

# Control and Automation Engineering Education: combining physical, remote and virtual labs

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## 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

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 `bm-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

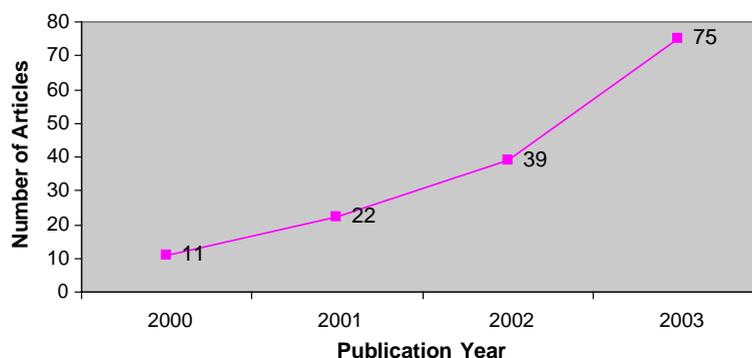


Fig. 1. Distribution of articles by year.

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.

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.

### 3. 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.

#### *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.

#### *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

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.

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