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Determining the mobile commerce user requirements using an analytic approach

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Abstract

Independent studies have shown that mobile commerce (m-commerce) can have an important influence on business and society in the future. Hence, network designers, service providers, vendors and application developers must carefully take the needs and considerations of various users into account to provide better services and attract them to m-commerce. Consequently, identifying the m-commerce user requirements and their significance becomes an essential and crucial process for the standardization and improvement of associated systems. On this line, the objective of this paper is to propose an analytic framework to provide practitioners a more effective and efficient model for prioritizing m-commerce requirements.
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Keywords: Mobile commerce; User requirements; Fuzzy analytic hierarchy process

1. Introduction

It is increasingly becoming an understatement to say that the Internet and related technologies are changing the ways we live. Clearly, these technologies will affect peoples' lives in ways that have yet to be imagined. In recent years, Internet providers have been increasingly interested in supporting users' activities in the mobile environment. With the rapid development of communication technologies, various kinds of mobile applications have become popular. Using mobile devices like cell phones or palmtops, people play games, check e-mails, surf and even check prices on the stock market. As a revolutionary technology, mobile computing enables us to access information anytime anywhere even in the absence of physical network connections [31]. Going beyond the computer-mediated electronic commerce or e-commerce of the 1990s, this new type of mobile commerce or m-commerce is characterized by novel, location-based services delivered by a variety of handheld terminals [16]. Yang [50] indicated that there are currently 94.9 million m-commerce users worldwide in 2003 and the segment is expected to grow to 1.67 billion by 2008. Delivering value added, interactive, and/or location-based mobile services (e.g., banking, content download, emergency/roadside assistance, etc.) to customers seems to be increasingly important in gaining a competitive edge by strengthening relationships with key customers [32,53]. These and other independent studies have shown that m-commerce can have an important influence on business and society in the future [23,39]. Hence, network designers, service providers, vendors and application developers must carefully take the needs of various users into account to provide better services and attract them to m-commerce [40].

The primary measure of success of a designed system, being it a product, a software system, or a service system, is the degree to which it meets the purpose for which it was intended. User satisfaction is commonly acknowledged as one of the useful proxy measures of m-commerce system success [55]. Hence, it is an essential to identify the user requirements for setting m-commerce systems standards. In addition, because of limited resources, it is always unfeasible for organizations to devote their efforts to concurrently address all the m-commerce user requirements. Determining the importance of the user

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requirements enables organizations to develop priorities when they establish or improve their m-commerce services standards. Motivated by those points, the objective of this paper is to propose an analytic framework to provide practitioners a more effective and efficient model for prioritizing m-commerce requirements. The proposed framework consists of three main steps:

(i) identifying m-commerce user requirements;
(ii) structuring m-commerce user requirements; and
(iii) identifying the importance weights for m-commerce user requirements.

Determining the correct importance weights for the user requirements are essential since they directly affect the target values set for the design characteristics. Various methods have been attempted to determine the importance weights. The simplest method to prioritize user requirements is based on a point scoring scale, such as one to five or one to ten. However, this method cannot effectively capture human perception. Prioritizing user requirements can be viewed as a complex multi-criteria decision-making (MCDM) problem. The analytic hierarchy process (AHP) [42], a MCDM method, has been used largely in weighing user requirements (such as [1,13,19,22,33]). However, customers' expectation always contains ambiguity and multiplicity of meaning. Furthermore, it is also recognized that human assessment on qualitative attributes is always subjective and imprecise. Hence, the conventional AHP seems inadequate to explicitly capture the importance assessment for user requirements. In this research, the linguistic assessment of user requirements is converted to triangular fuzzy numbers. These triangular fuzzy numbers are used to build a pairwise comparison matrix for the AHP [3]. By applying the fuzzy AHP methodology, one can obtain the importance weights for the m- commerce user requirements.

The paper is organized as follows. The related studies are summarized in Section 2. The third section describes the m-commerce user requirements. Section 4 presents briefly the employed method, namely fuzzy AHP, to compute the requirements weights. Section 5 comprises an application of the proposed framework and gives the analytic results obtained. In the last section, some concluding remarks are given.

2. Background

2.1. Related work

Based on works of Mennecke and Strader [35] and Varshney et al. [48], Ngai and Gunasekaran [36] proposed a five level integrated framework for m-commerce literature: m-commerce theory and research, wireless network infrastructure, mobile middleware, wireless user infrastructure and m-commerce applications and cases. Our study focuses generally on the wireless user infrastructure, but more specifically on m-commerce from users/customers point of view. Some important recent studies that can be found in the related literature are summarized in the following.

By stating that understanding the adoption of wireless application protocol (WAP) services is increasingly important for enterprises interested in developing m-commerce, Hung et al. [21] identified the critical factors of WAP services adoption; explored the relative importance of each factor between WAP adopters and non-adopters by using structural equation modeling and examined the causal relationships among variables on WAP services adoption behavior. The results indicated that the critical factors influencing the adoption of WAP services include connection speed, service costs, user satisfaction, personal innovativeness, ease of use, peer influence, and facilitating conditions.

The work of Mahatanankoon et al. [34] investigates the various aspects of mobility and how consumers perceived different mobile applications. The authors first examine the value proposition of mobility. M-commerce operation modes and potential consumer-based applications are then investigated. A consumer perception survey was conducted to reveal the attributes that are perceived as important by consumers for making m-commerce choices. Three data analysis stages were carried out. In the first stage, based on an initial pilot study, the authors generate a pool of 44 consumer-based mobile applications. In the second stage, they further refine these applications by examining the histogram of each application, and rank them according to what seemed to be the most preferred by the consumers. In the last stage, they use exploratory factor analysis to classify different types of mobile applications.

Fu et al. [18] state that a meaningful model is needed as a reference for the implementation of wireless systems. Hence, they propose such a model on the basis of the relevant literature and a practical case study. Following the case study presentation, they investigated the success factors in m-commerce implementation, proposed a possible wireless system implementation model, and analyzed the differences between wireless system and information system. Their study shows that different implementation models and strategies are needed according to the needs and purposes of the system.

Wang and Liao [55] develop a comprehensive model and an instrument for measuring user satisfaction with m-commerce systems. They introduce and define the m-commerce user satisfaction (MCUS) construct that consists of four factors such as content quality, appearance, service quality, and ease of use. Wang and Liao [55] provide also empirical validation of the construct and its underlying dimensionality, develop a standardized instrument with desirable psychometric properties for measuring MCUS, and explore the measure's theoretical and practical application.

Lin and Wang [32] developed and validated a customer loyalty model in the m-commerce context. Based on the information system and marketing literature, a comprehensive set of constructs and hypotheses were compiled with a methodology for testing them. A questionnaire was constructed and data were collected from 255 users of m-commerce systems in Taiwan. Structural modeling techniques were then applied to analyze the data. The results indicate that m-commerce customer loyalty is affected by perceived value, trust, habit, and customer satisfaction, with customer satisfaction playing a crucial intervening role in the relationship of perceived value and trust to loyalty.

Wu and Wang [56] present an extended technology acceptance model (TAM) that integrates innovation diffusion theory, perceived risk and cost into the TAM to investigate what determines user m-commerce acceptance. Their model consists of seven variables such as perceived risk, cost, compatibility, perceived usefulness, perceived ease of use, behavioral intention to use, actual use. The proposed model is empirically tested using the data collected from a survey on m-commerce consumers. The structural equation modeling technique was used to evaluate the causal model and confirmatory factor analysis was performed to examine the reliability and validity of the measurement model. The results show that perceived usefulness and perceived ease of use all indirectly influence the actual usage through behavioral intention to use and the most important determinant for behavioral intention to use is compatibility. Finally, based on these findings, Wu and Wang [56] suggest that m-commerce providers and managers should improve their compatibility with various user requirements, past experience, lifestyle and beliefs in order to fulfill customer expectations.

To conclude, apart from a few recent reports and research studies on m-commerce that take into account the users/customers point of view only Derek [15], to our knowledge, determines clearly some user requirements, especially for security in wireless mobile systems. The current work will contribute to the existing literature by identifying and prioritizing m-commerce user requirements. Moreover, all previous studies make use of statistical techniques for data analysis. However, a MCDM method, namely fuzzy AHP is used in this work, which makes it enough apart form other existing ones.

2.2. Relevance to computer standards and interfaces

In order to develop successful m-commerce systems, identifying user requirements is essential. These requirements have to be taken into consideration carefully by network designers, service providers, vendors and application developers and tried to define suitable computer standards [46] to respond these needs. The ability to define standards and common rules will facilitate the rapid adoption of the m-commerce and increase speed to market of this technology. At the same time, "interface" is determined as one of the important characteristics of functionality requirements of m-commerce systems as detailed in the next section. In sum, we believe that the identification of user requirements that will assist in developing standards related to m-commerce systems and interfaces will be of great interest to a wide range of "Computer Standards and Interfaces Journal" readers.

3. M-commerce user requirements

To comprehensively identify the m-commerce user requirements, a two-step approach is followed. Firstly, a list of preliminary success factors is identified based on an extensive review of m-commerce, mobile business and mobile applications literature (such as [2,5,20,21,26,34,55,56]). Secondly, the identified requirements are subject to the examination and modification of information technology experts. During the interviews, experts are encouraged to suggest user requirements other than those shown on the preliminary list. In any application having the objective to satisfy its customer, one must focus to the needs of system users. These needs relate partially to some general concepts like safety or price; in addition to these, mobile applications create their own requirements for the customers like individualization of the applications or the used interface. By this two-step approach, 13 factors were finally retained and grouped into three categories as detailed below.

3.1. Functionality

The functionality in the mobile applications indicates the interface between mobile technologies and the user of these applications. The user must feel at ease reaching the mobile platforms. An unspecified problem stopping the application will cause a difficulty relating to the return of the user to this application. For better describing the functionality, it is necessary to detail its sub-criteria.

- *Simplicity* [2,5,21,45,55,56]: The access of the user to the mobile applications should require only minimum knowledge of technologies. One should not intimidate the user by the complexity of the mobile platform. The user must be at ease by using the mobile applications, as it is it by using the conventional models.
- *Usability* [5,21,29,55,56]: This concept indicates the contribution of the interface to the comprehension of the user of mobile technologies. The auto-completion (If I type my name once; with the next time, with only one letter, the system can supplement my name) or the knowledge of the identity to the following accesses are examples of the usability.
- *Flexibility* [17,41,45,46,55]: The flexibility of the mobile applications indicates the adaptation of the capacity to answer various volumes of user according to the request considered. The reduction of the speed and the interruption of the access caused by the density of the request will move away the user from the mobile applications. The integration of technologies would also provide the necessary functions and capabilities to deliver the dynamic content to mobile systems.
- *Interface* [5,21,28,30,36,55,56]: The interface of the mobile applications represents the physical aspect characterizing the connection between the mobile applications and the user. The interface must be, firstly, comprehensible to be able to meet the user's needs. It must guide the customer of the mobile applications through the stages considered.
- *Speed* [5,21,55]: The principal objective pushing the user to prefer mobility is the speed of the mobile applications. The same applications in "motionless" platforms cause a wasting of time no necessary for the man of 21st century. Consequently, an optimal speed in each application is one of the more essential needs in mobility.
- *Accessibility* [5,17,29,55]: The user requires mobility to be accessible everywhere and all the time, because it is the objective of the user by using the mobile applications. Like the access

occurs different places, the mobile applications must adapt to the several places according to the density of the request.

3.2. Profitability

The user would like to know the profit that it will receive while reaching the mobile applications instead of using the same applications in a conventional way. This profit can be concrete or conceptual, according to the aim had by the user. One can categorize the concrete profit and the conceptual profit by groups representing the monetary aspects and the abstract aspects of profitability.

- *Added value* [5,30,32,55,56]: The user must be convinced that using the mobile applications, it acquired a value that the other models do not provide him. This perception is the key factor of the satisfaction of the user. The user want to response with a value perspective the question "Why I use mobility instead of carrying out the same application by the conventional ways? ". The perception of this value must be evoked with the aim of holding the user.
- *Options of payment* [13,32,38,49,55]: The more the user will feel at ease concerning his options of payment, the more there will be a possibility of the return of this user to the application considered. Pre-payment, and the payment with credit are the most adopted models. These options must be developed in order to answer the requests increasing of the users.
- *Price* [12,21,30,32,55,56]: The price of the mobile applications includes/understands the price of the service and the price of access. The optimization of the price planned for the use of a mobile application attracts the user; because if an application is roughly at same price some is the reached platform (mobile or not), the user prefers the mobile platform because of the accessibility of this.
- *Individualization* [5,55]: To be able to satisfy the user, it is necessary to concentrate on the characteristics of the individual concerned. It is not sufficient any more to target a vague type of user. The user must perceive that the mobile application where it reaches can meet these specific needs. With the aim of individualization, it is necessary that the user belongs to a specific market segment.

3.3. Credibility

The credibility of the mobile applications is what makes their uses frequent. If the user experienced a problem during the transaction or the payment, it is certain that it will not use the mobile applications once more. The credibility of the mobile applications has two aspects: what is produced by the system itself and what is perceived by the user. One can divide these two aspects into three groups.

- *Reliability* [15,17,29,45,56]: The reliability of a mobile application is perception, by the user, of the image created by the supplier of the mobile services and the operator of the mobile network. The user will rely on the mobile system, in spite of the problems of safety (negligible), if the image created is reliable.
- *Safety* [5,15,29]: Safety is the technical aspect of the credibility of the mobile applications. It must be ensured by protocols and by technologies available and it must be widened as long as necessary.
- *Correction of the system* [15,29,41,56]: The correction of the system includes/understands the correction of the propagation of information and the correction of the interface of the system. The user requires the exactitude of any received information of the reached mobile application. A tested fault can damage all the correction of the system.

4. The fuzzy AHP methodology

It is not possible to assume that an identified m-commerce user requirement is of equal importance. For this reason, the most well-known MCDM approach, namely AHP [42], may be used for criteria weight determination, as suggested by Salmeron and Herrero [44] and Işıklar and Büyüközkan [22]. AHP assumes that evaluation criteria can be completely expressed in a hierarchical structure. The data acquired from the decision-makers are pairwise comparisons concerning the relative importance of each of the criteria, or the degree of preference of one factor to another with respect to the each criterion. For details on the use of AHP and its various calculations, the reader is referred to the work of Saaty [42]. In the conventional AHP, the pairwise comparison is made by using a ratio scale. Even though the discrete scale has the advantages of simplicity and ease of use, it does not take the uncertainty associated with the mapping of one's perception (or judgment) to a number into account. However, it is also well recognized that human assessment on the relative importance of individual customer requirements is always subjective and imprecise. The linguistic terms that people use to express their feelings or judgment are vague. Firstly, as advocated by Zadeh [51], fuzzy set theory has become an important theory to deal with the ambiguity in a system. In this paper, the widely adopted triangular fuzzy number technique is used [54].

A fuzzy number is a special fuzzy set $F=\{x \in R | \mu_F(x)\}$, where x takes its values on the real line R_1: $-\infty < x < +\infty$ and $\mu_F(x)$ is a continuous mapping from R_1 to the close interval [0,1]. A triangular fuzzy number can be denoted as $M=(l, m, u)$. Its membership function $\mu_M(x): R \rightarrow [0,1]$ is equal to:

$$\mu_M(x) = \begin{cases} 0, & x < l \text{ or } x > u, \\ (x-l)/(m-l), & l \le x \le m, \\ (x-u)/(m-u), & m \le x \le u \end{cases} \quad (1)$$

Where $l \le m \le u$, l and u stand for the lower and upper value of the support of M, respectively, and m is the mid-value of M. When $l=m=u$, it is a non-fuzzy number by convention. The main operational laws for two triangular fuzzy numbers M_1 and M_2 are as follows [24]:

$$\begin{aligned} & M_1 + M_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2), \\ & M_1 \otimes M_2 \approx (l_1 l_2, m_1 m_2, u_1 u_2), \\ & \lambda \otimes M_1 = (\lambda l_1, \lambda m_1, \lambda u_1), \lambda > 0, \lambda \in R, \\ & M_1^{-1} \approx (1/u_1, 1/m_1, 1/l_1) \end{aligned} \quad (2)$$

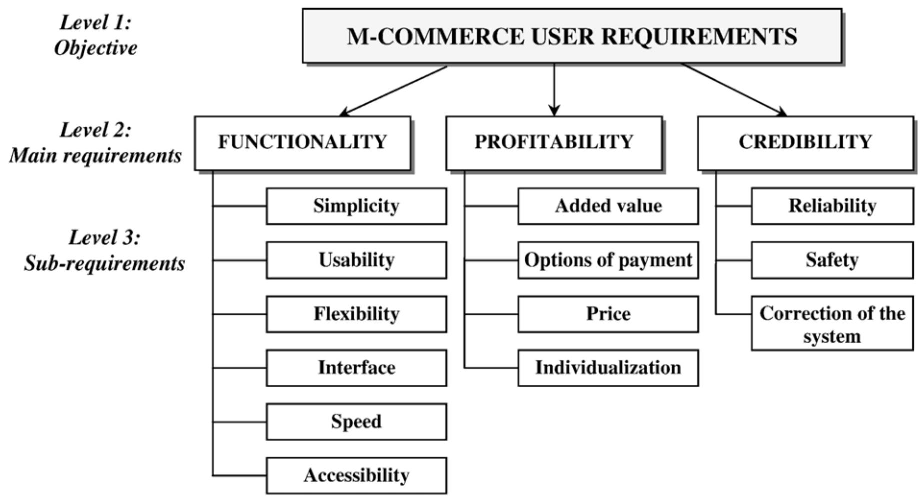

Fig. 1. A hierarchy model of the determination of the m-commerce user requirements problem.

In order to deal with the uncertainty and vagueness from the subjective perception and the experience of humans in decision process, many fuzzy AHP methods are proposed by various authors since the seminal paper by Van Laarhoven and Pedrycz [47]. For detailed discussions on this subject, the reader may be referred to Büyüközkan et al. [7]. In this paper, we make use of Chang's fuzzy extent analysis for AHP [11] because of its computational simplicity and effectiveness and we also integrate the improvement proposed by Zhu et al. [52] to the methodology. Recently, Büyüközkan [6] has applied this method to select best e-marketplace alternative while Chan and Kumar [9] employed it in the global supplier selection problem. Similarly Bozbura et al. [4] used this approach to improve the quality of prioritisation of human capital measurement indicators.

Let $X=\{x_1,x_2,\ldots,x_n\}$ be an object set, and $U=\{u_1,u_2,\ldots,u_m\}$ be a goal set. According to the method of Chang's extent analysis model, each object is taken and extent analysis for each goal, g_i, is performed respectively [10,11]. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, i = 1, 2, \ldots, n \tag{3}$$

where all the $M_{g_i}^j (j=1,2,\ldots,m)$ are triangular fuzzy numbers. A triangular fuzzy number can be denoted as $M=(l, m, u)$ where

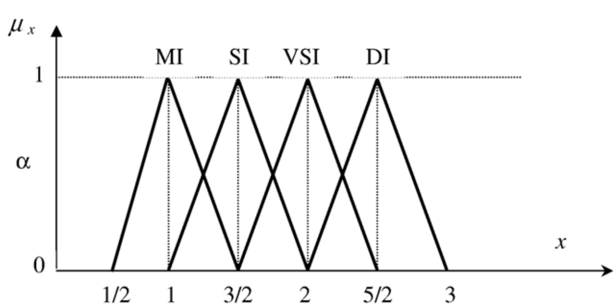

Fig. 2. Triangular fuzzy importance scale.

$l \le m \le u$, l and u stand for the lower and upper value of the support of M, respectively, and m is the mid-value of M.

The steps of the improved Chang's extent analysis model [52], which is applied in this study, can be given as follows:

Step 1. The value of fuzzy synthetic extent with respect to the ith object is defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \tag{4}$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that

$$\sum_{j=i}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{5}$$

and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1}$, perform the fuzzy addition operation of $M_{g_i}^j$ $(j=1,2,\ldots,m)$ values such that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{6}$$

and then compute the inverse of the vector in Eq. (6) such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{7}$$

The principles for the comparison of fuzzy numbers were introduced to derive the weight vectors of all elements for each level of the hierarchy with the use of fuzzy synthetic values. We now discuss these principles that allow the comparison of fuzzy numbers [52].

Table 1
Triangular fuzzy importance scale

Linguistic scale for importance degree	Explanation	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equal importance (EI)	Two requirements are the same importance	(1, 1, 1)	(1, 1, 1)
Moderate importance (MI)	Experience and judgment slightly favour one requirement over another	(1/2, 1, 3/2)	(2/3, 1, 2)
Strong importance (SI)	Experience and judgment strongly favour one requirement over another	(1, 3/2, 2)	(1/2, 2/3, 1)
Very strong importance (VSI)	A requirement is favoured very strongly over another; its dominance demonstrated in practice	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Demonstrated importance (DI)	The evidence favouring one requirement over another is the highest possible order of affirmation	(2, 5/2, 3)	(1/3, 2/5, 1/2)

Step 2. The degree of possibility of $M_2 \geq M_1$ is defined as

$$V(M_2 \geq M_1) = \sup_{y \geq x}\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right] \tag{8}$$

When a pair (x, y) exists such that $y \geq x$ and $\mu_{M_1}(x)=\mu_{M_2}(y)$, then we have $V(M_2 \geq M_1)=1$. Since $M_1=(l_1, m_1, u_1)$ and $M_2=(l_2, m_2, u_2)$ are convex fuzzy numbers we have that

$$V(M_2 \geq M_1) = \text{hgt}(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, \text{ if } m_2 \geq m_1 \\ 0, \text{ if } l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, \text{otherwise} \end{cases} \tag{9}$$

where d is the crossover point's abscissa of M_1 and M_2. To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.
Step 3. The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i $(i=1,2,\ldots,k)$

Table 3
The fuzzy evaluation matrix of the main m-commerce user requirements

	Functionality	Profitability	Credibility
Functionality (F)	(1,1,1)	(1/2, 1, 3/2)	(1/2, 1, 3/2)
Profitability (P)	(2/3, 1, 2)	(1,1,1)	(1, 3/2, 2)
Credibility (C)	(2/3, 1, 2)	(1/2, 2/3, 1)	(1,1,1)

can be defined by

$$\begin{aligned} &V(M \geq M_1, M_2, \ldots M_k) \\ &= V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and} \ldots \text{and } (M \geq M_k)] \\ &= \min V(M \geq M_i), i = 1, 2, 3, \ldots, k \end{aligned} \tag{10}$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k) \tag{11}$$

for $k=1,2,\ldots,n$; $k \neq i$. Then the weight vector is obtained as follows:

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \tag{12}$$

where A_i $(i=1,2,\ldots,n)$ are n elements.
Step 4. After normalization, the normalized weight vectors are,

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \tag{13}$$

where W is not a fuzzy number.

5. Importance weights of the m-commerce user requirements

As previously mentioned, in the third step of our framework, we apply the fuzzy AHP methodology for criteria weight determination. The main m-commerce user requirements together with related attributes are given in Fig. 1.

In order to perform a pairwise comparison among the requirements, a linguistic scale has been developed. Our scale is depicted in Fig. 2 and the corresponding explanations are provided in Table 1. Fig. 2 shows the triangular fuzzy numbers $M=(l, m, u)$

Table 2
A sample questions from the questionnaire and answers

Please read the following questions and put check marks on the pair wise comparison matrices. If an attribute on the left is more important than the one on the right, put cross mark ‘‘X’’ to the left of the ‘‘Equal importance’’ column, under the importance level (column) you prefer. On the other hand, if an attribute on the left is less important than the one on the right, put cross mark ‘‘X’’ to the right of the ‘‘Equal importance’’ column, under the importance level (column) you prefer.
With respect to the overall objective, evaluation *of m-commerce user requirement*
Q1. How important is *functionality* when it is compared to *profitability*?
Q2. How important is *functionality* when it is compared to *credibility*?
Q3. How important is the *profitability* when it is compared to *credibility?*

With respect to: overall objective		Preference of one requirement over another									
Questions	Requirement	Demonstrated importance	Very strong	Strong importance	Moderate importance	Equal importance	Moderate unimportance	Strong unimportance	Very strong unimportance	Demonstrated unimportance	Requirement
1	Functionality				*						Profitability
2	Functionality				*						Credibility
3	Profitability			*							Credibility

Table 4
The fuzzy evaluation matrix of the functionality sub-requirements

	Sm	*U*	*F*	*I*	Sp	*A*
Simplicity	(1, 1, 1)	(1, 3/2, 2)	(2, 5/2, 3)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2, 5/2, 3)
Usability	(1/2, 2/3, 1)	(1, 1, 1)	(3/2, 2, 5/2)	(1, 3/2, 2)	(1, 3/2, 2)	(3/2, 2, 5/2)
Flexibility	(1/3, 2/5, 1/2)	(2/5, 1/2, 2/3)	(1, 1, 1)	(1/2, 2/3, 1)	(1/2, 2/3, 1)	(1, 1, 1)
Interface	(2/5, 1/2, 2/3)	(1/2, 2/3, 1)	(1, 3/2, 2)	(1, 1, 1)	(1, 1, 1)	(1, 3/2, 2)
Speed	(2/5, 1/2, 2/3)	(1/2, 2/3, 1)	(1, 3/2, 2)	(1, 1, 1)	(1, 1, 1)	(1, 3/2, 2)
Accessibility	(1/3, 2/5, 1/2)	(2/5, 1/2, 2/3)	(1, 1, 1)	(1/2, 2/3, 1)	(1/2, 2/3, 1)	(1, 1, 1)

where $l \leq m \leq u$, l and u stand for the lower and upper value of the support of M, respectively, and m is the mid-value of M. Similar to the importance scale defined in Saaty's classical AHP [42], we have used five main linguistic terms to compare the criteria: "equal importance", "moderate importance", "strong importance", "very strong importance" and "demonstrated importance". We have also considered their reciprocals: "equal unimportance", "moderate unimportance", "strong unimportance", "very strong unimportance" and "demonstrated unimportance". For instance, if criterion A is evaluated "strongly important" than criterion B, then this answer means that criterion B is "strongly unimportant" than criterion A.

The evaluator group consists of the three experts that have extensive working experience in the mobile business/commerce area in Turkey and five Turkish m-commerce users. A questionnaire is provided to get the evaluations. The evaluator group is invited to answer the questions in the questionnaire during our invited meeting. A sample of questions from the questionnaire is given in Table 2.

The overall results could be obtained by taking the geometric mean of individual evaluations. However, since the group of experts came up with a consensus by the help of the Delphi Method [14,37] in our case, a single evaluation could be obtained to represent the group's opinion and it is transferred to a spreadsheet as shown in Tables 3–6.

The values of fuzzy synthetic extents with respect to the main user requirements are calculated by applying formula (4) as below:

$$S_F = (2,3,4) \otimes (0.077, 0.109, 0.146) = (0.154, 0.327, 0.584),$$
$$S_P = (2.67, 3.50, 5.00) \otimes (0.077, 0.109, 0.146) = (0.2056, 0.3815, 0.73),$$
$$S_C = (2.17, 2.67, 4.00) \otimes (0.077, 0.109, 0.146) = (0.013, 0.291, 0.584).$$

The degrees of possibility are calculated using these values and formula (9) as below:

$$V(S_F \geq S_P) = (0.2056 - 0.584)/[(0.327 - 0.584) - (0.3815 - 0.2056)] = 0.874,$$
$$V(S_F \geq S_C) = 1.00,$$
$$V(S_P \geq S_F) = 1.00,$$
$$V(S_P \geq S_C) = 1.00,$$
$$V(S_C \geq S_F) = (0.154 - 0.584)/[(0.291 - 0.584) - (0.327 - 0.154)] = 0.923,$$
$$V(S_C \geq S_P) = (0.2056 - 0.584)/[(0.291 - 0.584) - (0.3815 - 0.2056)] = 0.807.$$

The weight vector of the main requirement level of the hierarchy can be calculated by using formulas (10) and (11) as below:

$$d'(F) = V(S_F \geq S_P, S_C) = \min\,(0.874, 1.00) = 0.874$$
$$d'(P) = V(S_P \geq S_F, S_C) = \min\,(1.00, 1.00) = 1.00$$
$$d'(C) = V(S_C \geq S_F, S_P) = \min\,(0.923, 0.807) = 0.807$$
$$W' = (0.874, 1.00, 0.807)^T.$$

Hence, via normalization, we have obtained the normalized weight vectors of the main m-commerce user requirements Functionality, Profitability and Credibility as shown below:

$$W_{\text{Objective}} = (0.33, 0.37, 0.30)^T.$$

In a similar way, the importance weights of the sub-requirements with respect to functionality are calculated as follows:

$$W = (d(\text{Sm}), d(U), d(F), d(I), d(\text{Sp}), d(A))^T.$$

$W_{\text{Functionality}}=(0.28,\ 0.22,\ 0.10,\ 0.15,\ 0.15,\ 0.10)^T$. We can observe that for the functionality, simplicity and usability play a much more important role than other criteria.

The importance weights of the sub-requirements with respect to profitability are calculated as follows:

$$W = (d(\text{AV}), d(\text{OP}), d(P), d(\text{Ind}))^T.$$

$W_{\text{Profitability}}=(0.33,\ 0.22,\ 0.39,\ 0.07)^T$. We can conclude that in order to increase the profitability of a m-commerce system, price and added value appear to be more important than option of payment and individualization.

Table 5
The fuzzy evaluation matrix of the profitability sub-requirements

	AV	OP	*P*	Ind
Added value	(1,1,1)	(1, 3/2, 2)	(1/2, 2/3, 1)	(3/2, 2, 5/2)
Options of payment	(1/2, 2/3, 1)	(1,1,1)	(1/2, 2/3, 1)	(1, 3/2, 2)
Price	(1, 3/2, 2)	(1, 3/2, 2)	(1,1,1)	(3/2, 2, 5/2)
Individualization	(2/5, 1/2, 2/3)	(1/2, 2/3, 1)	(2/5, 1/2, 2/3)	(1,1,1)

Table 6
The fuzzy evaluation matrix of the credibility sub-requirements

	R	*S*	CS
Reliability	(1, 1, 1)	(1/2, 1, 3/2)	(1, 3/2, 2)
Safety	(2/3, 1, 2)	(1, 1, 1)	(1, 3/2, 2)
Correction of the system	(1/2, 2/3, 1)	(1/2, 2/3, 1)	(1, 1, 1)

Table 7
Composite priority weights for m-commerce user requirements

Main requirements	Local weights	Sub-requirements	Local weights	Global weights
		Simplicity	0.28	0.0924
Functionality	0.33	Usability	0.22	0.0726
		Flexibility	0.10	0.033
		Interface	0.15	0.0495
		Speed	0.15	0.0495
		Accessibility	0.10	0.033
Profitability		Added value	0.33	0.1221
	0.37	Options of payment	0.22	0.0814
		Price	0.39	0.1443
		Individualization	0.07	0.0259
		Reliability	0.38	0.114
Credibility	0.30	Safety	0.38	0.114
		Correction of the system	0.24	0.072

The importance weights of the sub-requirements with respect to credibility are calculated as follows:

$$W = (d(R), d(S), d(\mathrm{CS}))^T.$$

$W_{\mathrm{Credibility}} = (0.38, 0.38, 0.24)^T$. This means that reliability and safety have the same importance for credibility requirement.

Finally, considering the obtained results, composite priority weights for m-commerce user requirements can be calculated as given in Table 7.

Based on these results, it may be concluded that the price, added value, reliability, safety and simplicity requirements play a predominant role for Turkish m-commerce users. When considering the requirements separately, it can be seen that with simplicity, usability is also important for functionality characteristics in m-commerce evaluation process.

6. Conclusion

There is an increasing interest on m-commerce and its related subjects; however, the identification of user requirements is a less concerned issue. This study proposes an analytic framework for the identification of m-commerce user requirements. The hierarchy of m-commerce user requirements has been derived with a survey of the existing literature and by consulting industrial experts. In general, the evaluation problems adhere to uncertain and imprecise data, and fuzzy set theory is an important tool to model such situations. After identifying m-commerce user requirements, fuzzy AHP methodology is used to determine the requirements relative weights. The fuzzy AHP model applied in this paper is proved to be simple, less time taking and having less computational expense as compared to other existing decision-making systems (such as [4,6,9,25,27]). The results show that for Turkish m-commerce users, the most important requirements are price, added value, reliability, safety and simplicity. These results can be useful to researchers to better understand m-commerce theoretically, as well as to organizations in designing better accepted and satisfying m-commerce systems, standards and interfaces.

Although the proposed framework is illustrated by Turkish m-commerce users' perspectives, it can be attractive to replicate this study for different countries and compare the obtained results in a future study. Another fact is that in a complex system most of the factors are interacting. However, in this study, the user requirements are evaluated through fuzzy AHP methodology with the assumption of independency. It is clear that additional model refinement is required to better understand the correlations among criteria. The Analytic Network Process (ANP) [43], the general form of AHP, is capable of handling interdependence among elements by obtaining the composite weights. This method has been recently developed to use in a fuzzy environment [8]. Further research may include the application of this method to the m-commerce user requirements determination and contrasting the results with this work.

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