Utilizing RFID as an Intelligent Agent in Transportation Systems

---

Abstract

Radio Frequency Identification is an emerging that many organizations seek to effectively utilize in operations. Technologies such as GPS have been envisioned as agents that can be used to optimize transportation systems using real time data. In this transcript we investigate how RFID can be used effectively as an intelligent agent to support effective decision support in transportation systems.

Key Words

Transportation, RFID, GPS

1. Introduction

A Supply Chain can be expressed as the parts that are involved, directly or indirectly, in fulfilling a customer request [1]. By this definition, it can be seen that a supply chain consists of manufacturers, warehouses, retailers, transporters, and customers. The purpose of a supply chain is to maximize the value generated for the customer, namely maximizing the difference between the final product worth and the total expended by the supply chain to provide the product to the customer.

In order to succeed, the supply chain must be conducted to minimize the costs incurred. Supply Chain Management (SCM) is the responsible for the optimization of the flows within the stages and for minimizing the total cost at the supply chain. This term SCM is a unification of a series of concepts about integrated business planning that could became recently joint together by the advances in information technology (IT) [7]. Despite all that, many companies have not completely taken advantage of this process.

In today's world, the competition between companies, more demanding customers, and reduced margins make the scenario more difficult for companies to succeed. In this context, SCM became a very important practice for companies that want not only to keep in business but also have their results optimized and meet the clients' expectations.

Responsiveness in the supply chain has gained importance and it is a trend that apparently will dictate future decisions regarding supply chain design. According to [5] the themes that will have influence on logistics on the near future are:

- Strong corporate leadership will enhance logistics value through focusing on efficiency, effectiveness, and differentiation
- Value realization requires marketing of logistics capabilities within the company and to external customers
- Emphasis on the "scientific" aspect of logistics management in order to enhance the "art" of creating customers satisfaction
- Enhancing logistics value through integrating product, information, and cash flows for decision-making linking external and internal processes
- Logistics value enhanced by ownership of responsibility internally and externally to the firm
- Focus of successful companies is to create internal value for their organization and external value for their suppliers and customers

By those themes, it can be seen that SCM plays and will continue to play an active role in successful companies' routines. In order to achieve better results on the supply chain and better responsiveness to customers' necessities, new techniques such as real time inventory and dynamic supply chain have been developed.

2. Transportation in SCM

As a supply chain driver, transportation has a large impact on customer responsiveness and operational efficiency. Faster transportation allows a supply chain to be more responsive but reduces its efficiency. The type of transportation a company uses also affects the inventory and facility locations in the supply chain. The role of transportation in a company's competitive strategy is determined by the target customers. Customers who demand a high level of responsiveness, and are willing to pay for the responsiveness, allow a company to use transportation responsively. Conversely, if the customer base is price sensitive, then the company can use transportation to lower the cost of the product at the expense of responsiveness. Because a company may use transportation to increase responsiveness or efficiency, the optimal decision for the company means finding the right balance between the two.

The transportation design is the collection of transportation modes, locations, and routes for shipping. Decisions are made on whether transportation will go from a supply source directly to the customer, or will go through intermediate consolidation points. Design decisions also include whether multiple supply or demand points will be included in a single run or not. Also, companies must also decide on the set of transportation modes that will be used.

The mode of transportation describes how product is moved from one location in the supply chain network to another. Companies can chose between air, truck, rail, sea, and pipeline as modes of transport for products. Each mode has different characteristics with respect to the speed, size of shipments (parcels, cases, pallet, full trucks, railcar, and containers), cost of shipping, and flexibility that lead companies to choose one particular mode over the others. Typical measurement for transportation operations includes the following metrics:

- ***Average inbound transportation cost*** the cost of bringing product into a facility as a percentage of sales or cost of goods sold (COGS). Cost can be measured per unit brought in, but typically included in COGS. It is useful to separate this cost by suppler.
- ***Average incoming shipment size*** measures the average number of units or dollars in each incoming shipment at a facility.
- ***Average inbound transportation cost per shipment*** measures the average transportation cost of each incoming delivery. Along with the incoming shipment size, the metric identifies opportunities for greater economies of scale in inbound transportation.
- ***Average outbound transportation cost*** measures the cost of sending product out of a facility to the customer. Cost should be measured per unit shipped, oftentimes measured as a percentage of sales. It is useful to separate this metric by customer.
- ***Average outbound shipment size*** measures the average number of units or dollars on each outbound shipment at a facility.
- ***Average outbound transportation cost per shipment*** measures the average transportation cost of each outgoing delivery.
- ***Fraction transported by mode*** measures the fraction of transportation (in units or dollars) using each mode of transportation. This metric can be sued to estimate if certain modes are overused or underutilized.

The fundamental trade-off for transportation is between the cost of transporting a given product (efficiency) and the speed with which that product is transported (responsiveness). Using fast modes of transport raises responsiveness and transportation cost but lowers the inventory holding cost.

3. Information Technology and SCM

It is no surprise that IT played a big role in enabling many processes and ideas in SCM that seemed impossible prior to its inception. The first advance was the decreasing of inventory level by managers abandoning rules of thumb and adopting the setting of inventories based on service level desired and historical demand [7]. IT allowed the analysis of a great quantity of units and the process of recalculating the inventory level as the demand change. This ability made the companies more agile, while decreasing inventory levels and increasing service levels.

Another important fact that gave a great contribution to SCM was the Electronic Data Interchange (EDI). This technology allows the direct data interchange between companies using computers. EDI changed the relationship between the company and its customers, with its suppliers, and also with the employees. The ability of trading data almost instantly across the supply chain gave to companies the ability to manipulate more up-to-date information in a shorter period of time. This reduced the need for printing and transporting papers copies, enabled just-in-time practices, and helped to restructure logistics supply chain relationships. Together with EDI we can also mention the importance of the internet on global business by the electronic mail and the World Wide Web [4].

Artificial Intelligence Systems are responsible for many advances achieved by society and by SCM as well. Computers can be programmed in order to execute routine functions and according to the rules imposed to the computer it can be capable of behaving as an intelligent system that can execute complex activities in reduced time, and it is even capable of learning with its attempts during the time. This brought to logistics a much bigger capacity of processing information and executing tasks. Many activities such as some warehouse's department can operate without the human interference and this converges to a more responsive and accurate supply chain [4].

Some technologies, discussed later in this paper, can be used to make real-time adjustments to the supply chain. Those adjustments could be due to many events such as man power shortages or equipment breakdowns. For example, if a problem occurs to a truck or the roads conditions change due to weather, the system, supplied with this updated information, should be able to make the necessary corrections to the transportation routes of other trucks to compensate for the truck failure.

This system would be very useful for natural disasters such as Hurricane Katrina. With real-time information, the system would reallocate transportation and production to a place that would be the optimum solution. This kind of modeling would reduce the response time for such events from months or weeks to days or hours. This system can also be expanded to urban transportation within a city or long distances between two cities.

4. Real-Time Technologies

Radio Frequency Identification (RFID) and Global Positioning Systems (GPS) are emerging technologies that will allow for real time data collection to assist with decision support in SCM. RFID has a wide variety of applications. Some examples of RFID uses are library checkout stations, automatic car toll tags, animal identification tags, and inventory systems. Real-time data collected using RFID allows a supply chain to synchronize reorder points and other data. Real-time information can also be used to design and operate logistical systems on a real-time basis. GPS is currently used solely as a means to locate equipment and derive navigation directions.

An RFID system consists of a reader, tags and an air interface. The reader, also known as an interrogator, sends out a signal through an antenna. This signal is usually in the form of an electromagnetic wave. Because the signal is in the form of an electromagnetic wave, a direct line of sight is not needed to read the information on the tag. This is a major advantage of RFID. The signal is received by the tag and a response signal is sent back to the reader. This response signal contains a unique identifier associated with tag. The response signal can be powered in two ways corresponding to the type of tag. Passive tags utilize the energy of the original signal to send a response signal back to the reader. Passive tags have a limited amount of energy to power the response signal. Therefore, the amount of information transmitted by a passive tag is fairly small: quite similar to the information carried in a barcode. Active and semi-active tags use energy from an attached battery to power the response signal. The use of the embedded battery allows the response signal to contain more information and travel farther. The reader receives the response signal, decodes it, and sends that information to a database. Often the information in the response signal is connected to additional information in the database.

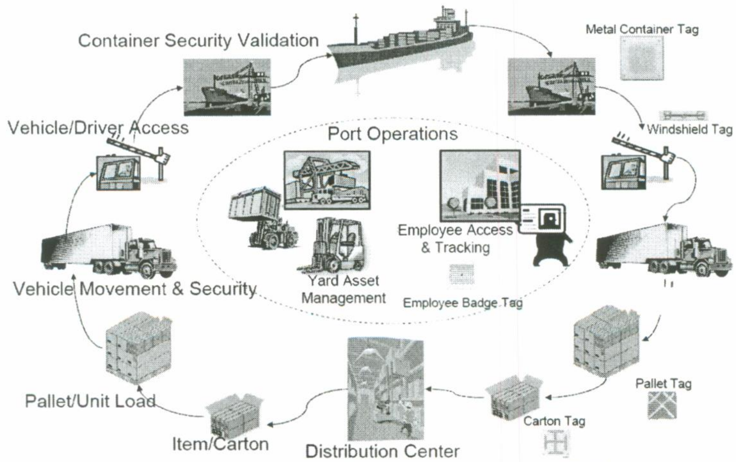

Figure 1: Integrated Supply Chain with RFID

RFID technology can be used throughout the supply chain in order to promote visibility. This visibility helps coordinate actions between entities in the supply chain. Figure 1 shows the relationships within the supply chain that can be affected by the implementation of the RFID technologies. An example of RFID implementation is the use of active tags for detecting tampering and monitoring security of maritime containers. Those types of tags also have the tracking advantages of RFID and can be used to improve operations management. Those tags can be seen on Figure 2.


Figure 2: RFID Container Seal

GPS systems consist of a series of satellites orbiting the Earth and receivers. GPS works by calculating the distances from a receiver to a number of satellites. With each distance between a receiver and satellite, the number of possible locations is narrowed down, until there is only one possible location. A receiver must calculate its distance from at least three satellites to determine a location on the surface of the Earth. However, four satellites are usually used to increase the location accuracy [2]. This process of location would be controlled by the positioning module of GPS system. An average GPS positioning and navigation system would also have the following modules:

- Digital Map Database
- Map Matching
- Route Planning and Guidance
- Human-Machine Interface
- Wireless Communication

There are three positioning technologies that can be used: radio wave based positioning, dead reckoning, and signpost. The use of GPS for navigation can have direct and indirect impacts on Intelligent Transportation Systems. GPS navigation systems can provide information about local surroundings. Also, emergency personnel can be provided with a precise location for situations, thus reducing response times.

Asset tracking is one of the most popular uses of GPS. One of the limitations of GPS is that receivers cannot communicate with satellites when indoors [3].

RFID and GPS are radio wave-based technologies that are currently used by many organizations. RFID is primarily used in inventory and material handling processes. Tags are placed on items. When these items pass by checkpoints where readers are located, the tag is read and the appropriate action can be taken. Real-time inventory can be kept by monitoring tag reads at strategic points like loading docks. RFID can also be useful in material handling. Items on a conveyor can be diverted at the appropriate times based on the information received from the RFID tag. GPS is primarily use to track assets such as vehicles and other expensive equipment. For example, if a truck breaks down, it is possible to locate the truck and get the shipment moving again in the fraction of the time it would take with a GPS receiver.

5. Future Technologies

Current applications of RFID and GPS systems have allowed for more effective tracking of inventory and assets. These technologies can be used in conjunction, but, the data has to be captured and written to a database to be correlated to other tags or receivers. If these technologies can be combined to produce hybrid systems, greater gains can be achieved. One focus of research is the nesting of GPS receivers and various RFID tag types. If tags and receivers were able to communicate with one another, even more accurate real time data collection could be achieved during transportation. This would also reduce equipment costs, because fewer readers would be required. The nesting would follow the form in Figure 3.

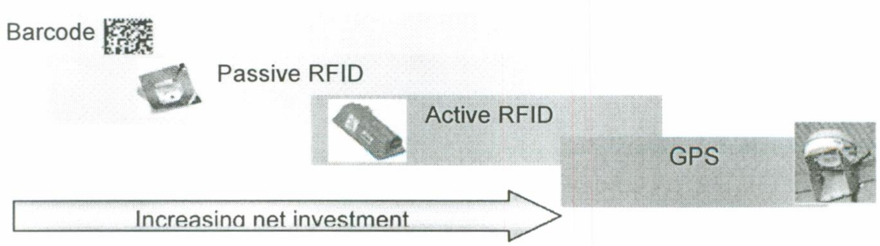

Figure 3: Nesting Diagram

If these technologies can be nested, it would allow the information in a barcode or a passive RFID tag to be collected by an active tag. This information could then be combined with the information contained within the active tag and transferred to a GPS receiver. The GPS receiver could then send not only its location but all of the information about the cargo being shipped [6]. A possible application of this nested technology approach would be in the railroad industry. Currently, there two passive RFID tags attached to the sides of all rail cars in the United States. In addition, most railroads are using GPS receivers to track locomotives. If nesting became possible, implementation would be easy in this case. Active tags could be used to capture the information correlated to the cargo in all of the rail cars and transmit it to the GPS receiver and thus to the inventory databases.

In addition to nesting technologies, more advanced tags can be developed to allow more detailed data collection. Tags that utilize sensors to capture and write data to the tag are being developed. Some tags have been developed, but are still very unreliable. These sensor tags could be used to monitor physical parameters, like temperature and humidity, as well as security parameters. The main problem faced by these passive sensor tags is the limited power supply. The sensor cannot use any energy while outside the range of the reader. Also, the amount of energy available while in read range is very small. This limits possible measurement techniques [8]. With these sensor tags, perishable goods could be monitored to guard against possible safety issues. This could include salmonella outbreaks caused by frozen chicken reaching too high of temperatures for too long and medications being held at temperatures that reduce potency.

6. Conclusion

Technologies are being used to allow real-time data collection. This allows for more dynamic SCM systems that are able to adjust to varying market and environmental conditions. RFID and GPS facilitate this dynamic supply chain management. RFID allows for up-to-date inventory levels, and when combined with GPS, can provide a means of tracking inventory as it moves from supplier to customer through the supply chain. New technologies are being developed to further the amount of information to decision support systems for SCM.

References

1. Chopra, Sunil, and Meindl, Peter. Supply chain management : strategy, planning, and operation. New Jersey: 2007, Pearson.
2. Dommety, Gopal, and Raj Jain. Potential Networking Applications of Global Postitioning Systems (GPS). Department of Computer and Information Science, The Ohio State University. 1996. Jan. 2007 <http://arxiv.org/abs/cs.NI/9809079>.
3. Feng, Shaojun and Law, Choi Look. “Assisted GPS and Its Impact on Navigation and Intelligent Transportation Systems.” IEEE 5th International Conference on Intelligent Transportation Systems. 926-931.
4. Johnson, J. C., Wood, D. F., Wardlow, D. L., and Murphy, P. R. Contemporary Logistics. New Jersey: 1999, Prentice Hall
5. Novack, A. R., Langley Jr., J., and Rinehart, L., M. Creating Logistics Value: Themes for the Future. Oak Brook: 1995, Council of Logistics Management.
6. Reade, Walter, and Jeffrey D. Lindsay. "Cascading RFID Tags." IP.Com (2003). Jan. 2007 <http://www.jefflindsay.com/rfid3.shtml>.
7. Shapiro, Jeremy F. Modeling the Supply Chain. Belmont: 2007, Thomson.
8. Want, Roy. "Enabling Ubiquitous Sensing with RFID." Computer 37 (2004): 84-86. IEEE Xplore. Jan. 2007.