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# The Implementation of an Intelligent Logistics Tracking System Utilizing RFID

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**ABSTRACT**

Due to globalization and the advancement of technology, the differences are lessened among businesses in terms of IT capabilities and product quality. Operation cost has become a critical key factor of success that determines company's profit level, as well as its competence in the market. Under the environment of electronic-commerce, logistics in the supply chain ensures a stable supply of stocks to satisfy customer's demands. An efficient supply chain requires a sound inventory system and operates in coordination with well designed shipping processes. Present shipping process uses barcode in tracking the flow of materials; however, scanning barcode one at a time is tedious and inefficient. Recently, RFID has been regarded as an important technology that influences the growth of global industries in the near future. RFID is able to effectively reduce the overall cost of logistics. However, application of RFID on supply chain management is still at its infant stage. Therefore, this research attempts to develop a prototype of a Smart Logistics Tracking System (SLTS) utilizing RFID. The proposed system aims to replace barcode with RFID, eradicate the time-consuming scanning procedure and ensures an efficient flow of materials. SLTS provides a cargo tracking platform that reports real-time location of the cargo and its flow.

***Keywords***: Radio Frequency Identification (RFID), Supply Chain Management (SCM), Electronic product code (EPC )

## 1. INTRODUCTION

With the ever greater computation power and affordable network communication, businesses incorporate Internet to automate order processing, purchasing, manufacturing, shipping, marketing, and various services through uniformed information exchange under predefined policies. Industry standard allows businesses to collaborate with up-and-down-stream partners. Supply-chain collaboration improves manufacturing efficiency, reduces holding and distribution cost, shortens time to respond to market change and enhances industry's competency as well as its viability. However, the development of logistics-associated technology is laggard compares to that of the information exchange. Present shipping process uses barcode in tracking the flow of materials; however, scanning barcode one at a time is tedious and inefficient. During the second US-Iraq War, US military teamed up SAVI Technology in building a real-time RFID logistics tracking system for military cargo. The use of RFID technology allows multiple ID scanning which accelerates the speed of material flow. Scholars and industries are now under research of making RFID an affordable technology for commercial use. The success of this attempt is promised to bring about a revolutionary progress in logistics and resolves various common inefficiency problems stemmed from bullwhip effect in supply-chain. In short, by utilizing RFID, businesses are able to deliver material efficiently and maintain a low holding cost.

Majority of the present cargo transportation undergoes rather slow processes due to the use of barcode which hinders the speed of material flow. With RFID, the overall performance of supply-chain can be improved significantly. However, application of RFID on supply chain management is still at its infant stage. Therefore, this research attempts to develop a prototype of a Smart Logistics Tracking System (SLTS) utilizing RFID. With SLTS, every unit of product is attached with an EPC (Electronic Product Code) tag before leaving the factory. From that point on, each handler of the down stream supply-chain (including those involved in the processes from factory to warehouse and warehouse to retailers until products are placed on the shelf) tracks the flow of goods by scanning RFID. In short, the proposed system is able to make distribution smoother the by integrating logistics information of the up-and-down-stream businesses.

## 2. LITERATURE REVIEW

### 2.1 Supply Chain Management (SCM)

According to Ccecil Bozarth[1], SCM is the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It is a discipline that devotes in developing and running supply chains in the most effective and efficient ways possible. As shown in figure 1, supply chain activities cover everything from product development, sourcing, production, and logistics, as well as the information systems needed to coordinate these activities. There are four objectives of SCM[5]:

- Consumer: SCM benefits the consumers by maintaining a stable supply of goods to keep the price low.
- Distribution Center: SCM serves regional market, integrates all end points and handles mass distribution operation. Distribution center utilizes computer-aided equipments in processing

customer orders, managing inventory, shipping, controlling cost and etc.

- Manufacturer: SCM enables quicker respond to demands and market changes. It offers flexible production plans, quality management and various logistics support. Overall, SCM enhances order processing.
- Supplier: SCM cuts down inventory which leads to reduced storage cost. SCM prevents stocking unsoldable goods due to bullwhip effect or unexpected market change.

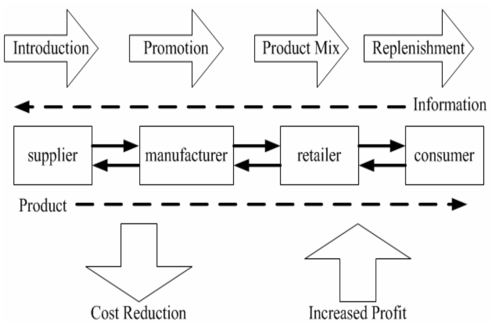


Figure 1. Supply Chain [6]

**2.2 Current Supply Chain**

The fundamental structure of present business organization is divided into departments including production, manufacturing, marketing, human resource, accounting and finance. The objective of all businesses are pursuing is to generate profits by selling products. Increasing incomes while reducing costs is the basic concept of survival.

Under current logistics system, factory delivers products to up-and-down-stream partners through supply chain within which routine inventory checks are applied at each stage. Businesses track goods by scanning the barcode attached on each unit using infra red reader. However, this process is rather inefficient because the items can only be scanned one at a time.

Therefore, this research attempts to develop a prototype of a Smart Logistics Tracking System (SLTS) utilizing RFID. The proposed system aims to replace barcode with RFID, eradicate the time-consuming scanning procedure and ensures an efficient flow of materials. SLTS provides a cargo tracking platform that reports real-time location of the cargo and its flow.

2.3 Radio Frequency Identification (RFID)

RFID is an identity management technique that utilized radio frequency (RF) to transfer and intercept identity information. RFID couples radio frequency identification technology with highly miniaturized computers that enable products to be identified and tracked at any point along the supply chain [2]. The system could be applied to almost any physical item, from ballpoint pens to toothpaste, which would carry their own unique information in the form of an embedded chip [3]. The chip sends out an identification signal allowing it to communicate with reader devices and other products embedded with similar chips [4].

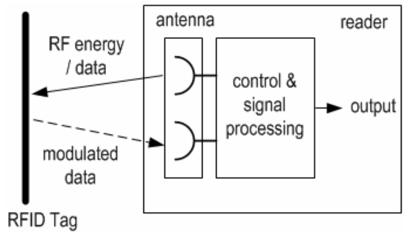


Figure 2. RFID structure [17]

A typical RFID structure (Fig 2) contains two major components: RFID tags and a reader. RFID Tag (transponder) contains antenna and memory. The antenna receives and responds queries from RFID reader, while memory stores ID information. There are two types of RFID tag: passive and active. Majority of RFID tags in existence are passive which converts RF energy into electrical power to generate respond signal. On the other hand, active tags require external power from embedded battery to generate initial signal.

RFID reader (interrogator) is consisted of antenna, signal processing module and control circuits. When object identification is required, reader issues query signal. Those tags within communication range receive the query will automatically respond with its ID. The reader intercepts the respond signals and retrieves the IDs that identify the items, their locations or statuses.

Currently, the concept of RFID still requires an integrated and systematic mechanism, including data content and technical / software standards. In comparison with other identification technologies, RFID has the following advantages:

- Faster data retrieval
- Multiple tag read/write access
- It is wireless (long read range)
- No line-of-sight requirement
- It is resistant to harsh condition
- It is reusable (reduce cost)
- RF is capable of penetrating paper, wood, plastic or other non-metal materials

Table 1. comparison between various systems

| | bar code | optical | vocal | finger pirnt | smart card | RFID |
|---|---|---|---|---|---|---|
| storage density | low | low | high | high | very high | very high |
| | limited | easy | easy | hard | not possible | not possible |
| cost | low | mid | high | high | low | mid |
| access speed | slow | slow | very slow | very slow | slow | very fast |
| max access range | 0-50 cm | <1 cm | 0-50 cm | direct | direct | 0-500 Cm |

Table 1 shows the comparison between various identification systems. RFID stores data digitally hence is able to store more information. Also, RFID is securer since data content is concealed within the chip. Besides, RFID provides faster ID access and longer access range. RFID is able to remotely identify personnel, live-stocks or objects that has RFID tags attached. RFID tags are commonly used for animal tracking, key/lock, anti-theft system and material tracking in the supply chain. As a matter of fact, there are enormous possible applications and potential business opportunities that should not be underestimated.

Electronic Product Code (EPC) is developed by Auto-ID center of MIT. EPC is a coding scheme, which is 96 bits long and can be segmented into four pieces: header, manufacturer, product and serial number (fig 3).

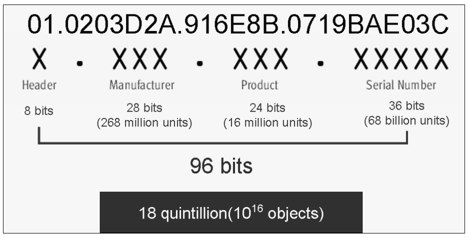


Figure 3. Electronic Product Code [20]

EPC supports current EAN standard manufacturer and product code which reduces the task of recoding [22]. EPC provides an encoding and decoding standard for RFID. A unique EPC-format identification data is written on each of the RFID tags. EPC will be requested upon item tracking and the data retrieved is then transferred to a shared database that serves interconnected companies [19].

## 2.5 Physical Markup Language (PML)

As defined in the PML Core specification [14], the goal of the Physical Markup Language (PML) is to provide a collection of common, standardized vocabularies to represent and distribute information related to EPC Network enabled objects. The PML vocabularies provide the XML definitions of the data exchanged between components in the EPC Network system. In other words, PML is used to describe EPC under network environment (fig. 4) and to enable internal and external communication among interconnected companies.

```
<pmlcore: Sensor>
  <pmluid:ID>urn:epc:1:4.16.36</pmluid:ID>
  <pmlcore:Observation>
    <pmlcore:DateTime>2002-11-06T13:04:34-06:00</pmlcore:DateTime>
    <pmlcore:Tag>
      <pmluid:ID>urn:epc:1:2.24.400</pmluid:ID>
      <pmlcore:Data>
        <pmlcore:XML>
          <EEPROM xmlns="http://sensor.example.org/">
            <FamilyCode>12</FamilyCode>
            <ApplicationIdentifier>123</ApplicationIdentifier>
            <Block1>FFA0456F</Block1>
            <Block2>00000000</Block2>
          </EEPROM>
        </pmlcore:XML>
      </pmlcore:Data>
    </pmlcore:Tag>
  </pmlcore:Observation>
</pmlcore:Sensor>
```

Figure 4: PML schema [10]

PML schema Core is comprised of the following elements:

- Sensor Element: The Sensor element is the main interchange element for PML Core messaging. This element is a composite element comprised of the following subordinate elements:
  - ID element
  - one or more Observation elements
- Observation Element: It contains the result of a measurement by a particular sensor. Each observation must be labeled with date and time. It can also be equipped with a unique ID, and a reference to the kind of command that was issued to make the observation. The Observation element consists of the following:
  - an optional ID element
  - an optional Command element
  - DateTime element
  - zero or more Data elements
  - zero or more Tag elements
- Data Element: The Data element must be used to represent the data captured when a sensor measured a particular property or entity, unless the data captured can be represented as Tag elements. The Data element consists of a choice of the following 3 elements:
  - Text element: must be used to represent captured data as string notation.
  - Binary element: must be expressed in hex.
  - XML element: must be in XML format.
- Tag Element: The tag element is a special kind of observed value introduced with recognition of the importance of automatic identifications in the EPC network. The “tag” entity represents any device that can be detected by a sensor. The Tag element consists of the following elements
  - ID element
  - optional Data element
  - zero or more Sensor elements
- ID Element: The ID element is used to capture tag identification information. The ID element has the following attributes.
  - an optional schemeID attribute
  - an optional schemeAgencyID attribute
  - an optional schemeVersionID attribute
  - an optional schemeURI attribute

## 2.6 Savant

Savant is “middleware” software designed to process the streams of tag or sensor data. Savant performs filtering, aggregation, and counting of tag data, reducing the volume of data prior to sending to Enterprise Applications [21]. The ONS provides a global lookup service to translate an EPC into one or more Internet addresses where further information on the object may be found. The characteristics of Savant are as follows:

- Savant is the basic working platform of Auto-ID System.
- It handles large amount of data.
- It provides flexible data filtering and monitoring.
- It controls the readers.
- It provides interface between readers and application software or ERP.

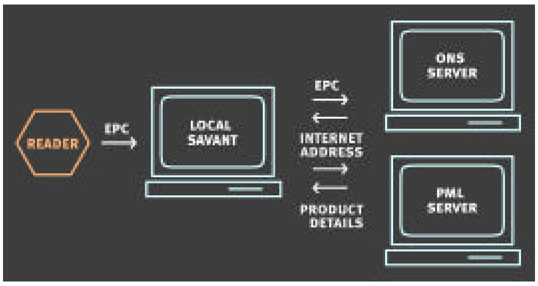


Figure 5. Savant Platform [21]

## 3. SYSTEM ARCHITECTURE AND DESIGN

### 3.1 System Framework

This research attempts to develop a "Smart Logistics Tracking System" (SLTS) utilizing RFID. SLTS consists of two major components: Logistics Tracking Center (LTC) and on-board Positioning and Tracking Module (PTM). LTC consists of ONS server and Savant; it is the central management panel that allows manager to monitor the material flow. PTM is a mobile tracking system that reports current shipping status to LTC.

Under proposed system, the traditional bar code scanning procedure is replaced with RFID technology which allows remote access of multiple data and has no line-of-sight requirement. Figure 6 shows the system framework and flow. Whenever item checking is required, RFID reader obtains IDs from tags, within its read range, then stores data to backend database. SLTS reduces resources and time required in the process.

As for logistics tracking, SLTS incorporates GPS (Global Positioning System) and GRPS (General Packet Radio Service) to achieve mobility and flexibility. GPS provides current location of the shipping items while GPRS serves as a communication channel for transmitting data. The mobile nature of SLTS enables flexible management and immediate response to changes; such capabilities are what barcode failed to provide.

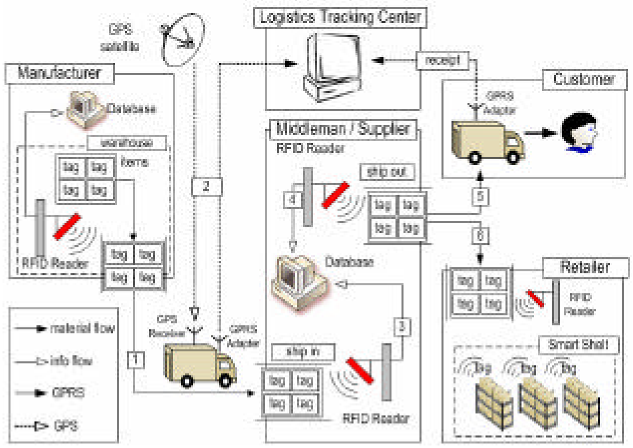


Figure 6. System Framework and Flow

Goods manufactured were attached with tags and stored in the warehouse. Before shipping, RFID reader examines the items delivered and updates the associated records in the database (step 1). If item tracking is requested while shipping, the GPS and RFID reader will report its current position and item information through GPRS to Logistics Tracking Center (LTC) (step 2). Upon arriving the supplier, the items were checked using RFID reader and database is updated accordingly (step 3). When shipping out the items, supplier uses RFID reader to perform item check and updates item information to database (step 4). Finally, as customer receives the products, RFID reader checks the item and the receipt will be confirmed with LTC through GPRS (step 5). Similarly, when receiving the items, retailer uses RFID to perform item check while confirming with LTC through GPRS. The items are then placed on the RFID-enabled smart shelves (step 6).

### 3.2 Logistics Tracking and Positioning

The most prominent feature about SLTS is its ability of tracking and positioning. Figure 7 illustrates a sample instance of material tracking in the LTC. SLTS provides interface to adjust the zooming scale, allowing managers to remotely inspect the shipping items along with neighboring street details. The map on the left shows each destination with a transaction ID (TID). With TID the items to be delivered can be referenced.

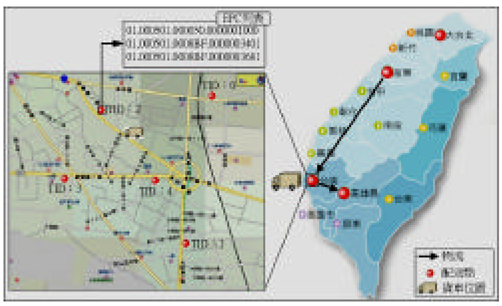

Figure 7. Real-time tracking

Figure 8 shows the on-board positioning and tracking module (PTM), which consists of GPRS adapter, GPS receiver and embedded micro processor. The processor is responsible of coordinating GPRS, GPS and RFID reader, as well as gathering information to be transferred back to the LTC.

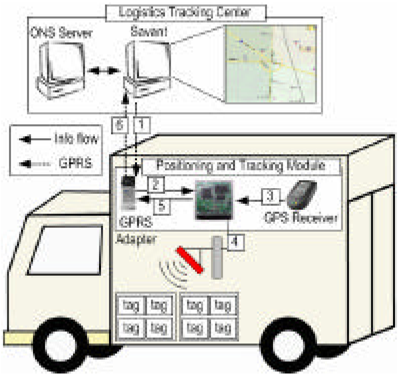

Figure 8. On-board Positioning and Tracking Module (PTM)

When item tracking is requested, LTC sends the query through GPRS to the target truck that loads the items (step 1). As soon as PTM receives the request, the micro processor commands GPS to reports it current position (step 2); at the same time, RFID reader scans the tags to obtain EPCs (step 3) for processor to verify the items being queried. The tracking result will be composed by processor and transferred through GPRS adaptor (step 4). Finally, LTC is able to reference more information by searching ONS based on the retrieved EPCs (step 5).

## 4. SYSTEM DEMONSTRATION

### 4.1 Logistics Tracking Center

Figure 9 shows the LTC's main system interface. The proposed LTC utilized MapExtreme to display the geographical information and maps out the current track locations. Section A is displays messages to inform user about the system's current status. Section B is the event list containing records that describe events reported by the monitor tracks. Each record is composed of several fields: event sequence, event name, event type, description and time.

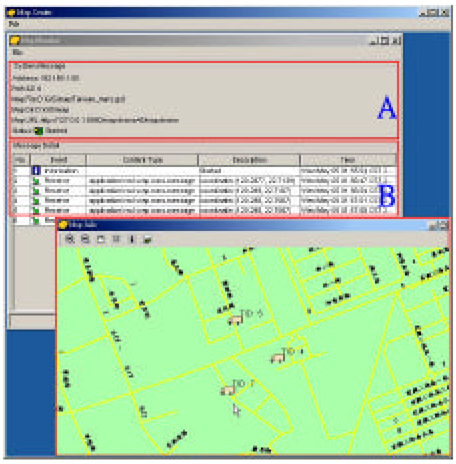

Figure 9. LTC main interface

### 4.2 Positioning and Tracking Module

Figure 10 shows the main interface of PTM which is implemented on a PDA running embedded Linux. Section A displays system status while section B keeps a list of even records indicating event, description and time occurred. PTM takes the coordination reported by GPS and send the information as in MMS format through GPRS back to the LTC.

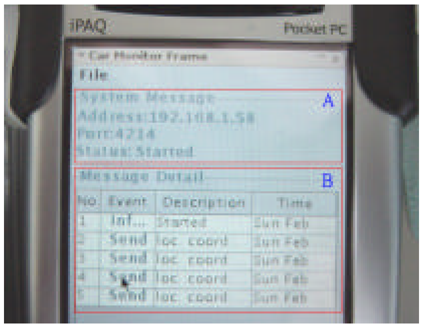

Figure 10. Positioning and Tracking Module

## 5. CONCLUSION

A sound logistics system can improve businesses' flexibility and performance while reducing overall cost of shipping and storage. Business should incorporate information technologies into supply chain to achieve efficient data exchange and information sharing and effectively integrate up-and-down stream partners. The proposed SLTS is a system that utilizes RFID to improve the efficiency of the traditional supply chain. With the assistance of real-time monitoring facility, mangers are able to keep track of material. However, further improvement should consider providing on-line shipment modification to offer greater flexibility to respond to the market change.

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