An RFID/WSN-based Monitoring System of Smart Logistics on E-Commerce

Yu Guo and Junxiang Li
Business School, University of Shanghai for Science and Technology, Shanghai, China
Email: 13120738202@163.com, lijx@usst.edu.cn

Abstract—Using the method of questionnaire, the requirements of e-commerce logistics information system are proposed in a list which states all the functional and nonfunctional requirements. In order to fulfill these requirements, an RFID/WSN-based monitoring system (RWMS) is established. The whole process of this monitoring system is described. After RWMS is applied, all the nonfunctional requirements are turned into functional.

Index Terms—RFID, WSN, smart logistics, information system

I. INTRODUCTION

As the overwhelming majority of people prefer to make a deal online, e-commerce has stirred increasingly up more people's attention. Trades of e-commerce can be completed by three steps—firstly consumers pay over the Internet, secondly sellers make deliveries, and finally consumers conform deliveries. The emergence of e-commerce is the trend of the development of the market in modern society. On the one hand, from the consumers’ perspective, e-commerce helps them save time, makes shopping more convenient and provides cheaper commodities with multiple options. On the other hand, from the sellers’ perspective, e-commerce offers a new way of sale and, in the meantime, saves cost such as rent. To e-commerce, for it’s not synchronous between payment and goods receipt, logistics has become the most important step in which process should be an ideal system to provide people seamless information. However, the problem is that although logistics develops at an amazing speed, it still can’t reach consumers’ demand.

II. LITERATURE REVIEW

Werner et al. denote that radio frequency identification (RFID) technology is not only proved to be effective in the fields of trade and stock-keeping, but also could be used in the field of foreseeing future uncertainties [1]. Chonghua Li et al. show the application of RFID in every link of logistics management such as the design of hardware and software for entering storage, the delivery of cargo from storage and examining goods of logistics warehouse management system by means of RFID technology [2]. X. Q. Xu et al. propose a smart reverse supply chain system, which is able to enhance the reverse supply chain real-time information transmission, as well as reduce the uncertainty and complexity of the product recycling process, based on RFID and other sensing and intelligent technologies [3]. R. Zhang et al. establish a logistics transportation vehicle system based on Wireless Sensor Network (WSN), which consists of vehicle module and cargo package module. This system is proved to be valid to real-time information exchange through experiments [4]. Lin Qi et al. contend that based on the technology of WSN, a cold chain shelf life decision support system is proposed, which provides not only the users’ seamless information flow but also data to let managers make decision in order to reduce the quality and economic loss [5]. L. Evers claims that the use of WSN will bring the leap to efficiency and quality of service on logistics [6]. C. Pang et al. conduct an experiment to show that based on point to point communication method, the WSN could work in a long distance to collect effectively dairy information and transmit to the data center [7]. Badia-Melis Ricardo et al. analyze two wireless technologies which are RFID and WSN that are being used for cold chain monitoring and tracking, especially, the variable of temperature [8]. A. M. Liang et al. state that the cold chain management system based on RFID and WSN enables to achieve traceability and quality assurance and enhances cold chain operations [9]. Junxiang Li et al. establish an RFID/WSNID system to monitor the food supply chain, accomplish the traceability of food supply chain and provide a seamless information flow of the chain [10]. Woohyung Chun et al. apply integration of wireless sensors network with RFID to provide item level inventory monitoring in retail stores in order to wipeout tag duplication. This formulation improves network latency and tag check-out rate [11]. Based on RFID and WSN technology, T. H. Shin et al. develop a seamlessly integrated information management framework that can provide logistics information to project stakeholders for their decision making. Time efficiency has been improved by about 32% compared to the traditional supply chain management according to pilot data [12]-[14]. Z. Zou et al. also presented a method with RFID and WSN for intelligent food logistics [15]. R. Tao et al. designed a warehouse vehicle positioning system based on RFID and WSN [16].

III. RESEARCH SCOPE AND METHOD

Step1) A literature review is given on smart logistics in which RFID and WSN technologies are used in supply
chain and logistics industry, and an integration of RFID and WSN technologies is used in the information system.

Step2) A survey is conducted in order to find out shortages of existing logistics information system and introduce the main technologies—RFID and WSN.

Step3) The new concept of RWMS is brought in, which concretely illustrates the RFID/WSN-based information system architecture design. Finally this system can meet requirements of customers.

In order to build the RWMS, a solid knowledge of RFID and WSN devices, zigbee, wifi and so on should be mastered. However, all of these knowledge stated above are not the research scope of this study. This study focuses on the architecture of the monitoring system, the application of the system into smart logistics and how this information system overcomes the disadvantages of the existing logistics information system.

IV. RFID/WSN MONITORING SYSTEM ANALYSIS

A. Survey Design and Analysis

Being direct user of logistics, almost everyone has such an experience of receiving or sending a delivery. Although the high-speed development of transportation and computer technology has made logistics faster and more transparent to users, the reality still can’t fulfill customers’ rigorous satisfaction. The methods adopted to the users’ requirement of RFID/WSN-based information system are collected by questionnaires. The questionnaires are distributed to 300 people with different backgrounds such as different genders, different ages, different jobs, different education histories. With the collected questionnaires being 208, removing 27 questionnaires without key variables, the number of valid questionnaires is 181.

The key factors of e-commerce logistics are cost, service, speed, scope and customization. Thus, the ideal information sharing system is a “user-defined” concept, and “customization” shows its ever-mounting importance as logistics development. To adapt to this “user-defined” concept, the design of questionnaire is mainly to ask people what are the advantages of current logistics information system, and more importantly what are the shortages of the system. Users’ requirements based on the survey and the system analysis are concluded and demonstrated via the following Table I.

<table>
<thead>
<tr>
<th>Requirement identification</th>
<th>Requirement details</th>
<th>Requirement type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>Be a system that enables users to know exactly when the delivery is sent</td>
<td>Functional</td>
</tr>
<tr>
<td>Req2</td>
<td>Be a system that enables users to know where the delivery is transferred</td>
<td>Functional</td>
</tr>
<tr>
<td>Req3</td>
<td>Be a system to precisely predict goods receipt time</td>
<td>Nonfunctional</td>
</tr>
<tr>
<td>Req4</td>
<td>Be a system that enables users to trace responsibility of damaged delivery</td>
<td>Nonfunctional</td>
</tr>
<tr>
<td>Req5</td>
<td>Be a system that enables users have access to query delivery on the Internet at any time</td>
<td>Functional</td>
</tr>
<tr>
<td>Req6</td>
<td>Be a system to timely update transfer information</td>
<td>Nonfunctional</td>
</tr>
<tr>
<td>Req7</td>
<td>Be a system to remind both consignor and consignee transfer information</td>
<td>Nonfunctional</td>
</tr>
<tr>
<td>Req8</td>
<td>Be a system to eliminate the loss of delivery and retrieve the lost delivery</td>
<td>Nonfunctional</td>
</tr>
<tr>
<td>Req9</td>
<td>Be a system that enables users to complain unsatisfied service</td>
<td>Nonfunctional</td>
</tr>
</tbody>
</table>

B. Main Technologies

1) Operating principle of RFID

RFID also called electrical tag, is a new kind of communication technology which can read and write related data of the specific objectives through identifying radio signals instead of generating physical or optical contact. When the identified objects enter the magnetic field emitted by reader, the information stored in the RFID chip will be sent out in responding to the energy of the magnetic field. The tag is defined as passive tag. When a tag emits initiatively signals on some frequency, which will be conveyed to the RFID system after the signals are decoded by reader, the tag is defined as positive tag. Positive tags equipped with a built-in battery are able to sense the temperature, humidity of the environment and feed information back to the RFID system timely. But positive tags are often made of relatively high cost, and couldn’t function in hostile environment. On the contrary, passive tags, which are not equipped with any batteries, can work in hostile environment and are made by low price. The operating principle of RFID system is stated by Fig. 1.

2) Operating principle of WSN

WSN is a wireless network consisted of thousands of mobile or static sensors that are combined by multi-hop and self-organizing. The procedure is that the sensors perceive, collect, handle and transmit information of objects in the network covered zone, and then send the information to the end-users of network. WSN is a system of self-allocation, self-handshaking, self-diagnose, which enable WSN system to become an attractive solution in terms of environment monitoring, logistics supervising and health care.
Generally, WSN system is constituted of three sub-systems, wireless sensor network sub-system, base station nodes sub-system, and software sub-system, respectively, corresponding to sensors, sensed objects and observers. The operating principle of WSN system is stated by Fig. 2.

![Gateway Data control platform](image)

**Figure 2. Operating principle of WSN**

V. RFID/WSN MONITORING SYSTEM

In order to provide customers seamless logistics information, this study establishes an RFID/WSN monitoring system. The RFID technology is used for precise location and traceability during every process of logistics. The WSN technology is used for fuzzy location and monitoring environmental factors such as temperature, humidity and pressure. The mechanism of precise and fuzzy location is that a large number of wireless sensors are randomly distributed in the monitoring zone. When a specific item is needed to find, the RWMS is firstly located this item in a small scale by these wireless sensors, and each item carries an RFID tag, then the system would locate the exact item by the specific RFID tag. The RFID readers could only read tags at a relatively short distance and the sink nodes may recognize a long distance, so the two technologies complement each other during the process of providing information and traceability. Furthermore, there is an online complaint subsystem to restrain logistics companies. The users can complain through the system if they are not satisfied with the services. The composition of RWMS is shown in Fig. 3.

![The composition of RFID/WSN-based monitoring system](image)

**Figure 3. Composition of RWMS of smart logistics on e-commerce**

Logistics is an indispensable procedure of e-commerce trades. There are two types of e-commerce logistics, normal delivery and abnormal delivery. The normal delivery is defined as delivery is conveyed timely and intactly and the abnormal delivery is defined as delivery is missing or damaged or delayed for a long time. This system enables both customers and sellers to conduct through the internet. When the commodity is sent out, each package is installed an RFID tag, and WSN nodes are randomly dispatched around the warehouses and transportation vehicles. As to the abnormal delivery, traceability of lost delivery and damaged delivery should be taken into account. The whole process of RWMS for smart logistics on e-commerce is shown in Fig. 4.

![RFID WSN](image)

**Figure 4. The whole process of RWMS for smart logistics on e-commerce**

RFID chain: RFID tags are embedded into some valuable items or bulking packages. Every time these items or packages enter the sensing zone of RFID readers, all the information written in RFID tags is uploaded to
the RWMS. Therefore the RWMS could realize real location and predict accurate arriving time. Furthermore, when the item is lost or damaged, RWMS could easily trace the lost item or locate the responsibility of damaged item.

WSN chain: wireless sensors are randomly scattered in monitoring zones, especially transportation tools. These sensors sense pressure, temperature, vibration, humidity and so on. And when these indices exceed some standard, the RWMS would automatically raise the alarm. Because WSN nodes are fairly cheap, when an item is need to be queried, the system uses WSN nodes to fuzzily locate firstly, which gives a small scale area that the item located. Then the system uses RFID tags to precisely locate the exact item. After applying this system, the nonfunctional requirements are fulfilled.

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Requirement details</th>
<th>Requirement type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req3</td>
<td>Be a system to remain users when the delivery arrives exactly without unexpectation as far as possible</td>
<td>Functional</td>
</tr>
<tr>
<td>Req4</td>
<td>Be a system that enable users to trace responsibility of damaged delivery</td>
<td>Functional</td>
</tr>
<tr>
<td>Req6</td>
<td>Be a system that real-time address information more accurate</td>
<td>Functional</td>
</tr>
<tr>
<td>Req7</td>
<td>Be a system that enable the traceability of damaged delivery</td>
<td>Functional</td>
</tr>
<tr>
<td>Req8</td>
<td>Be a system to eliminate the loss of delivery and retrieve the lost delivery</td>
<td>Functional</td>
</tr>
<tr>
<td>Req9</td>
<td>Be a system that enables users to complain unsatisfied service</td>
<td>Functional</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

Within the framework of smart logistics, a concept that an RFID/WSN-based monitoring system has been dawn will greatly improve the quality of service and make logistics more efficient and more convenient for users. As for e-commerce, the desynchrony between payment and delivery makes logistics become a necessary process in e-commerce trade. The concerns of users that particular articles should be protected, missing items should be traced, real-time transfer information should be queried and so on are solved after applying this system into smart logistics.

ACKNOWLEDGMENT

This research was sponsored by the National Natural Science Foundation of China (No. 71572113, 71432007, 11171221, 71303157), Shanghai First-class Academic Discipline Projects (No. XTKXX2012), the Innovation Program of Shanghai Municipal Education Commission (No. 14YZ089) and the Innovation Fund Project for Undergraduate Student of Shanghai (No. SH2014054, SH2014062, SH2015056, XJ2015083).

REFERENCES


Guo Yu was born in China in 1992. She obtained her bachelor degree at Business School of Shanghai University of Science and Technology in China on June, 2013. She is now a graduate student at the same school and university and is majoring in logistic engineering. During her study as a graduate student, she has published two papers about WSN and RFID.

Junxiang Li was born in China in 1971. He obtained his Ph. D from Dalian University of Technology in China in 2008. Now he is an associate professor and supervisor of postgraduate at Business School of University of Shanghai for Science and Technology in China. His major is management science and engineering and his research interests are Logistics Engineering, Industrial Engineering and Systems Engineering. He has published several papers in some known journals such as Journal of Optimization Theory and Applications and Applications and Computational Optimization and Applications.