

# Selection of the Success Factors of Mobile Commerce and Evaluation using AHP

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## Summary

With the development of information technology, ordinary commercial activities are evolving into e-commerce. In e-commerce, users can access services from any place as long as information technology is available. Currently, e-commerce is moving toward mobile commerce that allows users to do commercial activities while they are moving. Mobile commerce shares some characteristics with e-commerce but is also distinguished from it. Previous studies that analyzed the characteristics of mobile commerce have been made focused on specific regions or areas or from specific viewpoints.

The present study analyzed the diverse characteristics of the success factors of mobile commerce in consideration of the user aspect, the developer aspect and the operator aspect as well as the functional aspect, the technological aspect and the market aspect. The extracted factors were evaluated objectively using an analytics hierarchical process (AHP). Factors such as trust in system quality and understandability in contents quality identified through analysis in this study are part of success factors currently applied to mobile commerce

## Key words:

Analytics Hierarchical Process, Electronic Commerce, Mobile Commerce, MAUT, Ubiquitous Commerce

## 1. Introduction

Commercial activities based on information technology have used electronic data interchange between computers, but with the development of Internet technology, they evolved into e-commerce. In the 1990s, mobile commerce was recognized as a part of e-commerce. With the increase of mobile devices, the use of mobile commerce, which accesses and use desired information at any time while moving (Anywhere, Anytime), was popularized. In the late 1990s, over 3.5 million devices were used, but entering the 2000s, the number exceeded a trillion [1][2]. The market size also has already gone beyond 200 trillion won in 2004 [3].

Information acquisition pattern desired by customers in mobile commerce involves processes such as identification, information search, alternative evaluation,

purchase and delivery, and evaluation after purchase. Such a series of processes is an important factor for companies that intend to engage in mobile commerce [4].

Although mobile commerce is forming a large-scale market, previous researches have been focused on limited analysis of e-commerce. Thus, it is very important to know what the important success factors and available alternatives are to the companies. If the limitations of mobile commerce are understood in advance and overcome and factors for maximizing its advantages are analyzed and utilized, we can cope with changes in the market more actively. In this sense, it is very useful to examine the success factors of mobile commerce from the user aspect, the developer & contents provider aspect and the system aspect and furthermore from the functional aspect, the technological aspect and the market aspect.

E-commerce is similar to mobile commerce in some parts but they are different in many points [8], so it is difficult to promote mobile commerce based on the factors of e-commerce. Previous researches have been based on a limited part, but in this study, we analyze the components of mobile commerce environment by stage because the evolution from e-commerce to mobile commerce is quite complicated and they are different in many aspects. Thus, we made evaluation using analytics hierarchical process (AHP) to extract critical success factors for entering into the market of new mobile commerce that copes with the change of fundamental paradigm and to prioritize them through a quantitative method. In this paper, Chapter II reviewed related works, extracted the success factors of mobile commerce and alternatives, and examined major components and characteristics of AHP. Chapter III made calculation by applying AHP to evaluate the success factors of mobile commerce, criteria for alternative selection, and selection factors. Chapter IV prioritized extracted success factors and alternatives, and Chapter V drew conclusions.

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Manuscript received July 5, 2006.

Manuscript revised July 25, 2006.

## 2. Related Work

### 2.1 Extraction of success factors and alternative

According to theses that emphasized the various aspects of mobile commerce, [5] explained differences in mobile customers, the substructure of communication, and mobile application system, and [6] distinguished in terms of system quality, contents quality, users and user satisfaction. [7] analyzed the social and technology aspect of mobile commerce, the partially used environmental aspect, and the mobile commerce market in Western Europe. These aspects are quite important factors for businesses that intend to enter the mobile commerce market. As shown in the theses reviewed above, mobile commerce has been developed based on e-commerce and the development is proceeding to the form of ubiquitous commerce. Figure 1 shows the transition of commerce.



Fig. 1 Commerce Transition

In mobile commerce, the success factors can be divided into the user aspect, the developer & contents provider aspect and the system aspect, or into the functional aspect, the technological aspect and the market aspect. Application functions extracted alternatives from the functional aspect. Alternatives in the functional aspect are contents management, contents search function, personalization, promotion and catalogue management [16][18]. Mobile devices include every device necessary for users to use mobile commerce, and should create environment for easy access to materials necessary for the commerce. Accordingly, they should be smaller than devices used in existing wired environment, and be designed carefully in consideration of environmental constraints. The alternatives include appearance, high usability, various functions, access heterogeneous systems [19]. From the technological aspect and the framework of mobile commerce, middleware is a part of the system that works when users connect and use the system. In order for mobile devices to perform the complex mobile commerce programs safely, the middleware part needs to be managed properly. The alternatives include security, privacy, quick contents delivery, plug-in, technological maturity and scalability [16][20]. There are network types such as WAP, WiFi and WiBRO, and wireless network is changing according to the type and size of contents and currently the change is moving toward WiBRO [21]. For the smooth operation of e-commerce sites, system quality is important. It is very difficult to determine system quality and the component of system quality in mobile commerce is much more complicated than those in previous information

management systems and electronic commerce. The alternatives of system quality include quick response time, flexible integration, easy billing and payment, and trust [23][24][8]. Contents quality appears in the devices of mobile commerce users, and is expressed by users' satisfaction. The alternatives of contents quality include trendy contents, social concern, diffusion, brand image, the lateness of contents and understandability [22][8]. An important success factor is to allow mobile commerce users to utilize their experiences through interface that satisfies their functional demands and understandability. The alternatives of usability include easiness to learn and use, transaction and low cost [23][8][25]. User satisfaction is also related to contents quality. That is, high contents quality enhances user satisfaction. There are personal satisfaction with individual uses of contents and organizational satisfaction expressing organizations' satisfaction with contents [8][6]. Success factors and alternatives listed above are presented in Table 1 below.

Table 1 : Success and Alternative Factor

Success Factor	Alternative
Application functions	contents management, contents search function, personalization, promotion, catalogue management
Mobile devices	appearance, high usability, various functions, access heterogeneous systems
middleware	security, privacy, quick contents delivery, plug-in, technological maturity, scalability.
network	WAP, WIFI, WiBRO
system quality	quick response time, flexible integration, easy billing and payment, trust
contents quality	trendy contents, social concern, diffusion, brand image, the lateness of contents, understandability
usability	easiness to learn and use, transaction, low cost
User satisfaction	individual satisfaction, organizational satisfaction

### 2. Major elements and characteristics of AHP

AHP, a decision making method developed by Satty, uses multiple decision-making techniques such as Multi Attribute Utility Theory (MAUT). It is a Multiple Criteria Decision Making (MCDM) technique for solving problems with complex multiple criteria and is called hierarchical analysis method [11].

Hierarchical analysis sub-divides a complex decision-making problem into easily understandable hierarchy elements and makes decisions based on the elements. The method satisfies theorems such as reciprocal, homogeneity, dependency and expectation, and alternatives are extracted through four steps. First, the decision-making hierarchy is established, second, pair-wise comparison is made among the decision-making elements within each hierarchy, third,

the relative importance and consistency of decision-making elements are calculated from pair-wise comparison matrix, and lastly, alternatives are prioritized through generalizing the hierarchy structure [10]. Because AHP does not typify the theoretical frame of the hierarchization, we used the four steps proposed by Zahedi [12].

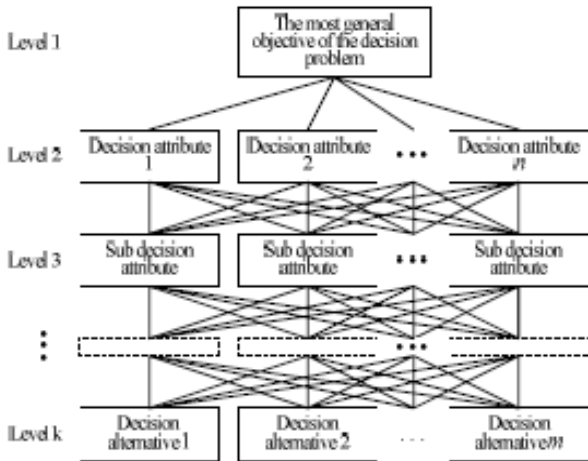


Fig. 2 Decision making Structure of the AHP

Figure 2 shows the decision-making structure of AHP. It extracts alternatives, derives by sub-dividing the decision-making problem, derive decision-making elements through pair-wise comparison, and calculate them [13].

AHP represents the values of given elements in pair-wise comparison matrix, and particularly in square matrix because it satisfies reciprocal. In case the size of square matrix is  $n$ ,  $j$  is created for  $i$  for  $A_{ij}$ , and the mean value of  $A_{ij}$  is used as a value assigned to the whole group. This can be expressed numerically as  $a_{ij} = \frac{1}{a_{ji}}$ ,  $a_{ij} = 1, \forall i$ .

When the relative weights of decision-making elements are estimated using the eigen value method, if the relative importance of  $n$  elements to be compared within a hierarchy is  $W_i$  pair-wise matrix  $A_{ij}$  is  $a_{ij} = \frac{W_j}{W_i}, (i, j = 1 \dots n)$ , and the all elements of

the matrix are expressed as  $\sum_j a_{ij} \cdot w_j = n \cdot w_i, (i, j = 1 \dots n)$  or  $\sum_j a_{ij} \cdot w_j = n \cdot w_i, (i, j = 1 \dots n)$ .

$$A = \begin{matrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \dots & \dots & \dots & \dots \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{matrix}$$

In  $A \cdot w = n \cdot w$ ,  $w = [w_1, w_2, w_3, \dots, w_n]$  is the eigen vector of the right side of matrix  $A$ . Using this equation,  $w$  is calculated.  $A \cdot w = \lambda_{max} \cdot w$  is an equation to

estimate the weight of a matrix, calculating  $\lambda_{max}$  the maximum eigen value of matrix  $A$ . Because  $\lambda_{max}$  is always larger than  $n$ , the value of pair-wise comparison matrix  $A$  has higher consistency as it approaches  $n$ . Consistency index is a value, based on which decision makers determine whether values assigned using the weight of pair-wise comparison are consistent, and is expressed as  $CI = \frac{(\lambda_{max} - n)}{(n - 1)}$ .

Consistency rate is calculated based on the consistency index to test the validity. Consistency rate is expressed as  $CR = \frac{CI}{RI} \cdot 100\%$ .

If the consistency rate is below 10%, the corresponding pair-wise comparison matrix is considered consistent. Table 2 shows random index used in consistency rate and Table 3 shows relative importance for pairwise comparison.

Table 2. Random Index

size (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.12	1.24	1.35	1.41	1.45	1.49

Table 3. Relative Importance for Pairwise Comparison

Value	Definition	Description
1	Equal	Two activities contribute equally to the objective
3	Moderate preferred	Experience and judgment slightly favor one activity over another
5	Strongly preferred	Experience and judgment strongly favor one activity over another
7	Very strongly preferred	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extremely strongly preferred	The evidence favoring one activity over another is of the highest degree possible of affirmation
2,4,6,8	Medium	Used to represent compromise between the preferences listed above

After calculation is made in the way presented above, the relative weights of decision-making are summed to prioritize alternatives to be evaluated. The general importance is expressed as  $C[1, k] = \prod_{i=2}^k B_i$ .  $C[1, k]$  means the general weight of  $k$  th hierarchy element in the 1st hierarchy, and  $B_i$  means  $n_{i-1} \cdot n_i$  matrix that contains the row forming the estimated  $w$  vector [13].

### 3. Application of AHP for Evaluating the Success Factors of Mobile Commerce

#### 3.1 Criteria for selecting success factors and alternatives

Success factors in mobile commerce consider not a part put all of the user aspects, the developer & supporter aspect and the system aspect. Even there were more success factors and alternatives in this study, but we extracted and selected 8 success factors and 35 alternative. Selection criteria were extracted through approaching in the functional aspect, the technological aspect and the market aspect based on the user aspect, the developer and supporter aspect and the system aspect. Figure 3 shows a factor selection model used as criteria for factor selection.

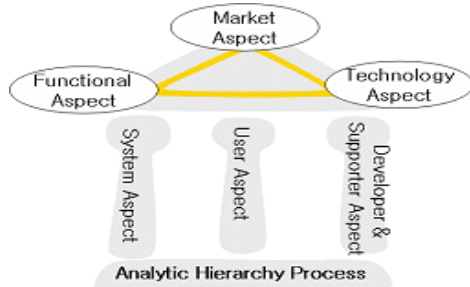


Fig. 3 Factor selection Model

The application function, the first alternative, is based on technological aspect for the efficient use of contents as it uses the system aspect and emphasizes the developer aspect. Second, mobile device was selected in consideration of the user aspect and functional aspect based on the system aspect and the developer aspect. Mobility is not an important factor in mobile commerce but this factor needs to be supported sufficiently, and smarter functions should be available based on better design, and data interchange should be made freely among heterogeneous systems. The middleware aspect emphasized the technological aspect based on the system aspect. Not only security, scalability, flexible integration, privacy and plug-in but the control of excessive traffic, the processing of pervasive data, and the quick delivery of contents were also considered. With regard to middleware, factors were selected focused on substructure for more flexible system operation, and system users, system developers and contents supporters were all considered.

Because wireless network works independently on several protocols, it is developing toward WiFi, which is being actively served in various countries based on WAP with complex protocols. Since it was adopted as the mobile Internet standard in Korea, WiBRO was acknowledged as the standard of next-generation wireless broadband transmission technology by IEEE. Because it covers a wider range of service and broader applications of

contents locally than WiFi, development has been made into the use of domestic standards, international standards and WiBRO the latest wireless network technology. The system quality aspect was approached from the technological aspect and some functional aspects based on the system aspect and the user aspect. It contains important factors that should consider both hardware and software. However, all these components should be formed on the basis of mutual trust, which is a very important factor in the user and system aspects. Contents quality is a major consideration related to contents, and is closely related to the user aspect and the market aspect. Based on lateness, contents should be easily understandable to users and substantial for rapid spread. All these factors should be based on contents that comply with social concern and trendy. The usability aspect emphasizes the user aspect and involves the functional aspect. User satisfaction is enhanced when contents are easy to use and small in volume, many transactions are processed smoothly, and charges for contents are low. The user satisfaction aspect emphasizes the user aspect more than any other aspects. User satisfaction is composed of personal satisfaction and organizational satisfaction, and the satisfaction is affected by the quality of contents and the time of contents use. The index of user satisfaction can be defined as in the table below.

Table 4 User satisfaction index

Value	Definition	Description
1	Moderate	Satisfied with the criteria moderately
3	Prefer	Satisfied with the criteria somewhat highly
5	Strongly prefer	Satisfied with the criteria strongly
7	Very strongly prefer	Satisfied with the criteria very strongly
9	Extremely strongly prefer	Satisfied with the criteria extremely strongly
2,4,6,8	Medium	Satisfied at a medium level of the criteria above

By setting success factors and alternatives through defining precise selection criteria as above, we select and evaluate the success factors and alternatives of mobile commerce.

#### 3.2 Alternative evaluation using AHP

Decision makers calculate the success factor and alternative elements of mobile commerce through pairwise comparison matrix using AHP.

Success factors and alternative elements are extracted as the optimal elements used in the market and are calculated stepwise as explained in the previous chapter. Decision-making elements are selected largely in three hierarchies. The top hierarchy sets the goal of problem, the middle hierarchy sets criteria for defining alternatives, and lastly, alternative elements are extracted Figure 5 shows the goals

and elements of the success factors of mobile commerce, and alternative elements. The value of each element is calculated through pair-wise comparison using AHP proposed by Saaty. The calculated value of each element shows decision makers which element is most important in mobile commerce environment and emphasizes weighty elements for future calculation to minimize failure when setting directions.

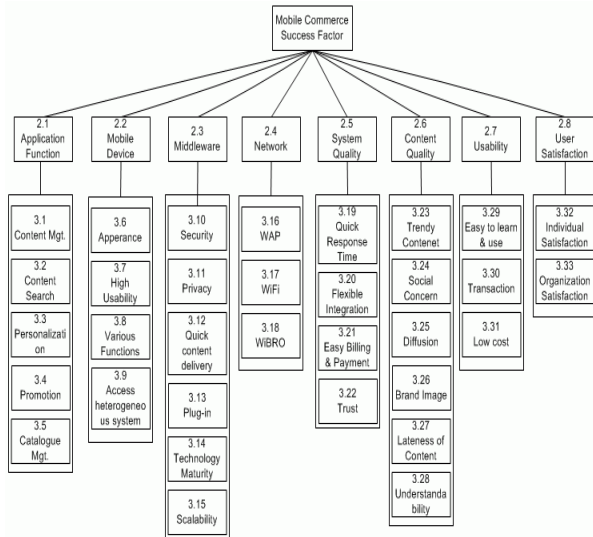


Fig. 5 Hierarchy Diagram of M-Commerce Success Factor and Alternative Factor

Tables below show values obtained through the pair-wise comparison of AHP matrix using the success factors and alternatives presented in Figure 5.

Table 5 The Coverage of Success Factor

2.1 Application Function 2.2 Mobile Device  
2.3 Middleware 2.4 Network  
2.5 System Quality 2.6 Content Quality  
2.7 Usability 2.8 User Satisfaction

	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
2.1	1	4	1/2	3	1/2	1/3	1/2	2
2.2	1/4	1	1/5	1/3	1/8	1/8	1/4	1/3
2.3	2	5	1	2	1/2	1/2	1	2
2.4	1/3	3	1/2	1	1/3	1/4	1/2	1/2
2.5	2	8	2	3	1	1/2	2	3
2.6	3	8	2	4	2	1	3	3
2.7	2	4	1	1/2	1/2	1/3	1	2
2.8	1/2	3	1/2	2	1/3	1/3	1/2	1

Table 6 Alternative Factor of Application Function

3.1 Personalization 3.2 Catalogue Mgt.  
3.3 Content Search 3.4 Content Mgt.  
3.5 Promotion

	3.1	3.2	3.3	3.4	3.5
3.1	1	7	5	2	3
3.2	1/7	1	1/2	1/4	1/3
3.3	1/5	2	1	1/3	1/2
3.4	1/2	4	3	1	2
3.5	1/3	3	2	1/2	1

Table 7 Alternative Factor of Mobile Device

3.6 Appearance 3.7 high usability  
3.8 various function 3.9 Access heterogeneous system

	3.6	3.7	3.8	3.9
3.6	1	1/6	1/3	1/9
3.7	6	1	4	1/2
3.8	3	1/4	1	1/5
3.9	9	2	5	1

Table 8 Alternative Factor of Middleware

3.10 Security 3.11 Privacy  
3.12 Quick content delivery 3.13 Plug-in  
3.14 Technology maturity 3.15 Scalability

	3.10	3.11	3.12	3.13	3.14	3.15
3.10	1	1/3	4	7	2	3
3.11	3	1	9	9	5	5
3.12	1/4	1/9	1	3	1/3	1/2
3.13	1/7	1/9	1/3	1	1/4	1/4
3.14	1/2	1/5	3	4	1	1
3.15	1/3	1/5	2	4	1	1

Table 9 Alternative Factor of Network

3.16 WAP 3.17 WiFi  
3.18 WiBRO

	3.16	3.17	3.18
3.16	1	1/3	1/7
3.17	3	1	1/3
3.18	7	3	1

Table 10 Alternative Factor of System Quality

3.19 Quick response time 3.20 Flexible integration

3.21 easy billing & payment 3.22 trust

	3.19	3.20	3.21	3.22
3.19	1	1/3	2	1/9
3.20	3	1	5	1/3
3.21	1/2	1/5	1	1/9
3.22	9	3	9	1

Table 11 Alternative Factor of Information Quality

3.23 Trendy Content 3.24 Social Concern  
3.25 Diffusion 3.26 Brand Image  
3.27 lateness of content 3.28 Understandability

	3.23	3.24	3.25	3.26	3.27	3.28
3.23	1	1/3	1/5	2	1/6	1/9
3.24	3	1	1/3	3	1/4	1/9
3.25	5	3	1	6	1/2	1/3
3.26	1/2	1/3	1/6	1	1/8	1/9
3.27	6	4	2	8	1	1/2
3.28	9	9	3	9	2	1

Table 12 Alternative Factor of using

3.29 Easy to learn and use  
3.30 Transaction 3.31 Low cost

	3.29	3.30	3.31
3.29	1	1/9	1/3
3.30	9	1	4
3.31	3	1/4	1

Table 13 Alternative Factor of user Satisfaction

3.32 Individual Satisfaction  
3.33 Organization Satisfaction

	3.32	3.33
3.32	1	7
3.33	1/7	1

Table 14 Importance of Application Alternative Factor

	3.1	3.2	3.3	3.4	3.5	sum	weight
3.1	0.4595	0.4118	0.4348	0.4898	0.4390	2.2349	0.4470
3.2	0.0656	0.0588	0.026	0.0435	0.0488	0.2780	0.0556
3.3	0.0919	0.1176	0.129	0.0870	0.0732	0.4513	0.0903
3.4	0.2298	0.2353	0.065	0.2609	0.2927	1.2635	0.2527
3.5	0.1532	0.222	0.1765	0.1224	0.1463	0.7723	0.1545
CR = 0.01							

When the relative importance of application alternatives in Table 6 is calculated from pair-wise comparison matrix, the result is as in Table 13. By calculating each alternative repeatedly, the general priority of the hierarchical alternatives is determined.

#### 4. Evaluation of the Success Factors of Mobile Commerce

This study extracted the success factors of mobile commerce not from a single aspect but considering all of the user aspect, the developer aspect and the contents provider aspect, and calculated them using the AHP model. The AHP model decided the decision maker's selection using the 9-point scale proposed by Satty. In this study, we calculated 8 success factors and 35 alternatives. If the alternatives in Table 14 are calculated in Table 5 as in Table 13, the general priority of success factors are determined. However, if the consistency index among the alternative exceeds 0.1, the alternatives are considered inconsistent, so not accepted, but as the index is 0.03, they are considered consistent. Table 15 calculated the overall importance and consistency index.

Table 15 Importance of M-Commerce Success Factor and Consistency Ratio

Criteria	weight	Alternatives	weight	Consistency Ratio	
Application Function	0.103	Personalization	0.447	0.01	
		Catalogue Mgt.	0.055		
		Content Search	0.090		
		Content Mgt Promotion	0.253 0.154		
Mobile Device	0.026	Appearance	0.048	0.02	
		high usability	0.320		
		various function	0.107		
Access heterogeneous system	0.525				
Middle-ware	0.133	Security	0.217	0.03	
		Privacy	0.483		
		Quick content delivery	0.055		
		Plug-in	0.030		
		Technology maturity	0.115		
Scalability	0.100				
Network	0.057	WAP	0.088	0.01	
		WiFi	0.243		
		WIBRO	0.669		
System Quality	0.203	Quick response time	0.083	0.02	
		Flexible integration	0.236		
		easy billing & payment	0.052 0.630		
Content Quality	0.279	Trendy Content	0.040	0.03	
		Social Concern	0.072		
		Diffusion	0.167		
		Brand Image	0.029		
		lateness of content	0.253		
Understandability	0.439				

Usability	0.125	easy to learn and use Transaction Low cost	0.073 0.727 0.200	0.01
Satisfaction	0.074	Individual Satisfaction Organization Satisfaction	0.875 0.125	0.00

As shown in evaluation above, the most important success factor in mobile commerce is trust, and a site should be operated so that its contents are easily understandable to users. In addition, transaction and user satisfaction are important factors, and the lateness of contents and privacy were also extracted as important factors. Through the calculation of importance in Table 14, individualization was found to be the most important alternative in the application function, and contents management and promotion were also found important. Figure 6 shows the result of calculation in Table 14. Table 15 shows the extracted success factors of mobile commerce and alternatives. This shows that the most important ones among the success factors are contents quality and system quality, and usability and middleware are also important factors.

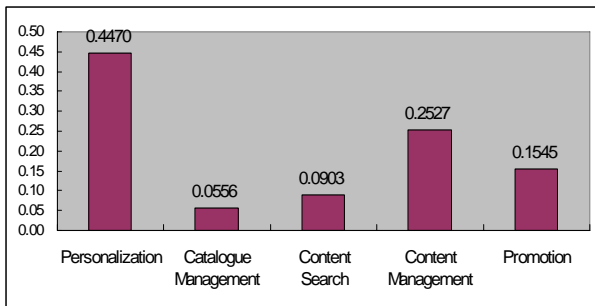


Fig. 6 Application Alternative Factor

Figure 7 shows the importance of alternatives calculated based on the importance of the success factors of mobile commerce. According to the alternatives of the success factors of mobile commerce in Figure 7, because users use mobile commerce frequently when it is easy to understand, high usability should be supported. In addition, personal satisfaction should be enhanced through easy acquisition of desired contents, and the number of transactions should be minimized. Mobile commerce users are more active than e-commerce users, and sites are visited more frequently when their contents are updated with latest data.

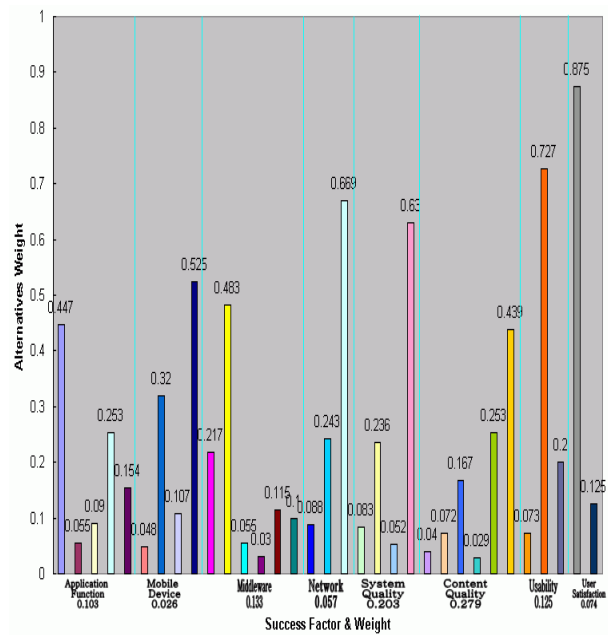


Fig. 7 Importance of M-Commerce Alternative Factors

#### 4. Conclusions

The present study extracted success factors and alternatives from mobile commerce sites and evaluated them using AHP. Success factors and alternatives were extracted in consideration of users, systems, developers and suppliers involved in mobile commerce, and were selected from the functional aspect, the technological aspect and the market aspect. Based on the selected elements, evaluation was made not for specific mobile commerce sites in a narrow sense but for mobile sites in a broad sense. The result of the evaluation shows what elements mobile commerce business managers pay more attention to. The most important success factor is contents quality, and system quality, middleware and usability are also important. In addition, the most important alternative is trust in system quality between mobile commerce operators and contents users, and the understandability of contents is also important for users to understand and use contents without difficulty. In addition, transaction in usability and the lateness of contents in contents quality are important, and privacy supported by middleware and flexibility of system integration in system quality are also important elements.

For future study, we need to measure users' satisfaction with mobile commerce using user satisfaction index, and evaluate commercial activities in ubiquitous environment, which is a process in the transition of commerce, using the success factors and alternatives of mobile commerce.

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