User Adoption of Location-Based Service

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***Abstract*—Location-Based Service (LBS) is an innovative mobile service emerged as the result of the popularity of mobile devices and wireless technology. Different LBS applications (abbreviated as "Apps") might have their own merits and demerits, and provide users with different operation interfaces and local-based functions. This study used Fuzzy Analytic Hierarchy Process (FAHP) to find the key factors that users would consider while adopting the LBS Apps. The results indicated that users would pay more attention to the location-based information acquisition functions, such as "providing good money-saving opportunities" and "obtaining location-based information", as well as the "decision convenience". Furthermore, users also consider the "information accuracy" of the location-based information provided by the LBS Apps as very important. However, "privacy risk" is a trade-off factor that comes together with the requirement of information accuracy. The findings of research result are useful to LBS providers in developing the LBS Apps, and also useful to LBS users in evaluating which LBS Apps are more appropriate for them to adopt.**

Keywords—Location-Based Service; Analytic Hierarchy Process; Fuzzy Theory

I. INTRODUCTION

The constant evolution and progress of information technology (IT) has brought the development of more and more innovative technological products and services, some of which have already changed people's habit and behavior, and have become indispensable roles in many people's daily life. Among others, the maturity of the mobile technology and the wide applications of the Global Positioning System (GPS) have also led to new generation of a killer technological service, that is, the Location-Based Service (LBS) [1]. The concept of LBS is to integrate GPS technology and mobile device with one another, so as to provide, according to variety of usage requirements and contexts, adaptive services and accurate local information that satisfy the user's expectations at any time and place [2].

In the past, people depended on desktop computers at a fixed location to look for related information (e.g., products and their customer reviews) of different stores (e.g., department stores and restaurants) they are interested in. Nowadays, users need only to open adequate applications (abbreviated as "Apps") and GPS on their mobile devices, then, they can search for and receive the information about nearby stores immediately [3]. Further, in the past, a user who needed to receive information about any promotional or discount activity in connection with products/services he or she was interested in, the user must search for such information by himself/herself. Now, the user needs only to install the related App on his/her mobile device, and then the App can automatically push the local information about the interested product/service promotional or discount activity to the user's smartphone or tablet according to his/her current location. The above convenient services and situations of innovative can be achieved through the integration of IT with information application services.

The LBS indeed provides people with many convenience services in their daily life. However, different people may have different expectations and needs of LBS. For instance, some users use LBS because they wish to find the information about local stores in real time, want other users wish to get at the earliest possible time the most recent news or promotional/ discount information of the products/services their interested. There are also users who use LBS because they want to exchange useful information with friends and family members at any time and place. In addition, some users use LBS only because they are curious about the services or deem them something cool and fashionable. Since different users of LBS are different in their needs and purposes, factors being considered by users in adopting these services will vary from user to user.

Currently, there are quite a few studies that discuss users' intention and behavior of adopting LBS, and most of these studies are focused on a single specific application service [4,5,6,7]. However, only a few of these studies have discussed the influential factors being evaluated while users want to adopt various types of LBSs. Based on the mentioned above, this study reviewed related market surveys and literatures and tried various LBS Apps practically. Then, we picked out App functions and some factors carefully that might be considered when users use the LBS Apps. We also established a hierarchical evaluation framework for this study. Then, we used the Fuzzy Analytic Hierarchy Process (FAHP) method to analyze the critical evaluation factors and the important functions users would consider and expect when adopt the LBS Apps.

II. LITERATURE REVIEW

A. Location-based services

Location-Based Service (LBS) is an innovative mobile application developed due to the progress of location-aware mobile devices [8]. This type of service will first detect the current position information of the mobile users' mobile device. Further, providing useful location-based information to mobile

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users, these information is inferred from recommendations made by recommender systems. Through LBS, the users could search for all kinds of information they need at any place and any time, and could obtain personalized information according to their current location in real time [9,10]. Presently, LBS has been applied in many business domains widely, such as entertainment and leisure, advertisement and marketing, mobile commerce, direction of travel and others [11].

B. Fuzzy Analytic hierarchy process

Analytic Hierarchy Process (AHP) is one of the decision-making methods most frequently used to solve the decision-making problem involving multiple evaluation factors [12]. This analytical method assumes that the hierarchical evaluation framework should be divided into multiple dimensions and factors [13,14].

In order to improve the disadvantage of subjective and fuzziness opinions brought by the component pairwise comparisons when implementing the AHP expert interview, Buckley [15] proposed the analytic hierarchy process with the fuzzy theory (called FAHP) method that combined the original AHP with the fuzzy concept. Compared with the traditional AHP, the FAHP method requires more complicated calculation steps, but it could more truly reflect the actual situation because FAHP can improve the shortcoming of ambiguity on the two components importance evaluated by decision makers.

III. RESEARCH MODEL

Based on the related literature review and the background of LBS, this study applied FAHP method to analyze the factors being considered by mobile users in adopting various LBS Apps. The process of this study is described in the following sections.

A. Selection of Evaluation Dimensions and Factors

The main tasks of LBS are providing various kinds of information at right time and place for users, and enabling users to obtain useful information in real time according to their current location. In other words, for users, LBS has a certain functional value to them. Further, LBS must be provided via wireless network (i.e., 3/4G), for users to receive nearby information. Therefore, factors such as, the availability of LBS servers, the stability of wireless network connection, the friendly interface of mobile Apps, and even the risk of privacy and cost, would be influential factors to consider while users adopting LBS. According to the above, based on the characteristics and functions of most popularly LBS Apps, we first classified the evaluation factors being considered by mobile users in adopting LBS into three dimensions, namely, "Functional Value", "Information and System Quality" and "Considerations of Risk".

Furthermore, referring to the consumption value theory proposed by Sheth et al. [16] and the fashion theory proposed by Miller et al. [17], this study further selected two other value dimensions most likely considered by consumers while adopting LBSs, namely, "Fashionable Value" and "Psychological Value". According to the above evaluation dimensions, we practically tried several types of LBS Apps and selected suitable evaluation factors under each evaluation dimension. In total, there are 22 evaluation factors and 9 sub-factors are included in this study.

B. Establishment of Hierarchical Evaluation Framework

Based on the above selected evaluation dimensions and factors, the purpose of this study is to evaluate and to analyze the importance factors be considered while users adopting LBS Apps. Therefore, we established a hierarchical evaluation framework for this purpose. The definition of the evaluation factors and sub-factors are summarized in Table I.

TABLE I. DEFINITIONS OF EVALUATION FACTORS AND SUB-FACTORS

Dimension	Factor		Definition
D1. Functional Value	F1.1	Obtaining location-based information	The LBS enables a user to search at any time and place to obtain required and useful information about facilities, stores and special offers available near the user's current location, etc.
	F1.2	Time utilization	The LBS can save users the time needed to search information about products/services (e.g., foods, clothing, transportation, sports and entertainments etc.), and the time needed to get to destination stores or desired facilities.
	F1.3	Providing good money-saving opportunities	The LBS enables users to save money by helping the user find information about various special offers, discounts, free-of-charge products/services, such as free parking spots, coupons, promotion activities, etc.
	F1.4	Decision convenience	The LBS helps users make purchase or itinerary decisions more effectively to meet their requirements or preferences.
D2. Fashionable Value	F2.1	App popularity degree	A user adopts the LBS because it receives many positive evaluations and is widely welcomed by a large number of customers.
	F2.2	Compliance with groups	A user adopts the LBS because it has been adopted by other reference groups (relatives, friends, colleagues, etc.) with whom the user is acquainted.
	F2.3	Showing personal style	A user adopts the LBS in order to demonstrate his/her distinctive style or personal taste.
	F2.4	Pursuit of fashion	A user adopts the LBS in order to prove he/she is on the cutting edge of times.

TABLE I. DEFINITIONS OF EVALUATION FACTORS AND SUB-FACTORS (CONT.)

Dimension	Factor		Definition
D3. Psychological Value	F3.1	First trial	A user adopts some types of LBS due to curiosity about these services.
	F3.2	Exploration	The use of LBS can explore and discover unfamiliar nearby restaurants, sightseeing spots or consumption activities.
	F3.3	Sense of pleasure	The use of LBS can give users satisfied or pleasant feeling.
	F3.4	Sense of achievement	The use of LBS can give a user the sense of achievement while completing different tasks or earning virtual medals in the service provided.
D4. Information and System Quality	F4.1	Information accuracy	The LBS can provide users with required, newest and correct information.
	F4.2	Information completeness	The LBS can provide users with the most complete information.
	F4.3	Personalization	The LBS allows users to set the types of push notifications and information search results according to personal requirements and preferences.
	F4.4	Service stability	The LBS can provide users with stable service connection quality and App operation.
	F4.5	Friendly interface	The LBS can provide users with a user-friendly interface, which is easy to understand and operate.
	F4.6	Response time	The LBS can respond to user requirements in a very short response time and its page load time is also quite short.
D5. Considerations of Risk	F5.1	Privacy risk	LBS users might be concerned about such as whether the user's current position is being tracked, the user's personal preferences or daily activities are under surveillance, or the user's privacy data have been leaked.
	F5.2	Dependence risk	LBS users might be concerned about the possibility that they might not know how do with a planned activity in case that the LBS is not available.
	F5.3	Cost risk	LBS users might be concerned about the high costs of purchasing mobile devices, renting a network and in-app purchase while the accompanied benefits are small.
	F5.4	Time risk	LBS users might be concerned about the time needed to learn LBS so long as to hinder their daily works or other activities.
F1.1 Obtaining location-based information	F1.1.1	Location-based information search and acquisition	The LBS enables users to search to get the required user-location-based information about restaurants, sightseeing spots, parking lots, etc. at any time and place.
	F1.1.2	Reminder and push notification of personalized location-based information	The LBS would automatically remind users or push the useful and personalized location-based information to users at any place and any time.
	F1.1.3	Multiple screening mechanisms for location-based information search and push	The LBS provides users with multiple ways to screen the location-based information, such as sorting the information according to the types of stores or facilities, consumption patterns, prices or distances.
	F1.1.4	Exchange of location-based Information	At the current location, the LBS enables users to recommend or share information with other persons by transmitting pictures, videos and texts.
	F1.1.5	Destination navigation	Combining the functions of Google map and GPS, the LBS enables users to locate nearby stores and activities, and navigates to the destination if needed.
F5.1 Privacy Risk	F5.1.1	Personal private data	The risk of leaking the user's privacy data, such as the number of ID, address, age, birthday and relationship status, while using the LBS.
	F5.1.2	Personal preferences and interests	The risk of indirect disclosure of the user's preferences or interests, such as the promotional activities, products or places, which the user frequently participated in, bought or visited, while using the LBS.
	F5.1.3	Personal location	The risk of leakage of the user's current location when using the positioning function of the LBS.
	F5.1.4	Daily whereabouts	The risk of indirectly divulging the user's daily whereabouts and habits when using the LBS regularly.

IV. Result Analysis

A. Descriptive Statistics Analysis

Based on the hierarchical evaluation framework of Table I, we designed our AHP questionnaire, and then conducted several personal interviews. The questionnaire interviewees were users who had already been using at least one LBS App. Total 15 mobile users were invited and interviewed. Table II shows the demographic information of our interviewees.

TABLE II. Demographic Information of Interviewees

Profiles	Items	Count	Percent
Gender	Male	9	60.00%
	Female	6	40.00%
Age	Below 20	7	46.67%
	20 and above	8	53.33%
Education	College	5	33.33%
	Graduate school	10	66.67%

In addition, the interviewees' experiences in using LBS Apps were queried and reported in Table III.

TABLE III. Interviewees' Experiences in Using LBS Apps

Item	Items	Count	Percent
Duration of using LBS Apps	Less than 1 year	2	13.33%
	1-3 years	9	60.00%
	More than 3 years	4	26.67%
Most frequently used LBS Apps	OrangeFish	12	23.53%
	Foursquare	7	13.73%
	Yelp	9	17.65%
	TripAdvisor	10	19.61%
	Others	13	25.49%
Frequently used LBS App types	Food	15	30.61%
	Housing	3	6.12%
	Transportation	8	16.33%
	Entertainment	10	20.41%
	Shopping	13	26.53%

B. Fuzzy AHP Analysis

- Evaluation of local fuzzy weight

The interviewees were required to complete AHP questionnaire by applying the 1-9 score pairwise comparison scale proposed by Saaty [18]. Each interviewee was requested to make the pairwise comparison for dimension layer, factor layer and sub-factor layer. Concerning the measurement of questionnaire, we also conducted the consistency test to check whether the consistency index (C.I.) and the consistency ratio (C.R.) of each question are smaller than or equal to 0.1 (C.I. and C.R.≤ 0.1), so as to guarantee the consistency of question responses form interviewee [18]. If there are any question that failed to pass the test of consistency, the interviewee was requested to conduct the interview once more. After all the questionnaires of interview had passed the test of consistency, the scores of all questionnaires were undergone the analysis of FAHP to gain the local fuzzy weight of every evaluation dimension, factor and sub-factor. The results of analysis are shown in Table IV.

TABLE IV. Local fuzzy weight of dimensions and factors

Dimension	LW	Factor	LW	GW
D1. Functional Value	0.476(1)	F1.1	0.388 (2)	0.185 (2)
		F1.2	0.074 (4)	0.035 (10)
		F1.3	0.394 (1)	0.188 (1)
		F1.4	0.144 (3)	0.068 (5)
D2. Fashionable Value	0.087(4)	F2.1	0.392 (2)	0.034 (11)
		F2.2	0.455 (1)	0.040 (9)
		F2.3	0.068 (4)	0.006 (20)
		F2.4	0.085 (3)	0.007 (18)
D3. Psychological Value	0.045(5)	F3.1	0.253 (2)	0.011 (16)
		F3.2	0.563 (1)	0.026 (13)
		F3.3	0.086 (4)	0.004 (22)
		F3.4	0.098 (3)	0.004 (21)
D4. Information and System Quality	0.276(2)	F4.1	0.284 (1)	0.078 (3)
		F4.2	0.233 (3)	0.064 (7)
		F4.3	0.234 (2)	0.065 (6)
		F4.4	0.144 (4)	0.040 (8)
		F4.5	0.005 (6)	0.014 (15)
		F4.6	0.056 (5)	0.015 (14)
D5. Considerations of Risk	0.116(3)	F5.1	0.609 (1)	0.071 (4)
		F5.2	0.024 (4)	0.028 (12)
		F5.3	0.092 (2)	0.011 (17)
		F5.4	0.059 (3)	0.007 (19)

Note: 1. LW: Local fuzzy weight; GW: Global fuzzy weight.
2. The numerals in the parentheses indicate the priority of the dimensions or factors.

- Priority of evaluation factors

After gaining the local fuzzy weight for each dimension and factor, we further calculated the priority of all evaluation factors. In this study, the local fuzzy weights of the dimension layer and the factor layer were multiplied to calculate the global fuzzy weight for each evaluation factor in the entire hierarchical evaluation framework. At the last, the critical evaluation factors considered while mobile users adopting the LBS Apps are ranked according to the evaluation factor's global fuzzy weights, as shown in Table IV. A subtotal of top five factors' global fuzzy weights exceeds fifty percentages of the total global fuzzy weights, implying these evaluation factors as extremely influential on users' concerns while adopting LBS Apps.

- Evaluation of obtaining location-based information

With respect to the factor "obtaining location-based information (F1.1)", most users consider the "location-based information search and acquisition (F1.1.1)" as the most important factor in adopting LBS Apps. Table V lists the priority of the evaluation sub-factors under the evaluation factor F1.1 obtained from the analytical results.

TABLE V. Priority of the Evaluation Sub-Factors of F1.1

Sub-Factors of F1.1	LW	Rank
F1.1.1 Location-based information search and acquisition	0.456	1
F1.1.2 Reminder and push notification of personalized location-based information	0.268	2
F1.1.3 Multiple screening mechanisms for location-based information search and push	0.136	3
F1.1.4 Exchange of location-based information	0.106	4
F1.1.5 Destination navigation	0.035	5

- Evaluation of Privacy Risk

The privacy protection is an important concern for the popularity and promotion of LBS. Therefore, this study further classified the factor of "privacy risk (F5.1)" into six sub-risks, in order to know what kinds of private data disclosure most users are quite concerned about while adopting the LBS Apps. As shown in Table VI, the most worried is the leakage of personal location.

TABLE VI. PRIORITY OF THE SUB-FACTORS OF F5.1

Sub-Factors of F5.1	LW	Rank
F5.1.1 Personal private data	0.235	2
F5.1.2 Personal preferences and interests	0.084	4
F5.1.3 Personal location	0.449	1
F5.1.4 Daily whereabouts	0.232	3

V. CONCLUSIONS

A. Discussions

LBS is an innovative mobile service emerged as the result of the popularity of mobile devices and wireless technology. Due to the constantly increased number of LBS users, the whole market of mobile applications has been glutted with a large quantity of LBS Apps. However, different LBS Apps have their own merits and demerits, and provide users with different operation interfaces and local-based functions. Therefore, in future development or promotion of any type of LBS App, the developers should first thoroughly understand what are the critical factors the mobile users will consider and what are the local-based functions the users expect most while adopting the LBS Apps.

This study applied FAHP to analyze the critical evaluation factors considered while mobile users adopting LBS Apps. The findings indicated the evaluation dimension "Functional Value" is the most important dimension for most users when they are considering to adopt LBS Apps, followed by the dimension "Information and System Quality. Furthermore, according to the global fuzzy weights and the importance priority of the evaluation factors in the entire hierarchical evaluation framework, we found that the mobile users have more attention to location-based information acquisition functions, such as "providing good money-saving opportunities (F1.3)" and "obtaining location-based information (F1.1)", as well as the "decision convenience (F1.4)" that can be brought by the LBS Apps to users when they are facing, for example, a purchase or itinerary decision making. The characteristics of LBS can provide real-time location-based information services, such as searching for local restaurants, promotional and discount activities offered by local stores, and nearby parking lots or gas stations. Therefore, the service providers should often keep close cooperation with different types of stores and government institutions, so that LBS users can always instantly check and obtain needed or useful information based on their current locations. It is hoped that with the location-based information, users, who are facing consumption or itinerary decision-making, can more effectively get products/services with high price-performance ratio to meet their requirements or preferences.

The users also consider the "information accuracy (F4.1)" of the location-based information provided by the LBS Apps as very important. In other words, the ability of providing users with most accurate and up-to-date information is highly important for encouraging mobile users to adopt these LBS Apps. However, the "privacy risk (F5.1)" is a trade-off factor that comes together with the information accuracy requirement. According to a further analysis of the privacy issues conducted by this study, as shown in Table VI, we found that users, who on one hand may consider the use of LBS Apps to obtain or search for the most accurate location-based information, also on the other hand have deep concerns about possible leakage of private information about their personal locations. This kind of concerns might possibly prevent users from adopting LBS Apps. Therefore, LBS App operators should have strict policy declaration and fair practices to protect the users' private data, so that the users can use these Apps without any concern. By doing so, it would be helpful in enhancing the users' confidence in using LBS Apps.

B. Future research

The results of this study are helpful to LBS App developers in developing the App functions. Furthermore, the findings also helpful to mobile users in evaluating which LBS App is more suitable for them to use. In the future, our hierarchical evaluation framework proposed by this study could be further applied with other decision analysis approaches for decision-making, such as the decision-making trial and evaluation laboratory (DEMATEL), Analytical network process (ANP) and others. The obtained analytical results can be compared with this study's findings to analyze the differences between them. Our hierarchical evaluation framework could also be applied to analyze various user groups, such as users of different ages or users of different jobs, to check the possible difference in their considerations while adopting LBS Apps.

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