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Design of a Transportation Destination Control System Based on RFID/GPS Technology

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Abstract. How to effectively control the transportation destination of goods during the process of logistics to guarantee transportation vehicles getting to pre-set destination has always been a concern of companies. Several severe problems such as goods fleeing, loss and recourse blocking that closely related to change of transportation destination have not only disturbed the order of market and the balance of price system but also hampered market expansion of developing companies. By dominating the authorization operation to the lock-control system in both loading and uploading place, this paper aims to design a transportation destination control system by taking advantage of principle of transportation management, theory of control and advanced logistics information technologies such as RFID,GPS/GIS and GPRS technology to transfer decision power into consignor. By supervising information from smart key in unloading location to avoid occurrence of above-mentioned abnormal phenomena effectively.

Keywords: Transportation Destination, Lock Control, RFID, GPRS

1. Introduction

From the microscopic view，logistics flow direction terminal of commodities means the end point of flow from starting point to the destination, which can be classified into three kinds:1 Nature flow terminal. Nature flow means the commodity flow decided by production and marketing, which start from production place and end at point-of-sale.2 Marketing flow terminal. Marketing flow, which reflects the commercial value of logistics, means the goods flowing from lower-price place to higher-price place. Marketing flow terminal is determined by law of supply and demand.3 Designed flow terminal. Designed flow refers to the flow that actually occurred during the process of logistics that

restricted by contract and interest. It is the flow direction terminal that the logistics transportation destination control system designed in this paper mainly dominated.

As one of the basic logistics factors, logistics flow direction which determine transportation destination plays a vital role in developing logistics efficiency and reducing transportation cost. However, many companies and logistics organizations, merely relying on research of improving performance of rules and regulations lack effective method managing logistics transportation destination in practical operation, especially in the process of point-to-point transportation, severe problems such as goods-fleeing, recourse blocking that closely related to change of transportation destination happened all the time. When a manufacture set a preferential price for a new sales region to boost production sales, some customers in this region will buy large amount of products more than their demand to sell the rest to customers in those higher price regions to profit from price variance. Take cement sales from a bulk cement producer for example. To expand sales volume in A city, the manufacture set a price of 344 RMB per ton to customers in A city to attract new customers. However, for the manufacture has been sold products in city B for a longer time, the sales volume and customers are more stable, the price of cement is 387 RMB per ton. It is estimated by employees from the manufacture that nearly 20 percent of cement that sold to city A is transferred to city B by a higher price. The sales volume of city A is about 1.6 million tons which means nearly 0.32 million tons of cement is sold to city B intentionally which will cause a loss of 13 million RMB to the manufacture. This is just a case of two sales regions of the cement manufacture. The economic loss caused by unmatched transportation destination from companies of various industries will be amazing. These behaviors have not only disturbed the order of market and the balance of price system set but also hampered healthy development of manufacture that also leading to the prejudice of interest of all parties involved.

2. Review on Transportation Destination Control Method

Due to the significant role of destination control related to transportation and enormous economic value if being efficiently used, many experts and scholars have conducted series of theoretical studies on how to control it. Overall, these studies can be divided into two categories: based on theory of channel management and by the use of modern logistics information technology. Channel management usually focused on the incentive and supervision activities exerted by the participants in the process of logistics, that is, to supervise the sales process of the whole channel by forming a specific group to enforce supervision function or to build up an effective mechanism of reward and punishment. Conglan Dai suggested to divide sales region rationally and packaging products with distinct pattern or color in different areas. Jianghui Hu proposed to attach unique code to every product to control product flow by

inspecting randomly in sales regions. So it is not hard to find out that channel management theory can barely solve the destination control problem fundamentally since it largely depends on feedback information got at end point of transportation, which unable to deal with the changes of transportation destination during the process.

The rapid development of identification and localization methods has stimulated the use of logistics technology to become into a new way to supervise and control transportation process. Modern information technology, especially RFID and GPS, has acquired widely use in daily transportation affairs. Some scholars have attempted to design an information system with help of advanced technology to manage transportation. Ruijian Zhang has design a transportation security system utilized RFID reader and GPS tracker which connected with the databases that serve as testing grounds for the implementation of security measures to identify drivers and track the load integrity. Alfredo Parreño Marchante et al. have defined an applicable system which could perform the complete traceability by recording data at transports, processing, packaging and storage stage to determine and control the perfect conditions of the cold chain of the product. Minbo Li has raised the idea of building up products tracking and tracing system by using RFID, by which products position information from the very beginning of the raw materials to the producing process then to sales places can be traced to monitor the transportation destination. Weihua Fang et al. have designed a cigarettes flow system based on GPS electronic lock, which applied GPS technology in electronic locks and using the GPS module to perform the guard and auto-alarm function during transportation process. Hongsheng Li et al have projected an electronic Custom-lock equipped with wireless receiver and GPS, GPRS systems, which has already been used in products getting through the Customs to monitor and control the flow through the supervision center.

Although all of their designs have their own advantage, the cost of both devices and maintenance of such complicated system will be relatively high if we control transportation process in a whole-process real-time manner. We still take the above-mentioned cement manufacturer as example. The average sales volume is 1,560,000 tons every month which needs at least 15,000 bulk cement trucks to complete the transportation if we use trucks that can load 40 tons cement three times a month. If every truck equipped with a terminal with GPS and RFID modules inside that worth at least 2,000 RMB each, the cost of all vehicle terminals will be nearly 30 million RMB. Meanwhile, 24-hour supervision requires real-time communication between terminal and control center via GPRS module. If we assume that average data traffic of equipment is 10MB one month, for traffic cost is 1 RMB per MB in China, the traffic cost will be 2 million RMB every month, 24 million RMB a year. Furthermore, control center needs to receive nearly 300MB data every second from 1.5 million truck terminals (by 20 kb/s) to save and process to find out abnormal phenomena, which will be a severe challenge to the capability of data

processing of control center and the cost of hardware, software and human resource to system operation and maintenance will be enormous. Total cost of the system will be nearly 60 million RMB for the first year and nearly 30 million RMB each year after to maintain normal operation. However, core business of manufactures is product design and production which means capital investment of transportation supervision system from manufacture will not be huge enough to afford above-mentioned system. The transportation supervision system should be cost-effective, easy to maintain combined with accurate effective data to manage and control which require fewer one-time expense. The goal of this paper is to design a direction control system by developing traditional transportation supervision system to fulfill these demands.

3. Design of Transportation Destination Control System

3.1 Constitution of the System

Lock transportation destination control system contains three major parts—electronic lock, smart key and control center. By mutual communicating, three components share information about location, vehicle, transporter and products during transportation process. The fundamental propose of the system is to intellectually manage transport vehicles to load/unload products in certain region determined by supply center to control the transportation destination during the process of logistics. Core information technologies of the system are RFID,GPS/GIS and GPRS. The constitution of the system is depicted in figure 1

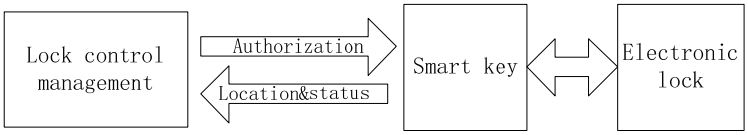

Fig. 1. Transportation Destination Control System Constitution

When product loading has completed and lock operation is required, smart key will get shipping information from control center and then send corresponding data to electronic lock. Electronic lock receives lock order from smart key and conduct lock operation; When unlock operation is required as products have arrived destination, smart key get logistics information from electronic lock and send it combined with its own location information to control center via GPRS to ask for unlock authorization. Control center receives open require and sends it to control system to check if all the information matches that in the database. If data is verified, control center will send unlock authorization to smart key. Smart key receives authorization information and then sends open order to electronic key to permit unloading operation. If location of unlock place is not corresponded with that in control system, smart key will show error message to operator and control center will record information about illegal open

operation trial of the transporter. In case of abnormal situation, like lock broken and information error, smart key will send warning information to control center to require manual intervention by administer.

3.2 Working Process of Transportation Destination Control System

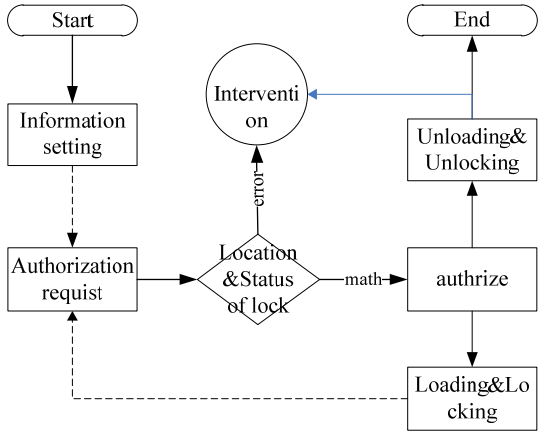

Fig. 2. Transportation Destination Control System Working Process

Working process of the system is shown in figure 2.

(1) Information setting. Logistics information should be entered into control system before transportation. The information contains vehicle or container information, transporter information, products information, destination, expected loading and unloading date.

(2) Lock authorization request. When electronic lock need to be locked, smart key gets information about the vehicle or container from control center and raises lock authorization request to control center.

(3) Lock information check. Control center receives lock request information from smart key and send it to control system to check if the information match corresponded with that in database.

(4) Authorization sending. If authorization request is approved, control center will send authorization information to smart key. Otherwise, smart key will show error information to operator and illegal lock trial will be recorded.

(5) Lock operation. Smart key receives authorization information from control center and sends lock order to electronic key after loading. After successfully locked the vehicle or container, smart key will send lock information to control center to record lock location and time.

(6) Unlock authorization request. When vehicle or container arrives appointed destination and electronic lock need to be opened, smart key will get

information from electronic lock and send it attached with its own location information to control center to require unlock authorization.

(7) Unlock information check. Control center receives unlock request information from smart key and sends it to control system to check if the information corresponded with that in database.

(8) Unlock operation. Smart key receives authorization information from control center and sends open order to electronic key for unloading. After successfully opened the vehicle or container, smart key will send unlock information to control center to record open location and time.

(9) Human intervention. Control system supervises unlock information regularly to find out locks that have not been opened in expected period to identify abnormal transportation destination phenomena to require human intervention.

4. Function Modules of Transportation Destination Control System

4.1 Electronic Lock

Electronic lock is used to control packaging equipment，like mechanical locks and lead sealing，of transportation vehicles or containers. Generally, locks of containers and vehicles are controlled by metal keys taken by transporters. However, electronic lock is controlled by RFID module inside it and only can be lock/unlocked when RFID module received certain order from authorized smart key. When lock/unlock data is written into RFID module, control measure of mechanical lock is then triggered, so that workers can load/unload commodities. The RFID power line runs through whole part of electronic key. When someone intentionally breaks lock, the internal structure of electronic lock is broken and electronic key will reset identifiers in RFID module automatically at the same time. Control system will recognize unusual broken according to identifiers and provide data proof to manual intervention. The structure of electronic lock is shown in figure 3.

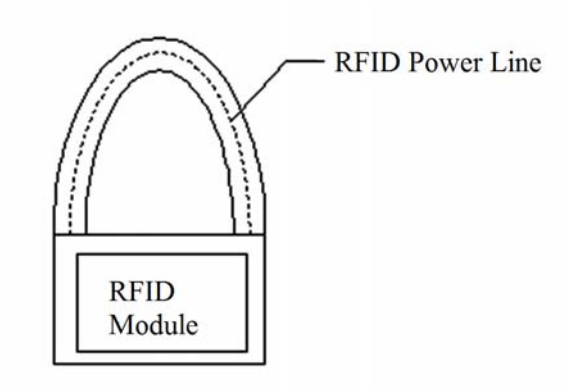

Fig. 3. Internal Structure of Electronic Lock

4.2 Smart Key

Smart key consists of 6 components--RFID unit, GPS unit, GPRS unit, control unit, battery system and User Interface. The schematic structure of smart key is shown in figure 4.

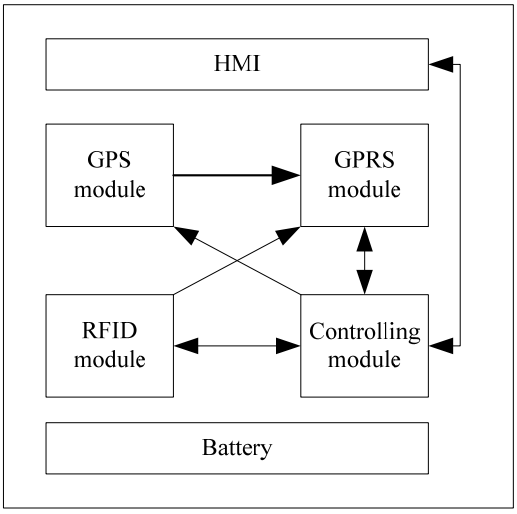

Fig. 4. Internal Structure of Smart Key

The function of smart key is:

(1) To read information from electronic lock and to request authorization from control center. When lock/unlock operation is in need, GPS unit will get location information, meanwhile RFID unit will get logistic information from electronic lock and then send all the information to control center together

through GPRS unit to require authorization to lock/unlock electronic lock. Once RFID electronic lock is broken, warning information will be sent.

(2) To receive authorization and write lock/unlock order into electronic lock. GPRS unit receives authorization information from control center and analyzes whether lock/unlock conduction is permitted. If receives permission order, RFID unit will write relevant data into electronic lock to lock/unlock the container or door of vehicle; Otherwise, the user interface unit of smart key will show error messages to customer to require try again at appointed location.

(3) To send feedback information. After electronic is successfully locked/unlocked, smart key will send lock/unlock information about the key to control center through GPRS unit. The information contains location information, lock/unlock date, vehicle information, transporter information, cargo information to help control center supervise status of electronic lock to find out abnormal phenomena.

(4) Query result display. Electronic key communicates with control center via GPRS to query related information which including expected delivery duration, vehicle/container information, departure time of vehicle, shipper information and transportation history record. If operation is illegal, smart key will show error message and guide operator to take proper action.

4.3 Control Center

Control center uses a computer software system combined with GPRS system to set logistics information into electronic lock, manage locking/unlocking authorized sending and supervise abnormal phenomena. Its main functions are as follows.

(1) Information setting management. This system is responsible of setting loading/unloading location information, vehicle information, cargo information and transporter information according to contracts signed by supplier and customer into electronic lock used on appointed loading tools or containers before products are transported.

(2) Lock/unlock authorization management. After arrival at destination, the smart key in unloading location sends out its GPS information, the ID of the electronic lock and the specific identifiers to apply for the lock/unlock authorization. If the information about unloading location and the ID of unloading tool or container matches that in the lock control system, the lock control system will allow the smart key to input specific identifiers into electronic lock , and add the ID of the smart key to the table of flow setting to complete the operation of locking/unlocking.

(3) Abnormal flow management. Abnormal flow phenomena include transport vehicles or container dose not load / unload cargo in specific location and artificially forced unlocking, information missing. The control center receives information from smart key and send it to control system to judge whether the information correspond to information preset according to contract. If information is incorrect, the lock control system will alarm automatically, transfer the system to manual control situation and add the disposal results to the lock control system.

(4) Lock/unlock information management. Control center receives feedback information from smart key and records it into control system. If an electronic lock is successfully unlocked, system will classify the information of lock into "completed" category. By regularly inspecting information about locks that have not been classified for a longer time than expected duration, system could find out abnormal phenomena and require human intervention.

5. Conclusions

How to control transportation destination effectively of products during the process of logistics to guarantee transportation vehicles/containers getting to pre-set destination has always been a concern of suppliers. In this paper, a transportation destination lock control system integrated with RFID, GPS/GIS and GPRS technology is designed followed with introduction of constitution and operation process of it. From an economic perspective, transportation destination control system is cost-effective for all the three parts of the system do not require massive investment. Firstly, RFID tag is cheap and can be read and written for times which means electronic key that can be thought as a traditional metal lock with a RFID tag imbed will not raise the cost of production. Meanwhile, control center only needs an equipment to receive and send out GPRS information with relative software to supervise transportation which will not be costly either. The most expensive part of the system may be smart key. Suppliers could choose to alternatively offer large quantity customers to guarantee their benefit to reduce cost. Last but not least, the investment will be worthy compared with huge lose that abnormal transportation destination may brought. From an operational perspective, the system has highly intelligence that drivers just need to send out lock/unlock require by system prompt from smart key and the operation process will be conducted by the system itself soon. Only few professional technicians are demanded to check abnormal information and implement intervention to keep system under maintenance. In short, the transportation destination control system is practical, easy to handle and economical for it does not require any particular technological prowess and runs well in any condition.

Compared with the traditional destination control theory and the current destination control methods, the destination control system could effectively control the logistic direction at the nodes of a series of operations, thus solve the wrong-directed flow errors within the right process of delivery, reducing the large amount cost of installing high-tech modules in the electronic locks. By transferring these high-tech and high-cost modules into the electronic keys which amount is fewer, the costing is better cost-effective and a mass of data brought by real-time monitoring is removed as well as the costly system maintenance. The whole system is well-intelligent and suitable for those products which have high product value, wide sales area and diverse price according to zones, so as to endow more control power to manufacture on consignment during the transportation process. When it comes to the application, different companies can make their own management rules according to the characteristics of their products and the system could be better used in real life. However, whether we could precisely estimate the whole transportation duration can directly influence the effectiveness of manual intervention, while it still needs to be better investigated to help us adjust and inspect the transportation destination.

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