Building a Seamless and Secure Supply Chain: RFID Enabled Devices Applications

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1. Introduction

Globalization has been seen as an inevitable trend in supply chain design. Companies are inclined to source manufacturing offshore, and utilize the efficient global transport networks to fulfill demands. Meanwhile, with the trend of containerization, more than half of the international cargoes are now shipped by standard ocean containers [1]. After Sep. 11th, 2001 terrorist attacks upon the United States, companies realized vulnerable supply chain might result in halting businesses, delaying order fulfilment, and ultimately losing customers. In governmental aspects, the issues of anti-terrorism and supply chain security have raised a series of projects, comprising governments and enterprises worldwide, to defend any potential damages resulting from terrorist attacks. Some of the extinguish examples are CSI (Container Security Initiative), focusing on the major ports where most of the US-bound containers originate, and C-TPAT (Customs-Trade Partnership Against Terrorism), a volunteered project which includes importers/exporters, offshore suppliers/manufacturers, and related international logistic vendors [2], initiated by U.S. CBP (Bureau of Customs and Border Protection). In addition to the above processes guidelines, U.S. also promotes the SST (Smart and Secure Trade Lane) project via civilian organization by implementing the technological system, including RFID, GPS, tracking system, electronic seal, and anti-intrusion containers with sensor and video system, in assuring the supply chain security [3].

2. Brief Introduction of RFID Technology

The concept of RFID was used as a method to identify aircrafts during the World War II. Recently, it has received much press of late, mainly due to the recent compliance mandates by many of the world’s largest retailers (Wal-Mart, Tesco, Marks and Spencer, Target, Gillette, etc.) [4].

2.1 RFID System Components

RFID systems include tags, readers and software to process data. A RFID tag has a chip to provide memory capacity and has an antenna to receive or response radio frequency signals. Generally, RFID tags come in three categories by power source: passive, active, and semi-passive. A passive tag requires no internal power sources and gets its power from readers’ antennas. Thus it is activated when a reader is nearby to power it. On the other hand, a semi-passive and a active tag have their own power source, usually a small battery, and usually are more expensive than a passive tag. RFID Readers are devices that read/write/interrogate tags, supplying energy to tags, and communicate with host computers. The data captured from readers are analyzed in the customized application systems for diversified applications and industries.

2.2 RFID Applications in Supply Chain Operations

RFID allows indirect scanning through multiple packages and pallet loads simultaneously and modifying the data in tags by readers when real status changes [6]. Hence RFID is promoted as a better solution than barcode in supply chain systems. In addition, RFID chips are extremely difficult to be counterfeited, so RFID based technology, such as e-seal, is exceptionally becoming for security applications. In logistics application cases, RFID is widely used to identify items, cases,
boxes, pallets, containers, vehicles, and other equipments. In manufacturing, RFID is usually used to monitor inventory, and to route materials/parts through production processes. In addition, RFID can provide immediate and substantial benefits throughout the whole supply chain, such as saving labour cost, reducing inventory, and reducing shrinkage and backorders [7]. When RFID is applied in a supply chain, manufactures, distributors, logistics providers and retailers can all share the same tags to reduce implementation costs and to track, secure, and manage items in the entire supply chain [8, 9, 10]. Moreover, RFID also can work with sensors and wireless network systems to come up with full-time and wide-scale monitoring.

3. RFID Applications For Cargo Transportation Security

As mentioned before, globalization has also led to advances in security devices and instruments and their strategic integration within the entire logistics activities. It is essential to ensure the integrity and security of containers entering the border of countries by monitoring and inspecting them along the way to avoid hazardous and illegal goods being smuggled. There are two security challenges for an inland FCL (full container load) container transportation: (i) the accuracy of the packing list of a container, which will be used for clearance and receiving process; (ii) the surveillance problem when a FCL container is moved between two controlled zones, such as free trade zones, container yards, and export processing zones, etc.

In this paper, we tried to demonstrate how RFID can be used to improve the packing list accuracy and ensure the integrity and security of the FCL container along the way with the aid of other technologies. For this reason, we proposed a seamless control mechanism for cargo security which comprised of passive RFID tagged on logistics case/pallet for delivery/receiving confirmation and automatic packing list generation; passive e-Seal for the integrity of container; AVL system for vehicle location and routes tracking/tracing; and an intelligent real-time management system for cargo security.

3.1 Documentation Accuracy

Documentation accuracy is the first step of synchronizing material flow (physical flow) and data flow (virtual flow). In this paper, sticking RFID tags on each case/pallet, recording stuffed boxes and pallets in the process of filling containers, and generating counterpart documentations automatically are used to ensure that right boxes/pallets are loaded upon the right container, and correct documentations are generated quickly. In pilot test, an alarm mechanism was activated when there was any discrepancy between planned and real loading lists to avoid wrong goods being shipped and to protect against the introduction of unauthorized material. RFID was used to reduce operational time and labour for collating data and correcting errors.

The output document can be used for packing list, customs clearance document, and advanced shipping note. On the other hand, RFID tags could be applied in the following transportation security based.

3.2 Conveyance/Container Security

Conveyance (tractor/truck and trailer) integrity must be maintained to protect against any intrusion by unauthorized personnel or materials. The fundamental objects involved in a container inland shipment are: a truck, a trailer and a container. Hence, in the pilot project, a seamless conveyance security control system using RFID, AVL and risk management rules to guarantee the integrity of each element and the relations among elements was proposed. The test scope was FCL containers moving between two control zones after completing the stuffing process.

RFID tags on trailers and e-Seals on shipping containers are automatically detected at a control gate as they leave with an outgoing shipment. The relationship among boxes, pallets, a container, an e-seal ID, a truck (usually is represented as a shipment), a trailer, and the target customers are built simultaneously. The information can be used for logistics service providers to evaluate drivers’ performance, truck utilization, to increase operational visibility, and to improve customer service. In the conveyance security control system proposed in this paper consists of the following main control parts and features:
3.3 Seamless Supply Chain Security Solution

1) Tracking/tracing vehicle location

In each truck, a GPS/GPRS/3G module is installed. Hence the real-time location of each truck could be monitored in dispatching centre via the AVL system, and tasks could be assigned to trucks dynamically depending on real up-to-date conditions. In addition, the historical routing, speed, and travel time are record, so AVL system could filter abnormal events, such as improper routes and long travel time, and alert control centre and the customs.

2) Verifying the container on the trailer

In the pilot test, a passive anti-metal RFID tag was inlayed on a trailer to identify a specific trailer automatically. When the stuffing process of a container is done, a passive e-seal is affixed to the container. Then the container is settled on a trailer, and the combination of e-seal ID and trailer ID is recorded and expected being consistent till the destination. Based on this expectation, the IDs pair would be verified along the way and at the receiving gate of the destination. If the consistence of the pair was broken, an abnormality assessing procedure would be activated.

3) Sensoring the correspondence of truck and trailer

It is reasonable and logical to require the connection of a truck and a trailer cannot be released en route without informing or permitting. Therefore, in this project, a switch sensor for the connection of the wiring between a truck and a trailer was designed and applied. The sensor is linked to a GPRS module in the truck. Once it detects the connection of the wiring between the truck and trailer is broken, a signal is sent through GPRS to the control centre near-real-time and a responding procedure will be activated. This mechanism is able to effectively deter terrorism and illegal activity, such as smuggling or container changes.

4) Checking the travel time at each control point en route

In most access control cases, RFID readers are deployed at departures and destinations, and any information in e-seals only could be detected while trucks pass through these RFID readers. Thus, even though e-seal could be used to monitor the container integrity, it couldn’t satisfy the needs of container security, especially when an abnormal event happens, and an alarm is needed as quick as possible.

In our solution, considering cost and efficiency, some extra checking points are selected en route and deployed with RFID readers. When trucks pass through these control points, the arrival time, the interval time between two contiguous control points, the e-seal ID/status and the trailer’s tag ID will be read and verified. These extra control points help to form a more precise conveyance security network.

Compared with using GPS system to monitor all the operating vehicles, this solution could mitigate the work loads of backbone system by filtering out skeptical vehicles, and it has lower operating cost while the amount of vehicles grows.

5) Managing cargo moving risk in real-time base

In this paper, an integrated real-time risk management system is used to coordinate e-Seal/tag/sensor status and vehicle location from all vehicles/containers en route. It analyzes and yields systematic feedbacks to all participators to improve the insufficient functions or existing
failures in operations. It also strengthens participators’ real-time monitoring capability to improve the conveyance security. The control methodology illustrated in this paper is not only applied in tracking the status of cargo transportation at control points, but also the process between any two points. Process-control, contrasted to points-control, can find out potential mistakes in shipping operations earlier and provide a near real time warming mechanism.

4. Conclusion

Visibility and security are two of the most concerned topics in supply chain management. Security supply chain should include not only visibility, but risk prevention, and disaster resilience. Taking advantage of new technology can carry out a win-win model between security and efficiency. This paper established a total solution consists of RFID technology, complementary technologies: GPS, mobile wireless, as well as sensors, modified managerial mechanisms, and legacy systems integration to satisfy seamless cargo tracking/tracing functions, prevent insidious risks, and improve operational efficiency. Although the logistics service providers are required to invest in the RFID related equipments and software at the initial stage, the system will help those companies to increase supply chain visibility, decrease the average operational cost, and provide better security and services to acquire future business opportunities. Obviously, RFID should be deemed as an enabling technology and requires sufficient tests to find out its best application models and equipment installation [11].

In future studies, information serialization is an important issue in supply chain security. When RFID is used at item level, current box level based model should be modified to liberate its potency in automation, and to carry more pedigree information to pledge security. The information shouldn’t narrowly be shared among few stakeholders, but to all the participants who can utilize the information to facilitate the supply chain operations.

References