Mobile Location-based Services: An Empirical Study of User Preferences

P. T. Chen and Y. S. Lin

Abstract—**Mobile devices are becoming increasingly popular; meanwhile, mobile location-based service (MLBS) is considered as a profitable opportunity for service providers. However, there has been a slow growth in the MLBS market in the past few years. Therefore, the current study aims to figure out user preferences for MLBS. Various mobile location-based services were reviewed and further classified into a hierarchy. The hierarchy was applied to investigate user preferences for MLBS using the analytic hierarchy process. The user preferred billing mode was also studied. Under such condition, MLBS providers can put their efforts and resources toward improving and providing prior services and billing mode selected by users. Afterward, the average revenue per user can be expected to rise, and the obstacles to MLBS development might be fewer.**

Index Terms—**Analytic hierarchy process, billing mode, Location-based services, mobile commerce, mobile location-based services, user preferences.**

I. Introduction

In the past, the use of 2G mobile communications has led to user frustration due to the typically slow data transfer rate of 9.6 kilobits per second via a global system for mobile communications (GSM) network. The low transfer rate severely limits the richness of the information and the complexity of the wireless data services and applications being offered. However, with the wide deployment of mobile communications and the advent of 3G mobile communication systems, the increased mobile bandwidth can now support a wide range of new mobile commerce services and applications, including faxing, sending large email messages, efficient Web browsing, navigating through maps, and using multimedia applications. In addition, the enhanced mobile communication speed and bandwidth allow mobile consumers to surf graphic-intensive web sites. With the availability of mobile broadband communication, mobile carriers are all aggressively preparing for multimedia-related applications and services.

According to the international telecommunications union (ITU), the number of worldwide mobile users will increase to five billion by the end of 2010. In Taiwan, the total number of mobile users and the penetration rate of mobile subscription have reached 26 million and 116.6%, respectively. Among these 26 million mobile subscribers, 18.2 million have subscribed to the mobile Internet service. These mobile service statistics show that the mobile handset has become an indispensible device in the daily life of the Taiwanese.

Location-based services (LBS) started in the United States in 1996 in accordance with the E-911 regulation proposed by the federal communications commission (FCC) to improve the emergency response to wireless calls [1]. Under the government policy, technologies had been improved rapidly. In addition, broad bandwidth in wireless transmission with location positioning techniques and the rich contents of mobile phone devices have been applied by service providers and users. Nowadays, location-based technology is not only applied to emergency rescue operations but also to many aspects in general [2], [3], for instance, local information checking (e.g., navigation and local weather forecasting) and providing entertainment guide (locating stores and finding friends).

The worldwide population of subscribers to global positioning system (GPS) location-aware services will grow from 12 million in 2006 to a projected 315 million in 2011, with North American growth reaching 20 million users up from 500,000 users in 2006 [4]. With the increase in the number of users worldwide, the LBS market shows high potential. According to market forecast reports, the LBS market is predicted to grow rapidly from 2006 to 2010. The LBS market in Europe is expected to increase from $191 million to $622 million [5], [6]. The U.S. market is expected to increase from $150 million to $3.1 billion [7]. Meanwhile, the Asian market is expected to increase from $291.7 million to $447 million [8]. However, the developing situation seems not as good as expected. More specifically, not all services that the service providers offer (or have already offered) would attract users. Thus, while mobile devices are getting increasingly popular, service providers consider LBS on mobile devices as a profitable opportunity. Under such circumstance, understanding user preferences for various mobile location-based services and billing mode are important. Therefore, the main purpose of the present study is to figure out user preferences for MLBS. Under such condition, MLBS providers can put their efforts and resources into the services and billing mode that users prefer more; thus, the Average Revenue per User (ARPU) can be expected to rise, and the obstacles to MLBS development might be fewer.

In the current study, analytic hierarchy process (AHP) approach is applied to discover user preferences for MLBS. By reviewing related literature and presenting MLBS situations, the MLBS developing situation and related information would be regarded as the basis for building a

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hierarchy of MLBS categories. Consequently, the definition of each MLBS category must be stated. By applying AHP and survey questionnaire, user preferences for MLBS would be discovered, and service providers can make efforts to improve and provide prior services selected by users.

MLBS companies have put significant efforts into establishing the basic factors for developing MLBS; however, user preference is one of the important issues for the mobile industry. Using AHP, not only can we obtain the weights of every service and further conclude user preferences for MLBS, but we can also make the results valid by pairwise comparisons.

II. Literature Review

A. Location-based Services

LBS are applications depend on the location of the user's device [9]. kosta, zibuschka, scherner, and dumortier (2008) [10] mentioned that the term location-based services "appeared in the end of the 1990s and is used for applications that leverage the user's physical location to provide an enhanced service or experience, such as route guidance, location of stolen or missing property, tourist and weather information, etc." Furthermore, junglas and Watson (2008) [8] stated that location-based services pertain to "any service that takes into account the geographic location of an entity." According to küHn (2004) [11], LBS is "a service for mobile users (terminals) where the awareness of the current, past or future location forms an integral part of the service." For Smith, mackaness, kealy, and Williamson (2004) [12], service contents may include real-time and geographic-based information to support user's dynamic spatial decision making.

There are two types of LBS: the closed system and the open system [9]. The closed LBS system does not have the capability to transmit data. One example of the closed LBS system is the GPS device, which receives information from the satellite with the application of the GIS system in the device itself. The other type, open LBS system, has the capability to transmit data. Specifically, devices are connected with platforms to receive tailored services. For example, Google's My Location service provides interactive services by combining with the Google Map system and pinpointing the location of the users. After the location has been pinpointed, the downloadable information, which is related to user locations, can be downloaded or viewed by the mobile users. Compared to the closed LBS system, the open LBS system shows more advantages by operating with platforms [9]. During the interactive processes, the latest information may be sent to users. According to Liang et al. (2008) [9], the feasibility of value-added service in the closed system LBS is not high. In addition, rao and minakakis (2003) [2] stated that "for mobile network operators, location-based services represent an additional stream of revenue that can be generated from their investments in a fixed infrastructure. For the end user, these services can help reduce confusion, improve the consumption experience, and deliver high-quality service options" [2]. Thus, the open LBS system is discussed in the current study [9]. However, the open LBS system can be applied in various devices. Hence, the present study focuses on mobile devices (cellular phones), rather than discussing every kind of device (i.e., RFID, GPS navigation device, and so on.). According to Liang et al. (2008) [9], the open LBS system, which focuses on mobile devices, is called MLBS.

After reviewing the two types of LBS system and the entities, the LBS delivery mode should be mentioned. There are two modes of delivering LBS. According to Jiang and Yao (2006) [1], various information services can be delivered to the LBS devices in two different modes. The first is the "push" mode where services are pushed to the end user automatically without the need of user request. The second is called the "pull" mode in which the user has to voluntarily request the information to be delivered from service centers.

In conclusion, LBS contents must be personalized depending on user preference. Sending personalized content related to the location of the users allows them to comprehend conveniently the local-related information.

B. Mobile Location-based Services

Mobile location services are wireless services that use the location of a handheld device to deliver applications, exploiting pertinent geospatial information about the surrounding environment of the user, their proximity to other entities in space (such as people and places), and/or distant entities (for instance, future destinations) [13], [14]. The most cited characteristics of mobile location-based services are their mobility [15], locatability [2], [16], [17], and compatibility to related services and applications. According to küHn (2004) [11], "an LBS is a service for mobile users (terminals) where the awareness of the current, past or future location forms an integral part of the service."

Mobile location-based services can be divided into many categories and operated on different devices. One common example is that for navigation service, a user might operate the related application on a GPS device or a smart phone (or a mobile phone). The current study focuses only on mobile phone applications to simplify its methodology and questionnaire and address the mobile telecommunication market directly. For the purpose of this study, classifying the services that could be offered (or have been offered) by MLBS providers is extremely important. Thus, different classifications for MLBS are reviewed in this section. After comparing the classifications, one frame is developed to construct the questionnaire items.

According to the GSM alliance services working group, MLBS may be defined according to the following categories [18]: emergency services, emergency alert services, home-zone billing, fleet management, asset management, person tracking, pet tracking, traffic congestion reporting, routing to the nearest commercial enterprise, roadside assistance, navigation, city sightseeing, localized advertising, mobile yellow pages, network planning, and dynamic network control. Cheng et al. (2005) [19] pointed out that MLBS has six categories, namely, Personal Security, Peer to peer/find me, navigation/point of interest look up/traffic, commerce/advertising/buying/billing,
gaming/location-based Imaging, and Asset Tracking/Field Services. Personal security services are applied to check the

location of children, elders, or pets. Moreover, security service firms can provide personal security services to ensure personal safety. Peer to Peer/Find Me services function to check the location of the user, the friends of the user, colleagues, or people who have connections with the user. Navigation/Point of Interest Look Up/Traffic services help users to check specific locations, products, or services. For instance, a user can check the nearest restaurant location, local weather report, or traffic condition through the Yellow Pages. Commerce/advertising/buying/billing services provide nearby stores' advertisements, promotions, and coupons to MLBS users. Furthermore, MLBS users can make reservations through the services. Gaming/location-based imaging services provide games and images related to specific locations. Asset tracking/field services can help users ensure the safety of their assets. In addition, users can apply the services to track buses or taxis. According to Tsai (2006) [3], mobile location-based services are good for tagging (e.g., weather report, information on nearby restaurants, finding a store, finding a parking space, sending advertisements, public transportation time table and related information, local news, and so on), tracking (e.g., positioning emergency calls, tracking assets, pets, friends, or families, and so on), tracing (e.g., navigation, direction to specific stores, the latest traffic information, and so on), and m-commerce (e.g., billing at a specific location, sending coupons, mobile transaction, and so on). Chen and Lin (2004) classified mobile location-based services into three main categories: entertainment, information (i.e., yellow pages, tourism and transportation, tracking, and public safety), and commerce (i.e., e-commerce).

For the above classifications from various studies, some of the services in different categories might cross with others in one classification.

In the present study, we conclude five MLBS categories, namely, entertainment, information, navigation, commerce, and security and tracking. Each category has its attached services. For entertainment, there are two services: MLBS community/friend-finder and gaming. For information, there are four services, namely, nearby location checking, entertainment information, local weather report, and finding a taxi. For navigation, there are three services, namely, traffic information, navigation, and map. For commerce, there are two services: nearby stores' coupons/sales information and mobile transaction/billing. For security and tracking, there are three services, namely, emergency rescue, roadside assistance, and tracking elders/children/pets/cars/property. To make each category more specific, the definition is stated as the following sections. In addition, each service can be provided independently. Under this condition, MLBS users would subscribe to the services independently.

1) Entertainment

Entertainment services in MLBS are full of entertainment functions. These services can fulfill the recreation needs of the users. In the present study, two services have been classified into this category: the MLBS community and MLBS games.

1) MLBS community/friend-finder

The MLBS community has a lot in common with the Internet community. The key difference is that the MLBS community contains local images and stories. The user may select the friend from the list, and then search the location of the friend under the category. Thus, mobile location-based services make it a lot easier for friends to meet without the traditional voice calls. In another situation in which friends do not know the place they are supposed to meet, MLBS community/Friend-finder service helps solve the problem by verifying locations. Aside from the tracking feature, mobile location-based services also allow users to post events, photos, and diaries on communities. The diaries will show the uploading location and time automatically; therefore, friends in the community can share their diaries. One example is the vibo map diary (vibo telecom, Inc.)[1]. In the United States, atandt wireless (AWE) provides a similar service named "friend finder" [20].

2) Gaming

MLBS gaming contains local factors that common mobile games do not have. Image-based services provide games and images related to specific locations [19]. Through solving riddles in contents, users may arrive at specific locations. For instance, vibo telecom, Inc[1]. Combined LBS with WAP games for MLBS gaming. In ireland, vodafone has promoted "botfighter." Orange has also promoted its "zone master" games in denmark [21].

2) Information services

Through MLBS information checking services, users can easily get information related to their present, past, or future location. "LBS tourist applications provide a wide range of localized information: landmarks, restaurants, petrol stations, ATM locations, etc." [22]. In the current study, information services are defined as services that only provide information, rather than additional value-added services (e.g., store reservations, billing, navigation, and so on). Nearby location checking, entertainment information, local weather report, and finding taxi services are contained in this category and discussed in the following section.

1) Nearby location checking

By applying the services, users can check their nearby location information depending on where they are [19]. This service is also called position requests [11]. For example, users can check a nearby gas station [23], ATM, parking lot, or restaurant [3],[19], or the route to the nearest commercial enterprise [18], as part of shopping locator services [2]. For example, Vodafone has promoted "Find and Seek" in the united kingdom and "night guide" in germany. In the united states, AWE has provided "What's nearby" for checking nearby information. In Taiwan, vibo has also promoted a related service.

2) Entertainment information

As the name implies, entertainment information service provides users with information on entertainment through MLBS, for example, tourist attractions [20], movies, and city sightseeing [18]. In addition, the service allows travelers to learn interesting facts about towns they are passing through while riding on a train [24].

3) Local weather report

This service provides a message multicast within a limited area of a specified type "geographic messaging" [11]. Local

[1] Vibo Telecom Inc. http://www.vibo.com.tw/CWS/index.html

weather report is a simple service that can assist users to check the weather depending on the location of the users [19]. This service can provide localized weather information on a specific area [24]. Different from the weather report received from TV or radio broadcasts, these weather reports may be more detailed and suitable for any specific location where users are situated. For instance, Vodafone has promoted a service named "Station," which can provide local weather reports [20].

4) Finding a taxi

Users can call taxis through the positioning system. Once users signal their need for a taxi using the service, the positioning system will pinpoint the location of the users, and send an SMS to the nearest taxi driver. If the nearest taxi driver refuses the request, the system will send an SMS to the second nearest taxi driver [25]. Users can also apply these services to track buses or taxis [19].

3) Navigation services

Navigation services assist users to trace the location they want to go to. In addition, through this service, users can also receive traffic information as the basis for choosing the best path.

1) Traffic information

The traffic information service may assist users receiving nearby traffic-related information [3]. For example, users can receive information about roadblocks, traffic jam [18], or accidents. By receiving such information, users can determine if they are willing to pass the road or not. According to Hand et al. (2006) [22], "Dynamic traffic information can be sent to a user about roadblocks or traffic congestion along a route. LBS applications can calculate the shortest route from the user's current location considering all these factors." For example, KDDI provides related services called "EZ@NAVI" and "EZ Navigation" [20].

2) Navigation

Navigation service helps users to figure out their driving directions [2] or their network planning or dynamic network control [18], [23]. Users may apply the navigation service to reach their destination easily. Users can apply the GPS navigation application through their mobile phones rather than carry another GPS navigation device. Taiwan Mobile has collaborated with Garmin and promoted a related navigation service in 2008 (Taiwan Mobile Inc.)[2]. Aside from the common navigation service, there are additional services like guidance to/reservation of parking space [11].

3) Map

Today's navigation support is based on paper maps or electronic maps; hence, the state of the infrastructure and route guidance is based on static information [11]. Map service helps users know where they are located and access maps of nearby locations.

4) Commerce services

Commerce services assist users in dealing with their purchasing activities. For instance, MLBS users can make reservations through mobile transaction and billing services before they go to a restaurant. In addition, nearby stores' coupons or promotional information could be sent to MLBS users to aid them in their purchasing activities.

[2] Taiwan Mobile Inc. http://www.taiwanmobile.com/

1) Nearby stores' coupons/sales information

While they approach stores, restaurants, and other establishments they intend to visit, users will receive coupons, sales information, or advertisements from nearby stores [3]. Moreover, MLBS users can make reservations through the services [19] and enjoy coupon discounts [2]. Therefore, users may present their coupons received through the mobile phones to purchase goods without printing out and presenting the coupons to stores. Meanwhile, the Taiwan Cable Connection (TCC) offers a unique service called ''828 portable gourmet'' service, which provides mobile telephone customers with geographic information on the nearest gourmet restaurant by simply dialing the numbers ''828' [24].

2) Mobile transaction/billing

Users may receive the information, advertisements, or coupons from nearby stores; then, they can make reservations and payments by SMS. Mobileone (Singapore), loopt, dodgeball (United States), and GeoMe (Spain) reveal some successful cases related to this service [19]. In Taiwan, Cheng Sheng security and Chungwa Telecom (CHT) have collaborated to offer ''MiniBond'' [24]. Home zone billing provides a direct incentive to ensure the mobile device remains the users' choice for communications, regardless of location.

5) Security and tracking services

Security and tracking services assist users in ensuring their personal safety and the safety of their families, friends, pets, or assets. Emergency call positioning is also included in this category.

1) Emergency rescue

As mentioned above, emergency rescue was the first service and the origin of the LBS (E-911 regulation). Such service can guide rescuers in locating a destination efficiently and accurately, especially in the case of emergency alert services [2], [18] or positioning emergency calls [3]. In a catastrophic situation, rescue operations could be greatly enhanced by coordinated actions [11].

2) Roadside assistance

Combined with MLBS, the time of roadside assistance may be reduced greatly because it is much easier to track where the users are instead of simply communicating through voice calls.

3) Tracking elders/children/pets/cars/property

To avoid elders, children, or pets from getting lost [3], MLBS provides a tracking assistance to users. Aside from tracking loved ones, users can also track their property, goods, or cars at any time and place [1]. Moreover, MLBS applications can assist in the retrieval of stolen goods [22]. Cheng et al. (2005) [19] suggested that security service firms provide such services to ensure personal safety [24]. In Japan, KDDI collaborated with SECOM and together they promoted "CoCoSecom," which offers applications for tracking elders, children, pets, cars, or property. In addition, DoCoMo's "Ima-DoCo" may also track children [20].

After defining every subcategory, the provided services were classified into subcategories. Nevertheless, the current study focuses on general users; thus, fleet management service is excluded because it is usually applied by specific companies or corporations. Each service listed in the

questionnaires will be rated based on user preferences for MLBS. In the end, the analyzed result can serve as a recommendation for MLBS providers in designing future services.

C. MLBS Provision Situations in Different Countries

The MLBS provision situations in different countries were compared (Table I). In Europe, mobile location-based services include the MLBS community, MLBS game, nearby location checking, entertainment information, local weather report, finding a taxi, traffic information, navigation, map, mobile transaction, car tracking, fleet management, and roadside assistance. In Japan, mobile location-based services include the MLBS community, nearby location checking, local weather report, finding a taxi, navigation, nearby stores' coupons, tracking children, and emergency rescue. In the United States, mobile location-based services include the MLBS community, nearby location checking, local weather report, navigation, and emergency rescue. It is possible that different markets would have different user behaviors within the three areas. As previously mentioned, MLBS is still a growing industry in Taiwan; therefore, service providers may be unwilling to provide every kind of MLBS at one time because the ROI may not meet their expectations. Thus, figuring out user preference is important to the MLBS industry.

TABLE I: PRESENT SERVICE-PROVIDING SITUATIONS IN DIFFERENT COUNTRIES

Category	Services	Europe	Japan	U.S.	Taiwan
Entertainment	MLBS community	●	●	●	●
	MLBS game	●			
Information	Nearby location checking	●	●	●	●
	Entertainment information	●			
	Local weather report	●	●	●	
	Finding a taxi	●	●		
Navigation	Traffic information	●			●
	Navigation	●	●	●	●
	Map	●			●
Commerce	Nearby stores' coupons		●		●
	Mobile transaction	●			
Security Tracking	Emergency rescue		●	●	●
	Roadside assistance	●			
	Tracking elders/children/pets/cars/property	●	●		●

Sources: Chen et al. (2004); Chunghwa telecom (2010); Koutsiouris, polychronopoulos and vrechopoulos (2007); Lin (2003); Taiwan mobile (2010); Vibo (2010)

D. MLBS Value Chain

While mobile location-based services are in process, different roles in the industry shall cooperate as a framework. However, the MLBS market is still in development, and a concrete MLBS value chain has not been established. Instead, MLBS value chain might be different from experts' predictions. Nevertheless, LBS value chains are reviewed in this section as a reference for future research. On the other hand, LBS suppliers (e.g., service providers, content providers, location providers, and so on) can consider the advice as the basis for establishing the concrete LBS value chain.

During the LBS process, three parts of value activities are involved, namely, location of the user, service transmission, and billing [3]. First, the idea of the user's location is to pinpoint the location of the user using mobile terminal devices. Afterward, contents related to the present location of the user will be acquired under the push or pull mechanism. The service transmission process progresses while the services are being requested. After the services are provided, fees based on the used services will be charged through the billing mechanism. As such, the LBS sending process involves three aspects supported by independent providers who each plays a key role. In the aspect of locating the user, station device suppliers and mobile phone manufacturers play the key role in manufacturing the hardware for MLBS. Then, in the aspect of service transmission, content providers, platform providers, and software developers take on the key role in designing the software and contents. Finally, the mobile telecommunication service providers stand in the middle of the value chain and handle the billing mechanism.

According to Lin (2003) [21], the MLBS value chain consists of eight roles, namely, positioning technique provider, network equipment vendor, platform provider, content provider, application integrator, mobile device, system operator, and end user. Each of these actors involves many companies as presented. Positioning technique providers include snaptrack, CPS, True-Position, Nokia, Ericsson, Cell Loc, and SiRF. Network equipment vendors include snaptrack, CPS, True-Position, Nokia, Ericsson, Cell Loc, and SiRF. Platform providers include Nokia, CT Motion, openwave, cellpoint, webraska, mapinfo, and olemap. Among the content providers are mapquest, chinaquest, cellpoint, webraska, and olemap. Application integrators include nokia, locationnet, openwave, cellpoint, webraska, olemap, and MapInfo. Mobile device dealers include Nokia, Motorola, Samsung, sonyericsson, Panasonic, Fujitsu, Casio, and NEC. System operators include A Tand T, J-Phone, KDDI, NTT DoCoMo, Orange, T-Mobile, Verizon, and Vodafone. Positioning technique providers supply the required equipment to system operators, which may include positioning technique solutions and relevant system network equipment. Each of them is in charge of different roles. For content providers, other important roles include the development of software and contents on platforms and the integration of portals. Such integrations will further become the application or content for users.

MLBS contents and services are getting more varied with the mobile communication system improvement from 2G/2.5G to 3G. MLBS-related companies include telecommunications operators, mobile phone manufacturers, and content providers. These companies have attempted to use their advantages to develop MLBS markets.

III. Research Method

A. Building the MLBS Classification Hierarchy

An overview of MLBS classifications and services has been given in the literature review. As mentioned previously, some of the services may be included in several categories. To make every category specific, the hierarchy of MLBS categories (Fig. 1) was established deliberately in the present study by reviewing the mobile location-based services in different countries. As shown in Fig. 1, there are five categories, namely, entertainment, information, navigation, commerce, and security and tracking. Each category has its attached services. For entertainment, there are two services: MLBS community/friend-finder and gaming. For information, there are four services, namely, nearby location checking, entertainment information, local weather report, and finding a taxi. For navigation, there are three services, namely, traffic information, navigation, and map. For commerce, there are two services: nearby stores' coupons/sales information, and mobile transaction/billing. For security and tracking, there are three services, namely, emergency rescue, roadside assistance, and tracking elders/children/pets/cars/property.

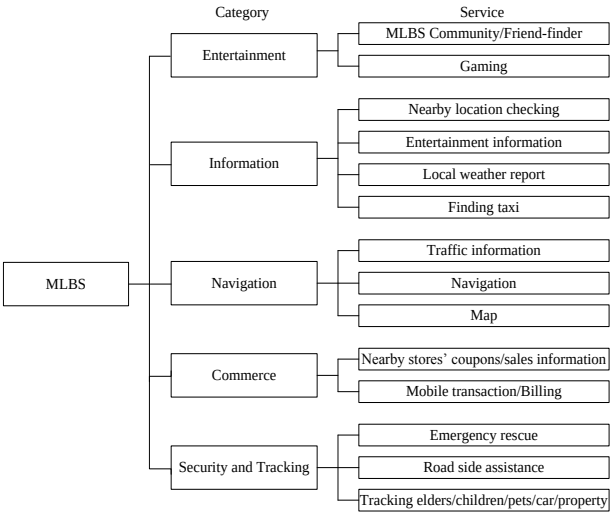

Fig. 1. Hierarchy of MLBS categories

B. Research Samples

According to FIND's report [26], about 70.47% of mobile phone users are between 14 and 42 years old. Young mobile phone users show more intention to use mobile-related applications. Therefore, young mobile phone users could be using higher frequencies than the elders in Taiwan do. Moreover, according to Kuo and Chen (2006) [27], 63% of Taiwanese mobile value-added users were between 21 and 35 years old in 2004. MLBS is a new application in the value-added services. Under such conditions, young mobile phone users who are between 14 and 42 years old were the objects of the current study.

Convenient sampling method was applied in this study. However, to avoid sampling respondents who are over 42 years old, respondents were orally asked about their age before starting to respond to the questionnaire. Respondents over 42 years old were not asked to respond to the questionnaire.

C. Questionnaire Design

The questionnaire consisted of four parts, namely, the user's willingness to use MLBS, user preference toward MLBS, billing mode, and demographics. The first part was the user's willingness to use MLBS with the purpose of figuring out the willingness and unwillingness of users and potential users to utilize MLBS.

In the second part of the questionnaire, pairwise comparison was applied to discover the preference of users for MLBS. There were two main sections: category comparison and service comparison. In the first section, the rate of preference of users for each category was compared. As mentioned in the previous section, mobile location-based services were divided into five categories, namely, entertainment, information, navigation, commerce, and security and tracking. In the second section, each service belonging to different categories was operated with pairwise comparison. The attached services to the categories were also mentioned in the previous section. For entertainment, there are two services: MLBS community/friend-finder and gaming. For information, there are four services, namely, nearby location checking, entertainment information, local weather report, and finding a taxi. For navigation, there are three services, namely, traffic information, navigation, and map. For commerce, there are two services: nearby stores' coupons/sales information, and mobile transaction/billing. For security and tracking, there are three services, namely, emergency rescue, roadside assistance, and tracking elders/children/pets/cars/property.

The purpose of the third part was to understand the preference of the respondents for billing modes. There are two sections in this part: user preference for charging solutions, and user preference for billing mode for each service.

The fourth part consists of the demographics for the purpose of generalizing the profiles of the respondents. Moreover, the differences among respondents could also be generalized. This part contains the following information: sex, age, education, profession, income, spending money, spending on voice communication (mobile phone), willingness quotas of expenditure on MLBS, charging mode, and method of obtaining MLBS.

D. Data Analysis

After determining the focused survey objects, the respondents were asked to explore user preferences for MLBS. To arrive at a sound decision to generate priorities, we needed to go through the following steps [28]-[31]:

1) Define the problem. The purpose of the present study was to explore the MLBS preferences of Taiwanese users. In this case, the problem would be very simple: What kind or which of the mobile location-based services would be the prior preferred options for users in Taiwan?
2) Structure the decision hierarchy from the top (goal) of the decision, through the intermediate levels (criteria), to the lowest level. In this step, we constructed a hierarchy and its set of criteria, as mentioned in Section 3.1.
3) Construct a set of pairwise comparison matrices. Each element would be compared in pair. If there are n

elements, the pairwise comparison should be operated for n(n-1)/2 times, as shown in the following matrix:

$$A=[a_{ij}]=\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ 1/a_{1n} & 1/a_{2n} & & 1 \end{bmatrix} \quad (1)$$

After establishing the matrix, we calculated the weight of every element. Saaty (1980) [28] enumerated four methods of calculating eigenvalues.

First is the average of normalized columns.

$$W_i' = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \qquad i, j = 1,2,\cdots\cdots,n \quad (2)$$

Second is the normalization of row average.

$$W_i' = \frac{\sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}} \qquad i, j = 1,2,\cdots\cdots,n \quad (3)$$

Third is the normalization of geometric rows.

$$W_i' = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\sum_{i=1}^{n}(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}} \qquad i, j = 1,2,\cdots\cdots,n \quad (4)$$

Fourth is the normalization of reciprocal of column sum.

$$W_i' = \frac{(1/\sum_{j=1}^{n} a_{ij})}{\sum_{j=1}^{n}(1/\sum_{i=1}^{n} a_{ij})} \qquad i, j = 1,2,\cdots\cdots,n \quad (5)$$

In general, the average of normalized columns method (2) is frequently applied to calculate the eigenvalue because most matrixes are against the consistency law. In this case, the outcome may be more accurate.

After having made all the pairwise comparisons, the consistency is determined using the eigenvalue, λmax, to calculate the consistency index. Before we calculate the consistency index, we have to apply the weights to evaluate the consistency vector (6).

$$v_i = (\sum_{j=1}^{n} w_j a_{ij}) / w_i \qquad i, j = 1,2,\cdots\cdots,n \quad (6)$$

The average of v_i is λ (7).

$$\lambda = \frac{\sum_{i=1}^{n} v_i}{n} \qquad i, j = 1,2,\cdots\cdots,n \quad (7)$$

Consistency index (CI) is as follows (8):

$$C.I. = \frac{\lambda\max - n}{n - 1} \quad (8)$$

where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value. The CR is acceptable if it does not exceed 0.10. If it does, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved. In this part, every respondent was asked to compare the relative importance of each pair of the categories. For every category, the respondents were asked to compare the services. At the end of this study, the respondents' opinions and preferences for MLBS were expected to be a valuable reference for MLBS providers in Taiwan.

4) Use the priorities obtained from the comparisons to weigh the priorities in the level below. Apply this to every element. Then, each element would get a weight as an evaluation for their priorities.

However, Expert Choice 2000 was applied to calculate the weight and consistency index. After gathering the questionnaires, the pairwise comparison data were established on the software named Expert Choice 2000. The data were further calculated by SPSS 12.0 to get the results.

IV. Empirical Study

The purpose of the current study was to discover user preferences for MLBS. To fulfill this purpose completely, respondents' willingness to use the MLBS, service information receiving channel, and billing mode were also investigated and discussed in the following sections.

A. Sample Characteristics

The current study collected 463 questionnaire responses. Given the consistency index in the second part of the questionnaire (MLBS preference), 173 questionnaires were disqualified; thus, the total number of the final responses used was 290.

Among the 290 respondents, 112 (38.6%) are males and 178 (61.4%) are females. The number of the respondents whose ages range between 19 and 22 years was 228 (78.6%), comprising the majority of the respondents. In terms of academic degree, there are two (0.3%) junior high school students, four (1.4%) high school students, 262 (90.3%) college students, and 23 (7.9%) graduate school students. In terms of professions, 274 (95.4%) respondents are students, 2 (0.7%) respondents have information technology-related careers, 1 (0.3%) respondent has an education-related career, 7 (2.4%) respondents have careers in the service industry, and 6 (2.1%) respondents have a medical/nursing career.

1) Cognitions about MLBS and Relevant Information Receiving Channel

1) Cognitions about MLBS

At the beginning of the questionnaire, respondents were asked to respond whether they know about MLBS or not. Out of the 290 respondents, 144 (49.7%) expressed knowledge of MLBS before they read the descriptions in the questionnaires. The other 146 respondents had never heard of MLBS before they read the descriptions in the questionnaires.

2) Situations of MLBS information receiving channel

If the respondents had already known about MLBS before they read the descriptions in the questionnaire, they were asked to respond to the information about their mobile telecommunication provider on receiving channels and preferred receiving channels. As shown in the previous section, there were 144 respondents who had already known about MLBS. Among these respondents, 118 received MLBS information from TV programs, 36 received telecommunications-related information from newspapers, 62 from magazines, 8 from books, 97 from the Internet, 36 from mobile advertisements, 16 through word of mouth, and 2 from other channels. The percentages were based on each type of channel.

2) Willingness to apply MLBS

After the respondents read the MLBS descriptions at the

beginning of the questionnaire, they were asked to respond whether they would like to apply MLBS or not. A total of 195 (67.3%) respondents were willing to apply MLBS. Out of the 290 respondents, 88 (30.3%) were neutral about applying MLBS, and only 7 (2.4%) respondents showed negative opinions of applying MLBS.

More than half (57.6%) of the 290 respondents were willing to pay zero to 100 NT dollars on MLBS every month. Among the 290 respondents, 76 (26.2%) would pay zero to 50 NTD on MLBS per month, 91 (31.4%) respondents would pay 51–100 NTD per month, 52 (17.9%) respondents would pay 101–150 NTD, 36 (12.4%) respondents would pay 151–200 NTD per month, 23 (7.9%) respondents would pay 201–250 NTD per month, and 12 (4.1%) respondents would pay more than 251 NTD per month on MLBS.

B. User Preference for MLBS

1) User preference for MLBS categories

In the second part of the questionnaire, respondents were asked to reply to the pairwise comparison based on their preference for MLBS. The data were established on a software named Expert Choice 2000. By applying Expert Choice 2000, the weight of each category and service was gathered. To compare with other variables, the weights were further transferred into SPSS 12.0. The preferred categories were navigation (weight = 0.21434), entertainment (weight = 0.20744), security and tracking (weight = 0.20164), information (weight = 0.19891), and commerce (weight = 0.1777).

2) Preference for MLBS

With regard to the services, the most preferred were community/friend-finder (0.10402), gaming (0.10342), nearby stores' coupons/sales information (0.09585), mobile transaction/billing (0.08185), navigation (0.08111), map (0.07894), tracking elders/children/pets/cars/property (0.07343), roadside assistance (0.07027), emergency rescue (0.05797), nearby location checking (0.05782), entertainment information (0.05726), traffic information (0.05429), local weather report (0.04877), and finding a taxi (0.03507) (Table II).

TABLE II: GENERAL RESPONDENTS' PREFERENCE FOR MLBS

Service	Weight	Preference
Community/friend-finder	0.10402	1st
Gaming	0.10342	2nd
Nearby stores' coupons/sales information	0.09585	3rd
Mobile transaction/billing	0.08185	4th
Navigation	0.08111	5th
Map	0.07894	6th
Tracking elders/children/pets/cars/property	0.07343	7th
Roadside assistance	0.07027	8th
Emergency rescue	0.05797	9th
Nearby location checking	0.05782	10th
Entertainment information	0.05726	11th
Traffic information	0.05429	12th
Local weather report	0.04877	13th
Finding a taxi	0.03507	14th

C. Billing Mode

1) Preference for charging solutions

There were three charging solutions, namely, Solution 1, charging independently for every service; Solution 2, charging for packages; and Solution 3, all-you-can-apply. The scores of Solutions 1–3 were 2.54, 1.88, and 1.59, respectively, with the lowest score as the most preferred solution. Hence, Solution 3 was the most preferred option. Meanwhile, Solution 1 was the least preferred option.

2) Pay channels for MLBS bills

This part explored the respondents' preference for pay channels to settle their MLBS bills. There were four options, as follows: integrating MLBS fees into the monthly telecommunication bills, paying MLBS fees to MLBS providers, preferred option to pay through any channel, and others. A total of 235 (81.0%) respondents expressed more preference for integrating MLBS fees into the monthly telecommunication bills than for other options. A total of 11 (3.8%) respondents preferred paying MLBS fees to MLBS providers, 40 (13.8%) respondents preferred the option to pay through any channel, and 4 (1.3%) respondents chose other options.

V. DISCUSSION AND CONCLUSION

The development of LBS has transpired for more than ten years. Relevant industry partners, for example, telecommunications operators, mobile phone manufacturers, and content providers, have put a lot of expectations into the development of LBS. Nevertheless, in previous years, location-based services have been mainly applied to emergency rescue and personal security. In addition, the limitations of mobile devices were also a key factor affecting MLBS development.

In the past, mobile devices usually did not have the GPS function. Recently, however, mobile device technologies have improved greatly. Furthermore, mobile telecommunication companies (including relevant industries), for example, Nokia, Google, and Apple, have put their efforts into extending the related functions of LBS. MLBS software platforms have been established recently. Thus, users can download the preferred software from the platform to solve the problem of having no united protocol. Moreover, users nowadays can download software from platforms as well as share their software using the same platform. This occurrence could result in the synergy for MLBS development.

A. Discussion

To enhance the development of MLBS in Taiwan, the current study tried to explore user preferences for MLBS in Taiwan.

The respondents' order of preference for MBLS categories is as follows: navigation (0.21434), entertainment (0.20744), security and tracking (0.20164), information (0.19891), and commerce (0.1777). The study of development trends of location-based services in the era of mobile broadband showed that Apple App Store and Google Android are the main application download platforms, and are also indications of the MLBS market. For both Apple App Store and Google Android, navigation and entertainment are the

most downloaded categories, thus implying the relevance of these two categories among the given categories.

The top three services for respondents were community/friend-finder (0.10402), gaming (0.10342), and nearby stores' coupons/sales information (0.09585).

Recently, networking communities (i.e., Facebook, Twitter, and so on) and GPS navigation have become popular. Android Market download ranks and the top eight LBS innovations prove that community-related services are the most popular services and have been downloaded by users most frequently [38]. However, it is not possible to have these applications if users do not have relevant devices. MLBS provides similar functions to users. There are two popular global applications: navigation, and travel and community-related category [38]. In contrast to other applications, MLBS relies on location and community as the key service elements. Moreover, users do more things on their mobile phones rather than just voice communication. Considering that most of the respondents are students (at a young age), they prefer entertainment-related applications more. In addition, mobile gaming and community/friend-finder may become a means for entertainment if users are outdoors. Nearby stores' coupons/sales information can also become useful applications for users when they are shopping. The online shopping market trend and consumer behavior [37] applied the in-depth interview and focus group methods to investigate user preference on the Internet and digital consumption in Taiwan, and found that college students preferred community and gaming services. Also, students were especially sensitive to price.

B. Implications

1) Practical implications

There are two popular application platforms related to MLBS—one is the Apple App Store, and the other is the Android Market. Navigation and travel-related category is the most popular download MLBS category in the Apple App Store from 2007 to 2009, whereas the travel and community-related category is the most popular in the Android Market [38]. Meanwhile, in the current study, navigation and entertainment (including community and gaming) are also the top two preferred categories for users in Taiwan. As such, MLBS providers and related companies can consider giving priority to developing navigation and entertainment categories. In this case, MLBS providers do not only put their resources in the target market and further save costs but also gradually lead mobile phone users to get accustomed to applying MLBS.

Taiwanese mobile users also show interest in community/friend-finder, gaming, and nearby stores' coupons/sales information. These three services are also popular in other countries. Many MLBS providers have promoted related applications. For instance, by applying geo-fencing, North Face sends an SMS (i.e., store information or promotional information) to potential consumers who approach the North Face stores [42]. However, developing a complete service is risky. In this case, MLBS providers can learn from Japan's experience (DoCoMo and Vodafone) with promoting simple functions for services to evaluate whether the services would be accepted by users [21].

Furthermore, different populations might have different preferences for MLBS. Therefore, MLBS providers should focus on their target market and customize the services for their target users. The relevant recommendations for each key player are as follows.

1) Telecommunications operator

Users preferred community/friend-finder (0.10402), gaming (0.10342), and nearby stores' coupons/sales information (0.09585). Therefore, the current study recommends telecommunications operators to provide community/friend-finder, gaming, and nearby stores' coupons/sales information in the beginning. Afterward, they may provide information or promotions related to the three services in the monthly bills. For example, users can get some discounts for telecommunications fees if they use MLBS. Promotions may increase the willingness of the users to apply MLBS.

2) Mobile phone manufacturer

The respondents preferred community/friend-finder (0.10402), gaming (0.10342), and nearby stores' coupons/sales information (0.09585). Therefore, the current study recommends mobile phone manufacturers to provide community/friend-finder, gaming, and nearby stores' coupons/sales information in the new mobile phones in the beginning to increase the willingness of the users to buy new mobile phones and utilize MLBS applications later on.

3) Content provider

Similarly, content providers should develop community/friend-finder, gaming, and nearby stores' coupons/sales information as MLBS applications in the beginning to increase the willingness of the users to access MLBS applications.

2) Academic implications

The current study reviewed the LBS categories and services in recent years and further classified them into five categories, namely, entertainment, information, navigation, commerce, and security and tracking. MLBS is developing, and various applications will be promoted day after day. Nevertheless, we believe the five categories can contain every service. In addition, the current study includes other aspects of user preferences on MLBS, such as willingness to apply the service and billing issues. Therefore, the study provides a basic reference for other researchers in the field.

C. Limitations and Future Directions

The current study investigated the MLBS preferences of young mobile phone users in Taiwan. The respondents mainly comprised students. The main group was aged between 19 and 26 years. Therefore, the results and conclusion of the present study are better applied to young mobile users who are about 19 to 26 years old. Furthermore, most of the respondents were from the south of Taiwan.

Further research may have the following directions. First, the number of objects can be increased to make the results more accurate. Second, future research may involve respondents of every age to find out the differences among the ages in terms of MBLS preference. Third, future studies may likewise include different professions to figure out the

differences among them. Fourth, future research can try to build strategies for developing different categories of MLBS. Furthermore, further studies may suggest different charges on service features.

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