, although the future for LBA seems promising, the emerging mobile application service is still at the development stage. In fact, most of the current businesses have launched their official applications and invited their customers to register membership to receive advertisements related to sales promotion, product experience, and shopping points. However, most of the advertisements sent through the applications are not based on LBA. In other words, not many businesses have built a complete LBA push platform to deliver information about their own products and services.

In recent years, experts and scholars have used scientific decision-making methods to explore topics related to mobile advertising. In their study, Lin and Yeh used the fuzzy semantics along with the Analytic Hierarchy Process (AHP) method to discover the influencing factors of consumers' willingness to purchase after reading SMS advertising [12]. Chen et al. applied the Fuzzy Delphi Method (FDM) to analyze the key success factors for a business to establish its mobile advertising applications and found the product brand, price, promotion, and user preferences are some of the major factors for the success of advertising [18]. In addition, Li et al. adopted AHP to examine various mobile advertisements, such as banner ads and pop-ups embedding in free mobile applications to determine the advertising effectiveness and privacy risks to consumers [11].

Few studies were done to analyze and explore the evaluation factors and effectiveness of LBA service based on a business's demands and perspectives. In general, an emerging service will generally be adopted after the demands and expectations to the service are well studied and comprehended as is the potential risk of adopting the new service. By using the scientific decision-making method to analyze the key evaluation factors of a business planning to establish the LBA push platform, the industry could understand this issue better. As a result, this study uses the AHP method combined with Fuzzy Theory to explore the evaluation factors a business would be concerned about when building a LBA push platform. The Fuzzy AHP method

[1] Mobile Marketing Association, Mobile Location Based Services Marketing Whitepaper Accessed from http://www.mmaglobal.com/files/MobileLBSWhitepaper.pdf, 2011

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belong to Multiple-Criteria Decision-Making (MCDM) and is most suitable for decision-making analysis when dealing with multiple evaluation dimensions and factors [6]. This method had been useful in the early research of SMS mobile advertising, but few studies have explored the evaluation factors of the emerging LBA services.

II. Literature Review

A. Location-based advertising service

Location-based advertising (LBA) service is the latest application in mobile advertising, and a new form of advertising media which combines the Internet with mobile technologies. At an early stage of development, online and Internet advertisements were delivered to customers through emails as the push platform [17]. Later, new forms of Internet advertising such as button ad, banner ad and pop-up were developed [19]. With the invention of cellphone in early 2000, Short Message Service (SMS) advertising came along, which can be seen as the earliest mobile advertising application [15]. However, many studies pointed out that most mobile users have negative perspectives toward SMS advertising as they do not feel comfortable to receive unattractive advertisements from a business without getting their permission [13]. In other words, the personalization and customization, as well as the timing and locations of sending advertisements, are key factors that influence consumers' perspectives on mobile advertising and their willingness to receive SMS advertisements [3, 14].

In recent years, with the gradual popularization of smart phones and mobile networks, consumers' preferences and locations can be tracked more accurately. This fact makes the LBA service a popular topic. Hühn et al. found that a customer would have high perceived value for a mobile advertisement if it is sent by a nearby business [1]. In addition, when customers reach the location in congruency with businesses mentioned in an advertisement, they are more willing to visit the stores and shop there [16]. Furthermore, some research indicated that applying LBA service would raise customers' concerns about leaking personal information and privacy [8, 25, 28].

B. Fuzzy Analytic Hierarchy Process

Finding the best solution is the primary goal for decision analysis. Many methods are adopted to optimize the process of decision making and AHP is one of the most widely used methods [23]. The AHP is a Multi-Criteria Decision-Making (MCDM) method, which is designed to help decision-makers examine key evaluation factors and find the best choices when facing multiple evaluation criteria and feasible solutions [27]. The advantage of AHP method is that it simplifies complex decision-making problems into an evaluation hierarchy [5]. The structure of AHP method includes problem-solving evaluation elements such as dimension, factor, and alternative and, thus allows decision makers to clearly see the relationships between each level [20]. Through pairwise comparisons among significant elements in each level and giving the results consistency, with numeric calculation, the importance weights of all elements can be obtained and eventually help find out the best solutions for decision-making problems [9].

AHP has been widely used to solve decision-making problems such as sorting, selection, evaluation and prediction [2]. Although traditional AHP can make a pairwise comparison and importance ranking for the importance levels among elements, human beings generally have a tendency not to follow the objective ranking and importance when making a decision. This fact can lead experts leaning toward biased results when comparing the importance between two evaluation elements. In the light of this, Buckley proposed Fuzzy Analytic Hierarchy Process (Fuzzy AHP) that combines AHP with Fuzzy Theory to solve the problem [10]. Through more meticulous and complicated arithmetic processing, Fuzzy AHP allows experts to more accurately reflect the actual human thinking when they are evaluating the importance levels of pairwise comparison in the evaluation hierarchy. This overcomes the human shortcomings of being uncertain and subjective when making decisions, thereby reducing the likelihood of getting inaccurate results and providing decision-makers the best solutions more efficiently. Different from AHP, Fuzzy AHP converts the data into triangular fuzzy numbers with more complicated calculation, which makes it results more reliable and relevant to the real case. The Fuzzy AHP calculation steps are as follows:

(1) Establish the evaluaton hierarchy structure: After checking the decision-making problem to be evaluated, selecting dimensions and factors for the target decision-making so as to build the evaluation hierarchy structure.

(2) Conduct pairwise comparison: Once the evaluation hierarchy structure is built, adopting the nine pairwise comparison scale between the dimensions and factors to conduct pairwise comparison for the priority of each factor [24]. Further, converting the nine scales into triangular fuzzy semantic membership functions [4, 7, 26]. The conversion of scale chart is shown in Table I.

TABLE I. Pairwise Comparison Scale and Triangular Fuzzy Numbers Conversion Table

Scale	Definition	$F_{ij}=(L_{ij}, M_{ij}, R_{ij})$
1	Equal importance	$1' = (1, 1, 3)$
3	moderate importance	$3' = (1, 3, 5)$
5	strong importance	$5' = (3, 5, 7)$
7	demonstrated importance	$7' = (5, 7, 9)$
9	extreme importance	$9' = (7, 9, 9)$

(3) Build pairwise comparison matrix: On the upper triangular part of the pairwise comparison matrix A, setting the score of the comparison result for a group of dimensions and factors made up of $A_1, A_2, A_3, \ldots, A_n$. Further, the reciprocal number of the score for the relative position on the lower triangular part is considerred, namely, $a_{ij}=1/a_{ji}$, where a_{ij} represents the relative priority of dimension/factor i to dimension/factor j.

(4) Convert the matrix value of the scores into the triangular fuzzy numbers: Following Table I, converting each score in the pairwise comparison matrix into the triangular fuzzy numbers (F_{ij}), where $F_{ij} = (L_{ij}, M_{ij}, R_{ij})$ is the fuzzy number of dimension/factor i to dimension/factor j.

(5) Calculate the local fuzzy weights of each dimension and factor: After obtaining the overall triangular fuzzy numbers of all dimensions and factors, the geometric mean of these triangular fuzzy numbers is further calculated to obtain the mean L_i, M_i, and R_i of the fuzzy numbers. Finally, calculating the local triangular fuzzy weights L_i', M_i', and R_i' of each dimension and factor.

(6) Obtain de-fuzzy value and normalization weight: After obtaining the local triangular fuzzy weights in the

previous step, we defuzzify the triangular fuzzy weights and convert them into a real number DW_i, then set the sum value DW_i of all dimensions and factors as 1. Next, conducting normalization to obtain the final local fuzzy weight DW_i' of each dimension and factor.

(7) Determine the priority of each factor: Subsequent to the steps discribed above, the local triangular fuzzy weights of each dimension is then multiplied by the lcoal triangular fuzzy weights of all factors under the same dimension, so that an global triangular fuzzy weights is obtained for each factor. Further, defuzzifyng the global triangular fuzzy weights and conducting normalization to obtain the final global fuzzy weight of each factor. Finally, the priority of each factor in the decision-making problem can be determined by reviewing the global fuzzy weight of the factor.

III. RESEARCH METHODLOGY

This study mainly uses Fuzzy AHP methods to conduct surveys and evaluation of businesses that have adopted or intend to adopt LBA push platform. The positive and negative factors of their decisions on building the platform are then analyzed. The definitions of LBA discussed in this study are defined by the Mobile Marketing Association in 2011, which is, a type of advertising that through any application, service, or activity applying uses' geographic information to deliver or improve marketing services. It includes GPS LBA, Wi-Fi LBA, Bluetooth LBA, etc. Further, this study established the evaluation hierarchy structure based on relevant literature and market research before conducting an AHP-based survey of individual business in order to discover the key factors of consideration by using Fuzzy AHP.

A. Selection of evaluation dimensions and factors

For business, the primary concerns for adopting a new technology or service involve with the benefits and costs for the organization. Therefore, based on the classification of the effectiveness of organization's information systems by Irani & Love and Shang & Seddon [21, 29], this study sets up three dimensions, which are "tangible benefits", "intangible benefits", and "considerations of cost". Furthermore, when establishing LBS advertising platforms, a business needs to consider its internal software and hardware as well as the proficiency of an external IT supplier, one more dimension is considered, namely, "maturity of environment". By analyzing the four dimensions mentioned above, this study selects 12 evaluation factors and defines each of them according to situations a business might be in when building a LBA push platform. The definitions of each evaluation factor are shown in Table II.

TABLE II. DEFINITION OF EVALUATION FACTORS

Dimension		Factor		Definition
D1	Tangible benefits	C1.1	Increasing customer flow rate	A business using LBA service to attract customers to visit its store and buy.
		C1.2	Attracting customers to experience a product	A business using LBA service to motivate more customers to visit its store and experience products and services.
		C1.3	Increasing click-through rate	A business using LBA service to attract more customers to click on the ads of its products and services.
D2	Intangible benefits	C2.1	Improving flexibility for real-time promotion	A business using LBA service to push various ads such as e-coupon, sales promotion and trial information based on customers' location.
		C2.2	Enhancing customer relationship management	A business using LBA service to 1) obtain customers' information including age, gender and preferred products/services, 2) push customized ads to enhance customer relationship management.
		C2.3	Improving business awareness and get product exposure	A business using LBA service to get exposure, and leading reputation of top technology among customers
D3	Considerations of cost	C3.1	Basic equipment Building cost	Cost for building and renting basic equipment of LBA service such as Bluetooth publisher and data server.
		C3.2	App development and ads design cost	Cost for developing LBA applications, advertising space and design plus the fee paying to advertising companies.
		C3.3	Maintenance cost	Cost for maintaining software and hardware of LBA service.
D4	Maturity of environment	C4.1	Mobile technology maturity	Whether the hardware/software of mobile technology in the market is mature for a business to adopt LBA service.
		C4.2	IT proficiency of external suppliers	Whether the IT/advertising companies in the market are professional to well provide LBA, ad design and marketing for a business to adopt LBA service.
		C4.3	Degree of internal e-organization	Whether the internal organization and management are well computerized and willing to accept new technology for adopting LBA service.

B. Building the evaluation hierarchy structure

Based on the above selected evaluation dimensions and factors, the purpose of this study is to explore the importance of evaluation factors a business would be concerned about when building a LBA push platform. According to this decision purpose, the evaluation hierarchy structure is established as shown in Fig. 1.

IV. ANALYSIS AND RESULTS

A. AHP Questionnire Design and Interview

This study develops questionnaires based on the evaluation hierarchy structure (Fig. 1) and conducts the surveys of AHP experts. The evaluation method of the surveys is based on the 1 to 9 scale pairwise comparisons developed by Saaty, which guides participants to compare targeted dimensions and factors [23]. The targeted participants are business owners and employees from consumer electronics and computer hardware retailers. This industry has higher knowledge and awareness of

information technology than other businesses such as restaurant and commercial district, therefore is an appropriate target for the preliminary study of "the factors that a business would consider for adopting LBA push platforms."

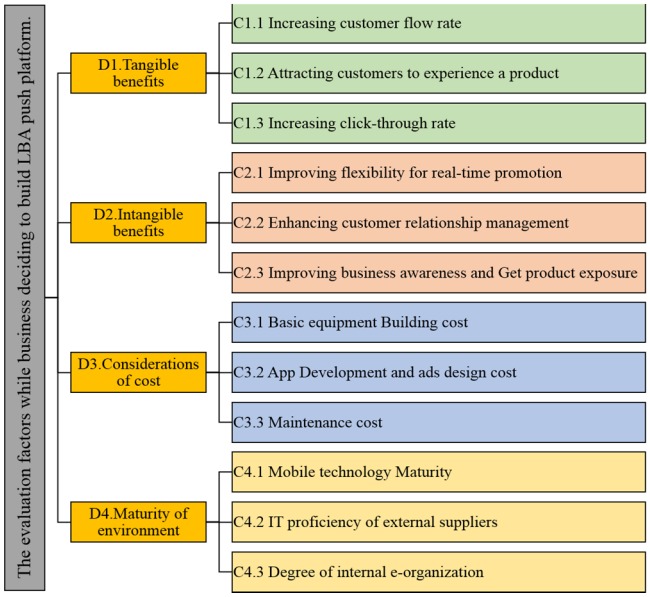

Fig. 1. Evaluation hierarchy structure

A total of 10 individuals participate in the face-to-face survey. Based on the advice by Saaty, each survey is evaluated by checking whether the *C.I.* and *C.R.* values of each question in order to verify the responded answers meet consistency [24]. Once a question fails the inconsistency test, the respondent is requested to take the survey once more and his/her responded scales are adjusted. The calculation of *C.I.* and *C.R.* are explained below:

$$C.I. = \lambda_{max}\text{-}n \,/\, n\text{-}1 \tag{1}$$

where λ_{max} is the maximum eigenvalue of each pairwise comparison question and n is the number of the hierarchical factors.

Saaty suggests $C.I. \leqq 0.1$ is more ideal [24]. However, when the research problem becomes complicated, the number of orders in the matrix would increase accordingly. As a result, it will be more challenging to verify the consistency of pairwise comparison. Considering this issue, Saaty proposes "random index" (*R.I.*) as shown in Table III, to adjust the changes of different *C.I.* values in different orders, which was later known as, "consistency ratio" (*C.R.*) [24].

TABLE III. RANDOM CONSISTENCY INDEX (R.I.)

Number of level factors (n)	1	2	3	4	5	6	7
R.I. value	0.00	0.00	0.58	0.90	1.12	1.24	1.32

Saaty also suggested that $C.R. \leqq 0.1$ is better [24]. When *C.R.* is less than or equal to *0.1*, it indicates that the consistency of pairwise comparison is dependable. The adjustment tool is shown in below:

$$C.R. = C.I. \,/\, R.I. \tag{2}$$

B. Local Fuzzy Weights of Evaluation Elements

When all the surveys pass the inconsistency test, the responded scales are compiled and analyzed with Fuzzy AHP so as to obtain the local triangular fuzzy number from each evaluation factor. After the process of defuzzification and normalization, the local fuzzy weights of each factor are coming out. The analysis results are shown in Table IV.

TABLE IV. LOCAL FUZZY WEIGHTS OF EVALUATION ELEMENTS

Elements	Lower score	Middle score	Upper score	De-fuzzy value	L-Weight	Rank
D1	0.175	0.444	1.103	0.574	0.441	1
D2	0.082	0.209	0.613	0.301	0.231	3
D3	0.115	0.294	0.656	0.355	0.273	2
D4	0.028	0.053	0.133	0.071	0.055	4
C1.1	0.279	0.654	1.319	0.750	0.619	1
C1.2	0.075	0.129	0.374	0.193	0.159	3
C1.3	0.105	0.218	0.486	0.270	0.222	2
C2.1	0.094	0.169	0.389	0.217	0.193	2
C2.2	0.088	0.139	0.248	0.159	0.141	3
C2.3	0.389	0.692	1.163	0.748	0.666	1
C3.1	0.144	0.272	0.659	0.358	0.306	2
C3.2	0.310	0.660	1.225	0.732	0.625	1
C3.3	0.043	0.067	0.133	0.081	0.069	3
C4.1	0.299	0.420	0.585	0.435	0.398	1
C4.2	0.202	0.402	0.690	0.431	0.394	2
C4.3	0.108	0.178	0.396	0.227	0.208	3

Note: *L-Weight represent the local fuzzy weight of element.*

C. Importance Ranking and Global Weights of Evaluation Factors

Furthermore, this study multiplies the local triangular fuzzy numbers of each dimension and factor to obtain the triangular fuzzy numbers of global and calculates the global fuzzy weights of each factor. Meanwhile, the importance ranking for the whole evaluation hierarchy structure is created based on the calculation. The results of these tasks are shown in Table V.

TABLE V. FACTORS' GLOBAL FUZZY WEIGHTS AND PRIORITY

Elements	Lower score	Middle score	Upper score	De-fuzzy value	G-Weight	Rank
C1.1	0.049	0.290	1.454	0.598	0.287	1
C3.2	0.036	0.194	0.803	0.344	0.165	2
C2.3	0.032	0.145	0.713	0.296	0.142	3
C1.3	0.018	0.097	0.536	0.217	0.104	4
C3.1	0.017	0.080	0.432	0.176	0.085	5
C1.2	0.013	0.057	0.413	0.161	0.077	6
C2.1	0.008	0.035	0.239	0.094	0.045	7
C2.2	0.007	0.029	0.152	0.063	0.030	8
C4.2	0.006	0.021	0.092	0.040	0.019	9
C3.3	0.005	0.020	0.087	0.037	0.018	10
C4.1	0.009	0.022	0.078	0.036	0.017	11
C4.3	0.003	0.009	0.053	0.022	0.010	12

Note: *G-Weight represent the global fuzzy weight* of evaluation factor.

V. CONCLUSION AND FUTURE WORK

The LBA service is still a developing application among mobile services and, as a result, the population of customers willing to receive and click on LBA is small. However, some studies have pointed out that LBA services can effectively

improve consumers' willingness to click and read mobile advertisements. This is a clue that weighing up the pros and cons before a business sets up its LBA push platforms is indispensable for the further development and promotion of this emerging service in the future.

This study uses cost benefit analysis and builds an evaluation hierarchy structure to examine factors that consumer electronics and computer hardware retailers are concerned about when planning to adopt LBA push platforms. In addition, Fuzzy AHP method is applied to analyze the key evaluation factors of building LBA push platforms. The results indicate that the factors of "increasing customer flow rate (0.287)", "App development and ads design cost (0.165)" and " improving business awareness and get product exposure (0.142)" are the top three key evaluation factors for a business to adopt LBA push platforms. According to the results, it is concluded that the main motive for a business aiming to attract more customers through LBA services is to improve its brand of business awareness and reputation so that customers are able to recall or recognize its products and services, and more willing to receive and to click its LBA. On the other hand, to avoid unexpected loss, it is critical for a business to carefully evaluate the opportunity of making a higher profit by investing a huge sum of money in building LBA push platforms.

The results from this study are expected to be further applied with other decision analysis methods, such as DEMATEL and ANP to evaluate differentiated factors involving various types of businesses such as department store, commercial district and food court, etc. for adopting LBA push platforms.

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