An Intelligent-Internet of Things (IoT) Outbound Logistics Knowledge Management System for Handling Temperature Sensitive Products

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ABSTRACT

A comprehensive outbound logistics strategy of environmentally-sensitive products is essential to facilitate effective resource allocation, reliable quality control, and a high customer satisfaction in a supply chain. In this article, an intelligent knowledge management system, namely the Internet-of-Things (IoT) Outbound Logistics Knowledge Management System (IOLMS) is designed to monitor environmentally-sensitive products, and to predict the quality of goods. The system integrates IoT sensors, case-based reasoning (CBR) and fuzzy logic for real-time environmental and product monitoring, outbound logistics strategy formulation and quality change prediction, respectively. By studying the relationship between environmental factors and the quality of goods, different adjustments or strategies of outbound logistics can be developed in order to maintain high quality of goods. Through a pilot study in a high-quality headset manufacturing company, the results show that the IOLMS helps to increase operation efficiency, reduce the planning time, and enhance customer satisfaction.

KEYWORDS

Artificial Intelligence, Environmentally Sensitive Products, Internet of Things, Knowledge Management System, Outbound Logistics Strategy

1. INTRODUCTION

In today’s dynamic and highly competitive manufacturing environment, providing good product quality is essential to maintain competitiveness and achieve customer satisfaction (Choi & Kim, 2013). It is especially important for environmentally sensitive products that can be easily damaged due to unfavorable environmental conditions, such as temperature, humidity, vibration, barometric pressure and light exposure, during the manufacturing and delivery process (Altmann, 2015). Taking electronic products for example, electronic chips and circuit boards may degrade and wear out easily under high temperature. High humidity brings moisture to electronic finished goods, which damages

DOI: 10.4018/IJKSS.2018010102

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internal components and, finally, decreases the service life. In order to ensure that the product quality meets the required standard, it is a usual practice for the manufacturer to establish quality control measures in the production line for testing the functionality of products and identifying product defects (Jozsef & Blaga, 2014). The quality checking at the end of the production process serves as the final stage to ensure that the product is of good quality. The products that pass the quality control process would then be stored in the warehouse until a customer order is received for delivery. However, different types of inventory have their own specific environmental requirements. Improper storage and handling during outbound logistics operations would also have negative effects on the product quality (Maldonado-Siman et al., 2015). Hence, it is essential to develop a total and complete solution in order to monitor the goods as well as to predict the quality of goods during the outbound logistics operations.

To keep monitoring of the workplace environment, industrial thermometers are installed in the fixed areas of the manufacturing plant, such as production areas and warehouses. Records of temperature and humidity are taken regularly, and manually, which are then reviewed by the warehouse manager to ensure the suitable workplace conditions. However, without real-time data capturing technologies on individual products, it is difficult to collect and retrieve data of specific types of products instantly. In addition, the monitoring systems in the current market involve recording raw environmental data, i.e. temperature and humidity, only. Rarely of these used for controlling the environment parameters throughout the storage and transportation process. The items, in fact, would be degraded when transporting from warehouses to customers due to longer delivery route and improper handling methods. Besides, with the data collected in the monitoring system, there is, however, little attention towards further investigation to transform the data to predict the relative quality of the goods. Warehouse managers usually develop outbound logistics strategies based on the past experience and opinions from experts, to estimate the quality of goods during transportation, which is not reliable. The relative loss, in consequence, may be increased due to the high risk of degraded inventory. Therefore, in order to ensure product quality, managing effective outbound logistics operations from the manufacturer to the end customer is a critical activity in a supply chain.

In this paper, an intelligent knowledge management system, namely Internet of Things (IoT) Outbound Logistics Knowledge Management System (IOLMS), is designed, with the objectives (i) to monitor environmentally sensitive products for outbound logistics, as well as (ii) to predict the quality of goods. The IoT concept is adopted for monitoring the product environmental conditions as well as managing outbound logistics operations. The sensing techniques in IoT cover not only temperature and humidity, but also movement, barometric pressure and light exposure. By integrating two artificial intelligence (AI) techniques, case-based reasoning (CBR) and fuzzy logic, an outbound logistics strategy can be formulated and adjusted by the prediction of quality change in the outbound process. The rest of the paper is organized as follows. Section 2 reviews the related literature on logistics operations of environmentally sensitive products, together with IoT and AI techniques in logistics strategy formulation. Section 3 describes the design of the IoT outbound logistics knowledge management system (IOLMS). The system is then implemented in a case company and the implementation flow is presented in Section 4. Section 5 presents the results and discussion, and conclusions are drawn in Section 6.

2. LITERATURE REVIEW

2.1. Logistics Operations of Environmentally Sensitive Products

Due to the special requirement of environmentally sensitive products, managing the logistics operations in a temperature-controlled supply chain is always a challenge in maintaining the product quality. In general, environmentally sensitive products refer to the type of goods that require temperature control and are easily affected by the external environment (Aung & Chang, 2014). Examples of
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