



A review for mobile commerce research and applications

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Available online 11 July 2005

Abstract

Although a large volume of literature is available on mobile commerce (m-commerce), the topic is still under development and offers potential opportunities for further research and applications. Since the subject is at the stage of development, a review of the literature on m-commerce with the objective of bringing to the fore the state-of-art in m-commerce research and applications will initiate further research on the growth of m-commerce technologies. This paper reviews the literature on m-commerce and applications using a suitable classification scheme to identify the gap between theory and practice and future research directions. The 149 m-commerce articles are classified and the results of these are presented based on a scheme that consists of five distinct categories: m-commerce theory and research, wireless network infrastructure, mobile middleware, wireless user infrastructure, and m-commerce applications and cases. A comprehensive list of references is presented. We hope that the findings of this research will provide useful insights into the anatomy of m-commerce literature and be a good source for anyone who is interested in m-commerce. The paper also provides some future directions for research.

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Keywords: Mobile commerce (m-commerce); Literature review; Framework; Future research

1. Introduction

There is no doubt that the use of wireless and mobile networks and devices is growing. From the 1990s onwards, we have been witnessing a great shift in methods of doing business with the emergence of the electronic commerce (e-commerce). Academics, businesses, and even individuals have been focusing on this new way of conducting business online. Ad-

vanced and mature wireless and mobile technologies facilitate e-commerce conducted from a wired network to a wireless network. Mobile commerce (m-commerce) can be viewed as a subset of e-commerce [31,66] and refers to “any transaction with monetary value that is conducted via a mobile network” [28]. When users conduct e-commerce such as e-banking or purchase products, they do not need to use a personal computer system. Indeed, they can simply use some mobile handheld devices such as Personal Digital Assistants (PDA) and mobile phones to conduct various e-commerce activities. In the past, these mobile devices or technologies were regarded as a kind of

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luxury for individuals. However, this situation has changed. The market for mobile technologies has seen significant growth in the past few years [61,64,142]. This is creating a new opportunity for the growth of m-commerce. According to a study conducted by Datamonitor [33], global m-commerce revenues will amount to \$31.7 billion by 2005.

M-commerce is a technological frontier and is an attractive area for research because of its relative novelty, rapid growth, and potential applications [111]. M-commerce applications have two major characteristics: mobility and broad reach. Mobility implies portability, e.g., users can conduct business real time via mobile devices. With m-commerce, people can be reached at any time via a mobile device. In this study, m-commerce refers to the conduct of commerce via wireless devices. In this paper, we classify the literature on m-commerce research and present a comprehensive review of these studies. The review covers 149 journal articles published between 2000 and 2003. The reason for selecting this time period is that the topic is fairly new and most of the research on m-commerce began to be conducted only during this period. The results, as shown in Fig. 1, show an increasing volume of m-commerce research in a diverse range of areas. The paper is organized as follows: first, the research methodology used in the study is described; second, the criteria used for classifying the literature on m-commerce are presented; third, the m-commerce articles are analysed and the classification results are reported; and, finally, conclusions are presented and the implications of the study are discussed.

2. Research methodology

Considering the nature of the research on m-commerce, it would be difficult to group the literature under any specific disciplines. Further evidence of this can be seen from the fact that m-commerce articles are scattered across various journals in disciplines such as business, management, marketing, engineering, information technology (IT), and information systems (IS). Consequently, various online journal databases shown in Table 1 were selected and searched to provide a comprehensive bibliography on m-commerce literature. The literature search was based on the descriptor, “mobile commerce” or “m-commerce”. The search was also limited to peer-reviewed journal articles. More than 340 articles were found in the initial search of the literature. The full text of each article was reviewed to eliminate those articles that were not actually related to m-commerce. Many of articles were excluded because they did not meet the selection criteria, described as follows:

- Considering the nature of the research field, viz., m-commerce, and the importance of being current in the field, we have only considered research articles published from 2000 and up to the end of 2003.
- Conference papers, master’s and doctoral dissertations, textbooks, and unpublished working papers were excluded, as academics and practitioners alike most often use journals to obtain information and disseminate their research findings. Hence, journals

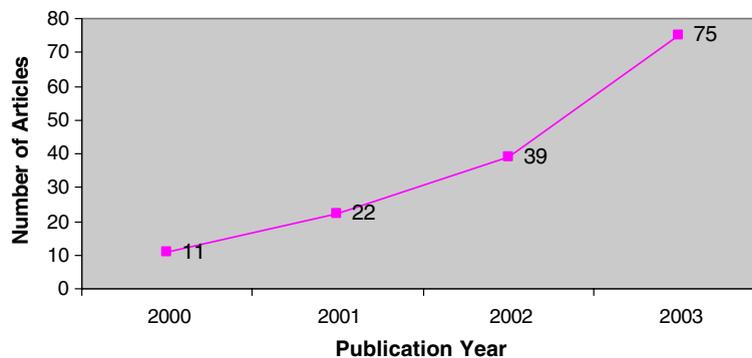


Fig. 1. Distribution of articles by year.

Table 1
The selected online databases for the m-commerce literature search

Online database	Subjects covered
ABI/INFORM database	Business and management
Academic Search Premier	Business, science, medicine, and various subjects
ACM Digital Library	Computer science
Business Source Premier	Accounting, business, economics, management
Emerald Fulltext	Marketing, human resources, quality management, information management, library and information services, training and education, general management, property, operations, production and economics, engineering
IEEE Xplore	Physics, engineering, computer science
Inderscience Publishers	Environmental, healthcare, management, technical
Ingenta Journals	Business, computing, engineering, education, science, social sciences
Kluwer Online	Accounting, biotechnology, business and management, chemistry, computing, economics, education, engineering, environmental science and technology, life sciences, mathematics, medicine and nursing, humanities, physics, and astronomy
Science Direct	Chemistry and chemical engineering, clinical medicine, computer science, earth and planetary sciences, economics, business and management science, environmental science and technology, life sciences, materials science, mathematics, physics and astronomy, social sciences
Springer Link Online Libraries	Business, science, engineering, medical and social sciences
Wiley InterScience	Business, science, engineering, medical and social sciences

represent the highest level of research, both in width and breadth [95].

- The criteria for exclusion further applied to the articles in journals if they were editorials, news reports, and book reviews.

The search yielded 149 m-commerce articles from 73 journals. Each of the 149 articles was carefully reviewed and classified into one of the five categories: (1) wireless network infrastructure, (2) mobile middleware, (3) wireless user infrastructure, (4) m-commerce theory and research, and (5) m-commerce cases

and applications, as graphically depicted in Fig. 2. Although this search was not exhaustive, it serves as a comprehensive platform for understanding m-commerce research.

3. Classification of m-commerce literature

Fig. 2 depicts a graphical classification framework for m-commerce articles. The framework is developed based on [88,137]. Varshney and Vetter [137] proposed a four-level integrated framework for m-commerce: m-commerce applications, wireless user infrastructure, mobile middleware, and wireless network infrastructure. M-commerce applications require the support of technology from the foundation of wireless user infrastructure, mobile middleware, and wireless network infrastructure [88]. In addition, corresponding theory and research activities are essential to provide guidance for the development of m-commerce. The classification framework recognizes that m-commerce articles consist of five levels and each of them is discussed as follows:

- *M-commerce theory and research*: This is the lowest level of the framework. The articles included here describe the development of m-commerce applications and guidelines, behavioural issues such as consumer behaviour, the acceptance of technology, and the diffusion of m-commerce applications and services. M-commerce economics, strategy, and business models; and legal and ethical issues such as privacy, regulations, and the legal environment when using m-commerce are included. Articles dealing with a general introduction to m-commerce, foundational concepts of m-commerce, and so forth were grouped under the heading “m-commerce overview, context, and usage”.
- *Wireless network infrastructure*: This is one of the pillar technologies of m-commerce that supports the development of m-commerce applications. Wireless network infrastructure plays an important role in m-commerce as this is the core part of m-commerce technology [124]. It provides wireless networks and network standards such as the Global System for Mobile Communication (GSM), Bluetooth, the wireless local area network (WLAN), radio frequency identification (RFID), the Third-

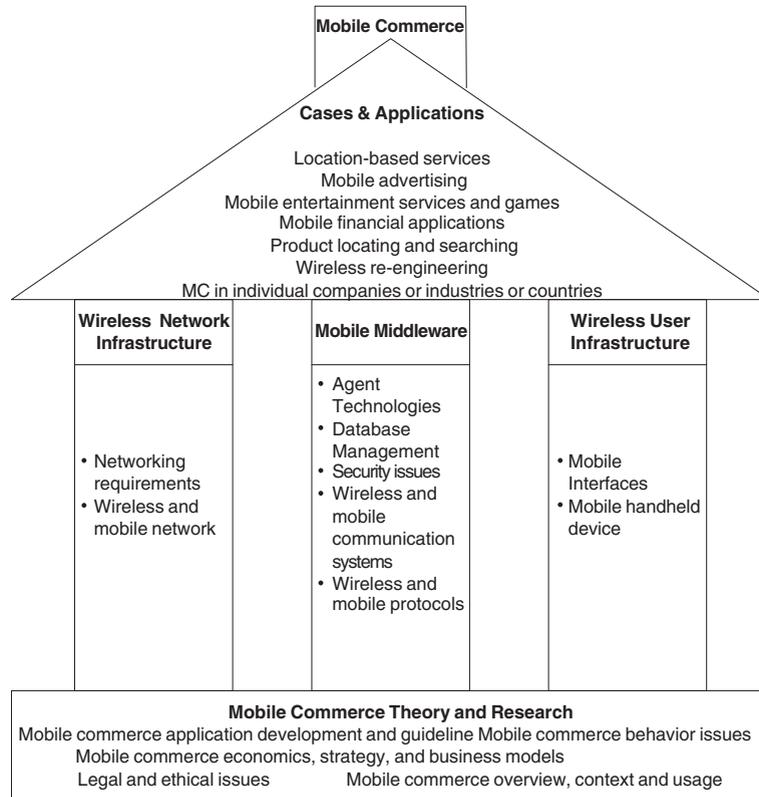


Fig. 2. Classification framework for m-commerce articles [86,135].

generation (3G) network, etc. Articles describing these wireless networks or network standards are grouped under “Wireless and mobile network”. In order to ensure the reliability and efficiency of the m-commerce applications and services running in a mobile environment, it is necessary for various networking requirements to be implemented in the wireless and mobile networks. “Networking requirements” cover articles on the wireless infrastructure requirements of m-commerce such as location management, multicast support, network dependability, quality-of-service, and roaming across multiple networks [137].

- *Mobile middleware*: Mobile middleware refers to the software layer between the wireless networks and the operating systems of the mobile devices to connect the m-commerce applications [138]. Five research issues were identified for mobile middleware based on [88,118,137]. While the connection time and data exchange for mobile devices are expensive, various agent technologies can be used

to support different m-commerce activities such as making payments and locating merchants [118]. “Agent technologies” can be found in publications about using software agents or mobile agents to support m-commerce activities, for example, carrying out negotiations [66,102] and searching for products [46]. “Database management” covers articles on mobile database management. In a mobile environment, the query processing, database location, and data recovery capabilities of a mobile database system may not use the traditional method to access information [118]. “Security issues” includes articles that discuss the security issues in m-commerce, for instance, designing a secure wireless network infrastructure for m-commerce applications using public key infrastructure or other techniques [26,48,117]. “Wireless and mobile communication systems” refers to some techniques, algorithm, methods, and components to connect and manage m-commerce applications. In order to communicate with the m-commerce applications or

mobile devices, a standard set of protocols is necessary. Hence, “Wireless and mobile protocols” covers articles that describe the protocols for m-commerce. Some common protocols for m-commerce include the wireless application protocol (WAP) and i-Mode.

- *Wireless user infrastructure*: Wireless user infrastructure consists of two parts, i.e., software and hardware [88,137]. Software refers to the operating systems and their interfaces while hardware means the mobile devices to communicate with the m-commerce applications, such as PDAs and mobile phones. In this classified framework, two issues relating to wireless user infrastructure were identified in this category. “Mobile interfaces” consists of publications that discuss interface designs or issues relating to the mobile applications or devices. A well-designed and usable interface is relatively difficult to achieve in a mobile environment because the mobile applications normally execute on a small and portable mobile hand-held device [97,129,139]. Corresponding guidelines for designing suitable mobile interfaces are necessary. Clearly, the classification cluster, “Mobile handheld devices” covers articles related to mobile devices.
- *Mobile commerce applications and cases*: m-commerce covers a wide range of applications. Varshney and Vetter [137] identified several important classes of m-commerce applications including mobile financial applications, mobile advertising, mobile inventory management, locating and shopping for products, proactive service management, wireless re-engineering, mobile auctions or reverse auctions, mobile entertainment services and games, mobile offices, mobile distance education, and wireless data centres. They gave a detailed explanation of each application. The classification framework proposed in this study is based on observations of the reviewed articles. We have identified six different m-commerce applications as addressed by Varshney and Vetter [137]. In addition, we have included cases about m-commerce in individual companies, industries, or countries in this category.

Each of the 149 articles was reviewed and classified into five broad categories. The articles were divided into sub-categories based on the nature of

their subject. All of the articles were further analysed by looking at:

- The distribution of articles by year of publication;
- The distribution of articles by journal; and
- The distribution of articles by subject.

4. Results and analysis of the classifications

The articles were analysed by year of publication, topic area, and journal. This particular analysis will provide guidelines for pursuing rigorous research on m-commerce and on its applications by explaining the chronological growth of m-commerce over the years, challenging areas of m-commerce theory and applications, and the major sources of information for different elements of m-commerce. The details are presented below.

4.1. Distribution by year of publication

The distribution of articles published by year, from 2000 to 2003, is shown in Fig. 1. Research output in m-commerce increased significantly since 2000. The number of published m-commerce articles doubled each year.

4.1.1. Distribution of articles by journal

In our result list, there were a total of 73 different journals from various disciplines (e.g., IS, IT, engi-

Table 2
Journals with more three or more articles on m-commerce

Journal	Number of articles
Communications of the ACM	17
International Journal of Mobile Communications	11
Mobile Networks and Applications	8
Electronic Markets	6
Computer	5
Internet Research: Electronic Networking Applications and Policy	5
Info – The journal of policy, regulation and strategy for telecommunications	4
Electronic Commerce Research and Applications	3
IEEE Transactions on Systems, Man and Cybernetics, Part A	3
International Journal of Electronic Commerce	3
Journal of Database Management	3

neering, management, business, etc.) that published m-commerce articles. Table 2 lists the journals that published three or more m-commerce articles. Most of these journals were IS/IT journals. Table 2 shows that the *Communication of the ACM* had by far the most articles (17 articles or 11.6% of the total). The *International Journal of Mobile Communications* (11 articles or 7.5% of the total), and the *Mobile Networks and Applications* (8 articles or 5.4% of the total) had the second and third largest percentages of m-commerce articles among the IS and IT journals. The *Communication of the ACM*, a monthly publication

of the Association for Computing Machinery, is dedicated to advancing the art, science, engineering, and application of IT. The *International Journal of Mobile Communications* has published quarterly since 2003 and aims to develop, promote, and coordinate the development and practice of mobile communications and applications. The journal, *Mobile Networks and Applications* provides articles on theory and practical applications in computing, data management, as well as wireless and mobile networking. It had been published quarterly since 1996 and became a bi-monthly publication in 2001.

Table 3
Distribution of m-commerce articles by subject heading

Classification criteria	Number of articles	Percentage of subject	Percentage of ALL subjects
<i>1. Mobile commerce applications and cases</i>			
1.1. Location-based services	3	10	2
1.1. Mobile advertising	1	3.3	0.7
1.2. Mobile entertainment services and games	3	10	2
1.3. Mobile financial applications	10	33.3	6.8
1.5. Product locating and searching	1	3.3	0.7
1.6. Wireless reengineering	2	6.7	1.4
1.7. M-commerce in individual companies or industries or countries	10	33.3	6.8
Total	30	100	20.4
<i>2. Wireless user infrastructure</i>			
2.1. Mobile interfaces	5	83.3	3.4
2.2. Mobile handheld devices	1	16.7	0.7
Total	6	100	4.1
<i>3. Mobile middleware</i>			
3.1. Agent technologies	6	17.1	4.1
3.2. Database management	2	5.7	1.4
3.3. Security issues	14	40	9.5
3.4. Wireless and mobile communication systems	10	28.6	6.8
3.5. Wireless and mobile protocols	3	8.6	2
Total	35	100	23.8
<i>4. Wireless network infrastructure</i>			
4.1. Networking requirements	8	61.5	5.4
4.2. Wireless and mobile network	5	38.5	3.4
Total	13	100	8.8
<i>5. Mobile commerce theory and research</i>			
5.1. Development of m-commerce applications and guidelines	5	7.7	3
5.2. M-commerce behavioural issues (consumer behaviour, acceptance of technology, and diffusion of technology)	20	30.7	13.6
5.3. M-commerce economics, strategy, and business models	19	29.2	12.9
5.4. M-commerce legal and ethical issues	7	10.7	4.8
5.5. M-commerce overview, context, and usage	14	21.7	9.5
Total	65	100	43.09

4.2. Distribution of articles by subject

The distribution of articles by subjects is shown in Table 3. A majority of articles (63 out of 147 or 42.9% of the total) were related to m-commerce theory and research, while the fewest were on the wireless user infrastructure (6 articles, or 4.1% of the total). The category of m-commerce theory and research can be divided into five broad topics. Two major topics made up a large proportion of this category or within all reviewed articles. They were “m-commerce behavioural issues” (20 articles) and “m-commerce economics, strategy, and business models” (19 articles). This reflects the fact that m-commerce is a relatively new area of research. In the preliminary stage of the development of m-commerce, researchers have attempted to identify the implications of customer behaviour and acceptance of technology on various m-commerce applications and services. Also, it was a time to develop a clear business model and strategy for m-commerce. Other topics on theory and research discussed in m-commerce articles were “m-commerce overview, context, and usage” (14 articles). These articles introduced general concepts of m-commerce, and “m-commerce legal and ethical issues (7 articles), on the regulations, privacy, and legal issues surrounding m-commerce.

The second largest number of articles published is related to mobile middleware, while articles describing security issues made up the largest subject area within this category. Of 35 articles on mobile middleware, 40% (14 articles) fell under “Security issues”, followed by 28.6% (10 articles) on “Wireless and mobile communication systems” as middleware.

After reviewing the m-commerce articles, the category of m-commerce applications and cases was divided into seven broad areas. The majority of the applications of m-commerce were deemed to be for financial uses such as mobile payments and mobile banking (10 articles or 33.3% of the subject). However, we could not find articles on the m-commerce applications that were classified by Varshney and Vetter [137] such as mobile auctions or reverse auctions, mobile distance education, etc. In this category, there were 10 articles describing cases of m-commerce in individual companies, industries, or countries.

There were relatively fewer articles on “Wireless network infrastructure” (13 articles, 8.8% of the total),

and “Wireless user infrastructure” (6 articles, 4.1% of the total). Both constituted less than 10% of the total number of reviewed articles. Most of the articles on

Table 4
Classification of the reviewed m-commerce literature

Classification criteria	References
<i>1. Mobile commerce applications and cases</i>	
1.1. Location-based services	[13,14,107]
1.1. Mobile advertising	[151]
1.2. Mobile entertainment services and games	[9,81,91]
1.3. Mobile financial applications	[3,15,35,49,63,64,69,73,90,103]
1.5. Product locating and searching	[43]
1.6. Wireless reengineering	[78,145]
1.7. M-commerce in individual companies or industries or countries	[5,6,18,21,34,52,53,58,99,148]
<i>2. Wireless user infrastructure</i>	
2.1. Mobile interfaces	[29,37,70,1297,139]
2.2. Mobile handheld devices	[112]
<i>3. Mobile middleware</i>	
3.1. Agent technologies	[24,30,46,79,86,101]
3.2. Database management	[23,71]
3.3. Security issues	[26,42,44,48,59,67,87,113,118,120,122,127,128,144]
3.4. Wireless and mobile communication systems	[72,100,101,105,109,116,125,130,141,154]
3.5. Wireless and mobile protocols	[12,57,106]
<i>4. Wireless network infrastructure</i>	
4.1. Networking requirements	[27,84,131–135,147,149]
4.2. Wireless and mobile network	[20,22,36,50,135]
<i>5. Mobile commerce theory and research</i>	
5.1. Development of m-commerce applications and guidelines	[96,99,114]
5.2. M-commerce behavioural issues (consumer behaviour, acceptance of technology, and diffusion of technology)	[1,4,7,16,25,39,45,51,54,55,68,76,77,82,85,94,119,121,141,143]
5.3. M-commerce economics, strategy, and business models	[2,8,11,17,19,28,38,41,56,60,74,75,98,108,110,126,140,150,152]
5.4. M-commerce legal and ethical issues	[32,47,83,89,92,104,146]
5.5. M-commerce overview, context, and usage	[10,31,40,65,80,93,115,118,123,125,136–138,153]

wireless network infrastructure and wireless user infrastructure were related to “Networking requirements” (8 articles) and “Mobile interfaces” (5 articles), respectively. Table 4 summarizes all of the reviewed articles that correspond to the subject headings. This is a helpful resource for anyone searching for m-commerce papers in a specific area.

5. Conclusions and future research directions

M-commerce has attracted the attention of both practitioners and academics. In particular, research activities on m-commerce have increased significantly after 2000. We believe that m-commerce is becoming increasingly pervasive. This paper identified 149 articles on m-commerce published between 2000 and 2003. Although this review does not claim to be exhaustive, it does provide a reasonable amount of insight into the state of the art in m-commerce research. We have examined other review articles on m-commerce, but none has presented a comprehensive review and analysis of m-commerce. The results presented in this paper have several important implications:

- There is no doubt that m-commerce research will burgeon in the future. Academics have many avenues for conducting research on m-commerce.
- It is not surprising that a large portion of the reviewed articles in this study were related to m-commerce theory and research, especially the study of “m-commerce behavioural issues”, “m-commerce economics, strategy, and business models”, and “m-commerce overview, context, and usage” because m-commerce is becoming a mature business discipline. We understand that different factors are important at different stages in the development of m-commerce technology. In the early stage, technology/infrastructure dominates. We expect more research to be conducted on user experiences and marketing at the mature stages.
- While we develop new m-commerce applications, the capabilities of the user infrastructure need to be considered [138]. Mobile devices are becoming smaller and smaller, but with faster processing times and larger storage capacity. Corresponding mobile interfaces also need to be modified in order to suit the requirements of new business models.
- Although we did not find many articles on “wireless network infrastructure”, this may not represent the actual situation. We believe that a certain number of articles on this subject have been published in the field of network engineering.
- Because the search descriptor was limited to m-commerce, some articles on such subjects as the wireless network architecture and network requirements may not have been searched, as no explicit mention of m-commerce may have been made in these articles.
- Currently, it seems that the most popular m-commerce application is that supporting financial activities. Mobile banking and payments are issues that have been widely discussed by researchers. However, it is surprising not to see many articles on other m-commerce applications. Varshney and Vetter [137] identified and classified 12 m-commerce applications, but we have only identified articles on six different m-commerce applications in our review. Among the applications, m-commerce entertainment services and games have a great deal of potential and will dominate global m-commerce revenues in the future [33]. Additional research is required in other related areas such as mobile education, mobile supply chain management, and so forth.
- There has not been much research on the relationship between culture and m-commerce. Cultural differences on adopting m-commerce could be an interesting area for investigation. For example, it would be of interest to examine the possible implications of cultural differences that stimulate the adoption of new mobile services based on new technologies that bring value to mobile users and create new business opportunities for the mobile industry.

In addition to the above implications, we would like to offer the following suggestions for further research in m-commerce:

- As applications of RFID technology grow [62], they are bound to offer new avenues for growth and new opportunities in this emerging frontier. RFID technology has existed for many years but it has only recently emerged as the technology used in supply chains. Certainly, applications of

RFID require further investigation, specifically their impact on supply chains. Other areas of research that could be pursued are security concerns relating to RFID in the supply chains, suitable models for the adoption of RFID in organizations, system architectures for integrating with legacy systems, etc.

Support and collaboration in B2B m-commerce among the members of a supply chain can be facilitated by mobile devices. There is no need to call a partner company asking for someone to find certain items in the supply chain. A cross-industry group can use such support from m-commerce devices to achieve better collaboration along the supply chain.

The reviewed articles were collected from online databases. Some journals, for example the journal of *Electronic Markets*, do not include all of its volumes for searching. The earliest volume of *Electronic Markets* that could be located in online databases was volume nine. In addition, sub-categories in the classification framework were identified based on our observations from reviewing the articles. We believe that more sub-categories should be added and updated in the classification framework particularly in the area of “m-commerce applications and cases”, as more applications can be found.

Acknowledgements

The first author was supported in part by The Hong Kong Polytechnic University under a research grant number G-YD23. The authors are grateful for the constructive comments of the referees on earlier versions of this paper.

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