# Fighting Friction

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## INTRODUCTION

Currently under development at MIT, Auto-ID technology holds great promise to solve age-old problems in material control through the application of low-cost, Radio Frequency Identification (RFID) tags. By placing RFID tags on individual items, cases and pallets, along with readers at strategic points within the supply chain, Auto-ID technology will provide instant two way communication by merging information with physical goods. Auto-ID technology also incorporates the Internet as a means of transmitting data gathered from RFID tags, combined with a new communication protocol called PML (Physical markup language).

RFID technology has been in use for approximately thirty years in the defense and transportation industries, where "active" RFID tags and proprietary systems are in place. Most of these applications involve different types of capital asset tracking and management. For example, rail cars and steamship containers are tracked through switching rail yards and holding terminals at ports. Each active tag requires a small battery that provides electric power to generate and transmit the radio frequency signal. Active tags can be read from a relatively long range—up to 30 meters. However, the greater the scanning distance, the greater the chance of a "frequency collision." Also, with longer read distances, the opportunity of providing exact location information diminishes. The tiny batteries are moreover somewhat expensive, thus limiting widespread use. Common prices for active tags range from $2 or more per unit, depending on capability and order size.

Since 1999, MIT has conducted research to drastically reduce the cost of Auto-ID technology through the use of "passive" tags. With this technology, each tag does not contain a battery. Rather, the energy needed to power the tag is drawn from electromagnetic fields created by readers that also serve a dual purpose of gathering the signals emanating from the passive tags. Since no fixed power source is required, passive tags hold a great advantage over active tags in terms of lower cost per unit. This opens the possibility for the use of passive tags in a far greater number of applications. Gradually, as costs decrease, passive tags will selectively replace bar codes as a means of gathering information within supply chains. The goal is to produce a passive tag for less than 5 cents per unit. At this cost, passive tags are feasible for widespread application within a number of industries, including high volume consumer goods manufacturing. Items such as razor blades, batteries and perfume, all with high selling prices, are excellent candidates to utilize passive RFID tags for inventory control and theft prevention.

The MIT Auto-ID Center currently has financial support from 83 leading manufacturing and technology/equipment firms to research, develop and test passive tags for a number of RFID applications. Field test results completed during winter 2002, involving Wal-Mart, Proctor & Gamble, Gillette and Unilever, demonstrated that passive tags, along with the Internet infrastructure to handle data, worked as envisioned. These field tests dealt with pallet and case identification; however, other tests have shown that passive tags applied to individual items on store shelves also can be successfully read under laboratory conditions. Ongoing efforts involving more intensive field tests are planned for 2003 and will include scanning of tags placed on individual items made of metal or containing liquids. In summary, passive RFID works. Though the economics of passive tags are not fully understood at this time, the future looks bright for application of this technology to improve supply chain performance.

With passive RFID capability, a number of supply chain tasks can be automated to speed the flow of inventory and provide better service to customers.

For example, it is common that workers reconcile shipments against bill-of-ladings, packing and pick lists by using physical counts and manual data entry. Having humans perform these tasks causes friction at transition points within the supply chain leading to errors and slower processing times. By removing friction points through the use of passive tags, firms will better serve their customers with quicker, more accurate orders. Delivering superior service creates customer loyalty and eventually contributes to increased profit and market share. For the future, Auto-ID technology holds great potential in reducing supply chain friction.

The need for accurate, real time data about products in the supply chain is particularly important in the Consumer Goods (CG) industry. Many gains from improved manufacturing methods have been achieved, so CG companies are now looking to their supply chains for cost reduction. The CG industry moves large volumes of many different products through complex supply chains that often span great distances. To keep track of these movements, bar codes are currently used in distribution centers to track inventory and at the retail stores for faster checkout.

Despite the great success and widespread use of bar codes, it is becoming clear that the CG industry needs more specific information than what bar codes can provide to better manage the flow of goods. Additional information might include:

1. Complete bill-of-lading information attached to each item.
2. Manufacturing details, lot, plant and quality information for each item.
3. Technical aspects of the product, including proper usage.
4. Dynamic information, including temperature, humidity and vibration.

Though two dimensional bar codes do provide detailed information beyond product identification, all bar codes have limitations including a) the need for a direct line of sight from the scanner to the bar code, b) the ability to read only one code at time, and c) bar codes often require human intervention to capture data or to properly orient packages in the case of overhead bar code readers. In addition, bar codes provide only one-way communication and manufacturing systems are typically only updated on a batch basis. Bar codes seldom provide real time information or Internet connectivity to the data. There is always a chance the bar code will be missed or in other cases, read twice. Also, bar codes can be damaged or compromised in a way that makes them impossible to read. Auto-ID technology is designed to overcome all of these limitations and make it possible to automate the scanning process, providing real-time data.

**HOW AUTO-ID WORKS**

According to Professor Sanjay Sarma, research director of the MIT Auto-ID Center, a passive RFID tag has four components, the integrated circuit (IC), the antenna, the connection between the IC and the antenna and the substrate on which the antenna resides. The current cost for such a tag is about 50 cents per unit. However, manufacturing techniques being developed at MIT and in industry, offer the prospect of continuous manufacturing of tags using vibratory methods or fluidic self assembly (FSA) to place individual transistors onto the IC. Research shows that these manufacturing innovations, along with economies of scale and learning curve effects, will drive the cost for passive tags well below the current 50 cents per unit. In addition, new ways of producing antennas using conductive ink printed directly on packaging such as corrugated boxes, will contribute to the goal of a 5 cent per unit tag.

Alien Technology, employing FSA methods licensed from the University of California, Berkeley, is currently producing passive tags on rolls, similar to label production. The company is working with several partners to develop methods of automatic tag application to cartons. Recently, Philips Electronics announced a multi-year plan to produce billions of passive tags, starting in 2003, with vibratory methods and a "package" technique for connecting the IC to antennas. These, as well as other vendors such as Matrics, Inc. are taking the lead in producing the first commercial quantities of passive tags.

Besides mass-producing passive RFID tags, technology vendors are also focusing on reducing the cost of readers to the range of $100 to $200 per unit. Current projections call for this price point to be reached for an individual order of 10,000 readers. In addition, companies such as Matrics, Inc. and Savi Technology have developed special antennas that extend the capabilities of readers. With multiple antennas for a single reader, the effective scanning range for each reader is substantially increased. This reduces the number of readers needed to cover an area.

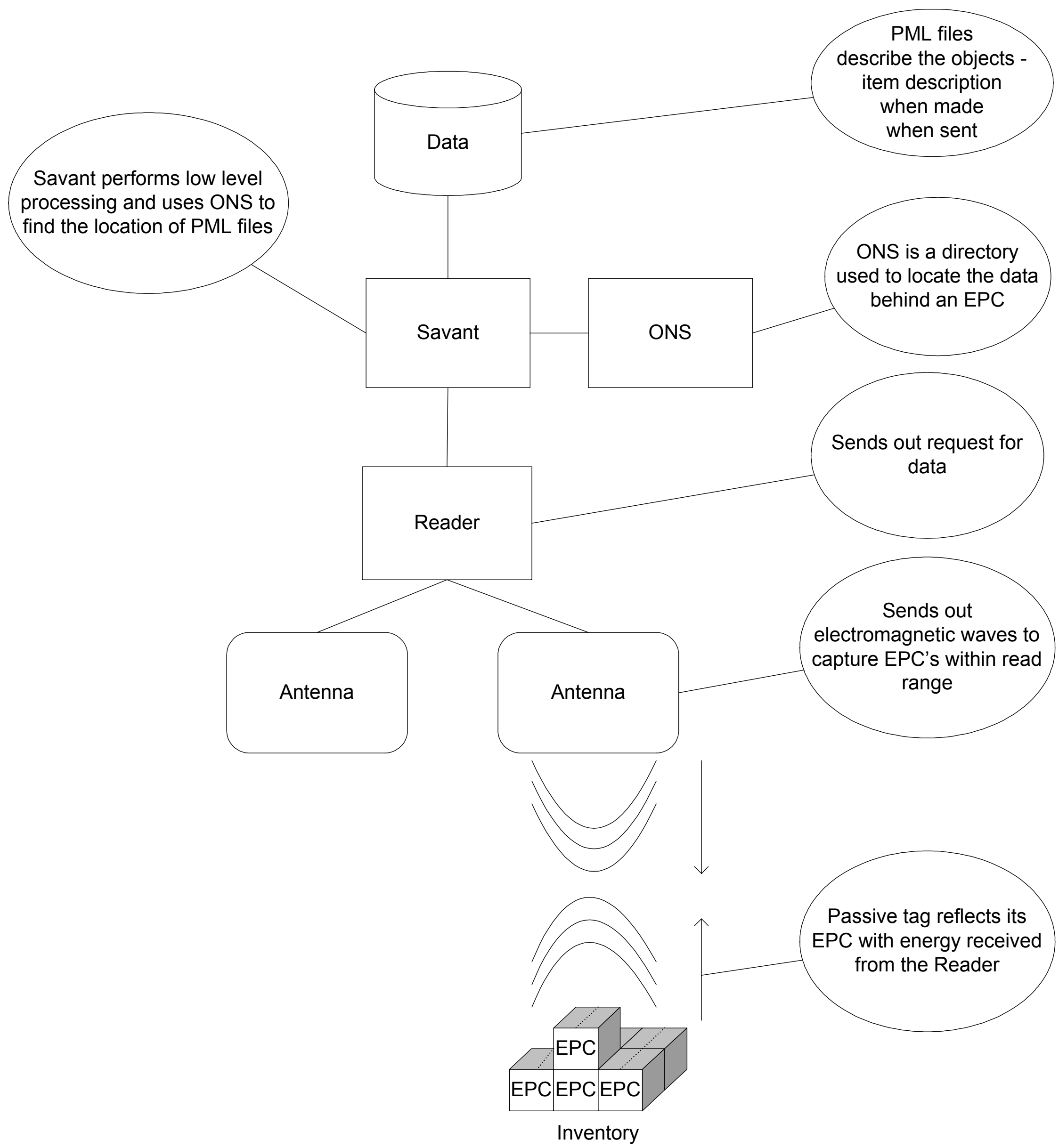
In conjunction with these advances by tag and equipment manufactures, the objective of the MIT Auto-ID Center is to create infrastructure and set open standards that will make it possible for wide adoption of passive RFID technology by industrial firms and US government agencies. The Center is defining, researching, and developing four components that make up Auto-ID Technology:

- ePC (electronic product code)
- ONS (object naming service)
- PML (physical markup language)
- Savant (data handling)

The ePC is a numbering system that contains enough combinations to identify trillions of objects. This is necessary because the ultimate goal of the MIT Auto-ID Center is to provide a structure for low cost identification at the item level, meaning every single product will have its unique code. PML is the communication format for the data and it is based on XML (extensible markup language) that is gaining popularity in eCommerce transactions. PML represents a hierarchal data format to store information. By having a standardized means of describing physical objects and processes, PML will facilitate inter- and intra-company commercial transactions and data transfer. ONS acts as a pointer to connect the EPC to the PML file stored on a network, either a local area network or over the Internet. It performs a similar function to the Domain Naming Service (DNS) of the Internet, which connects a text web address to an underlying IP address. An IP address is comprised of a 32-bit numeric address written as four numbers separated by periods, to find resources over the Internet. However, with the ePC, we start with a number and use ONS to find the product information linked to that number. Savant is a lower level software application that processes the data and performs error checking and de-duplication procedures in the event that more than one reader receives a signal from the same tag. It handles the scalability problem associated with the massive amount of data captured by Auto-ID. To summarize, the ePC identifies the product, PML describes the product, and ONS links them together.

To make the system work, products are tagged with passive RFID chips containing the ePC. The tags are placed on surface areas of pallets, cartons or contained within item packaging. Readers are positioned at strategic points throughout the supply chain where companies need to capture data. Readers constantly emit an electromagnetic field that is received by the tags through a small antenna. This energy activates the tag, and in turn, a signal is generated and transmitted to the reader. Through this process readers capture the ePC and interact with a Savant to look up the information on the product using ONS. The position of the reader receiving the ePC signal provides important information on location, and environmental conditions such as temperature, vibration and humidity, which is then linked through databases to the ePC. All this information is housed and written to corporate databases using the PML format. (See figure 1 – Technology Overview)

**Figure 1 – Technology Overview**



## EFFICIENT HANDOFFS IN ORDER FULFILLMENT

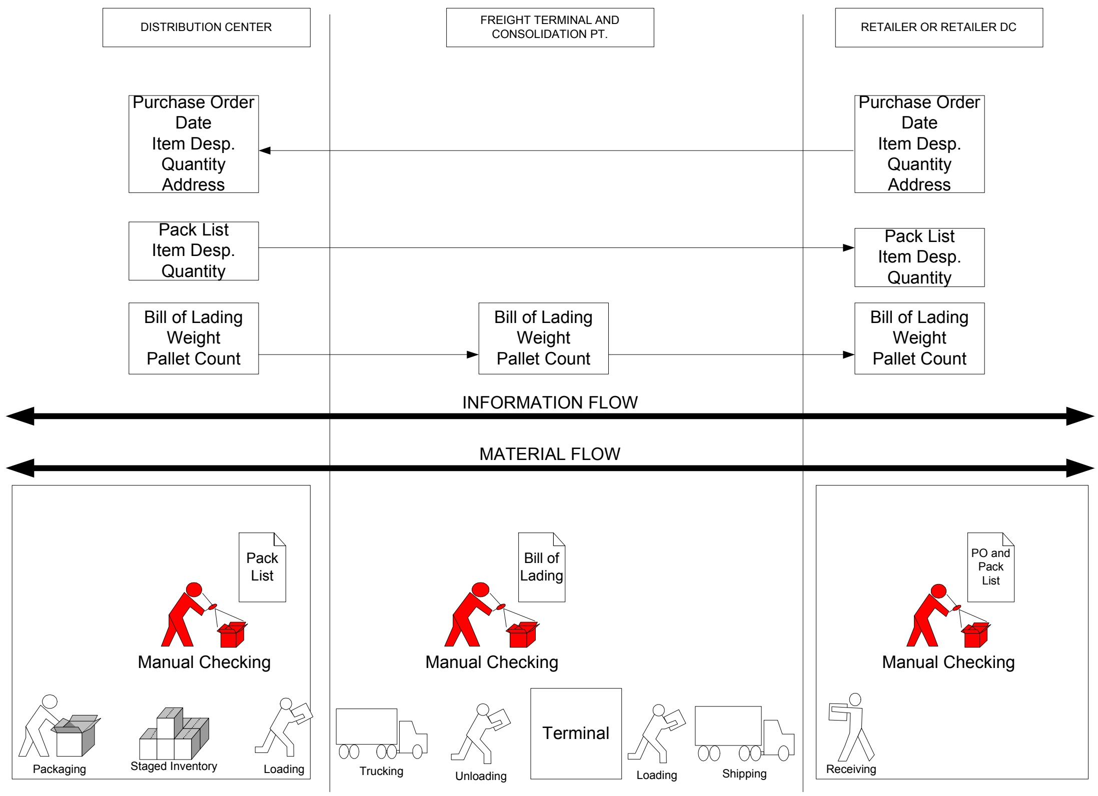
By looking at a typical order delivery processes, we can explore how Auto-ID will impact the supply chain. In shipping customer orders, goods are constantly transferred from one stopping point to the next. For example moving inventory:

- From a distribution center onto a truck.
- From the truck into a trucking terminal.
- From the trucking terminal onto another vehicle for transport to the retailer or retailer's distribution center.

At each transfer point, personnel perform a series of counts and documentation tasks. These tasks have two components that affect the supply chain. The first is a labor cost, because humans are needed to perform these tasks. This introduces the risk of error and exposure to loss through theft. The second disadvantage of manual processes is the friction it causes in slowing down the flow of goods. Each time a worker must manually check and record data to process an order impedes the movement of goods. Thanks to ERP systems, the data that supports the material flow is in digital form. With Auto-ID, data about materials location and condition is also captured in digital form. This capability allows companies to compare the results of the information and materials flow in real-time. Using Auto-ID Technology, the goods are passed near a scanner to verify the type and quantity before loading into truck or railcar. The results are compared against the packing list generated from a purchase order. Users can then determine whether the shipment exactly matches the packing list. If not, the system can automatically alert the distribution center staff about the discrepancy. Since Auto-ID technology doesn't rely on a direct line of sight to capture information, as is the case for bar codes, the labor involved in rearranging and orienting goods for scanning is eliminated. By decreasing the number of times inventory or shipments are manually verified, the manufacturer can increase supply chain velocity. Looking at a sample consumer goods company that was the subject of case study research at MIT, the time spent checking goods and reading bar codes, at just one distribution center, was over 11,000 hours per year. Auto-ID would eliminate the need for these manual procedures.

The process of counting, checking, and reconciling the goods does not stop at the manufacturer's distribution center. These tasks are repeated many times before goods arrive on retail shelves. For less than truckload shipments, goods are typically sent to a consolidation hub. Here the goods are removed from one truck and staged with other items. The new combination of goods is then loaded onto another truck for transport to either a retailer or a retailer's distribution center. Each time the goods are moved at the trucking terminal the trucking company performs a count for confirmation of the bill of lading. There is also a packing slip and freight record for each order placed on a truck that must be reconciled. During the consolidation process there is constant risk that the goods will be left behind or loaded onto the wrong truck. This results in lost inventory and poor customer service to retail outlets through late and incorrect deliveries. (See Figure 2 – As-is Process Flow)

Figure 2 – As-is Process Flow

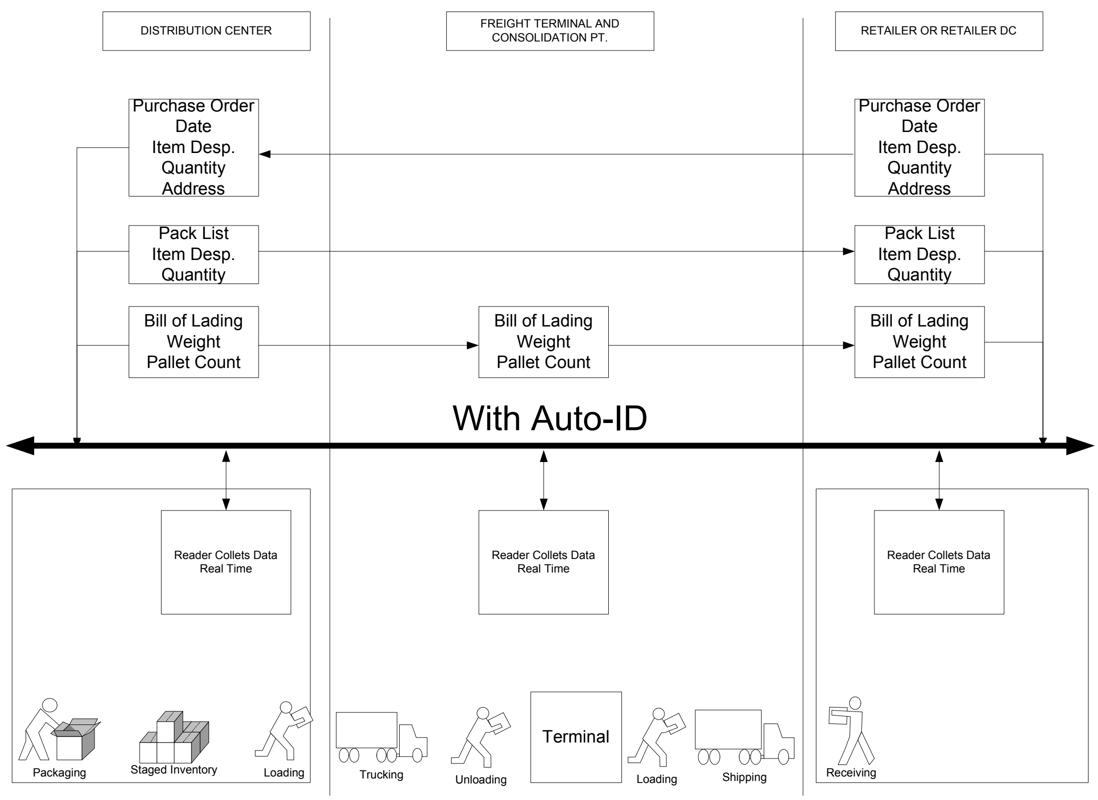



## The Auto-ID Process

By installing Auto-ID systems, companies can quickly count goods when they are ready for shipment, eliminating the need for manual counts. Manual counting and verification is purely an error reduction process that adds no value. With Auto-ID companies can quickly and accurately trace an item anywhere in the supply chain as long as there are readers to detect its presence. By knowing the location of the reader, we can infer the location of the item located within the reader's range, which is about three meters. For example, several readers could be situated on loading docks near truck bays. As forklifts move goods into trucks, the readers' could automatically scan and record the amount loaded. Orders can be instantly checked to ensure that the shipment has the right products and the right quantity. Auto-ID surfaces the problem of shipping the wrong unit or incorrect quantity of goods at the point of origin rather than at the end. By having the confirmation at each step, errors in shipments are caught along the way, when they are cheaper to remedy.

Auto-ID simplifies the process and reduces the supporting documentation required to fulfill an order. This reduces the chance that a document will be misplaced or forgotten altogether. The instant verification along each major transition point can locate where along the process the order was compromised. Manufacturers thus gain the leverage they need to bill correctly and reconcile disputes at each point in the supply chain. By automating these tasks, companies reduce friction in the supply chain. The goods are flowing faster, thus reducing the order cycle time and allowing for faster inventory turns and better customer service. (See Figure 3 – Auto-ID Process Flow)

Figure 3 – Auto-ID Process Flow




## UPC COMPARISON

Auto-ID is embarking on a similar path that the Grocery Industry faced when proposing the implementation and use of bar codes over 25 years ago. The Universal Product Code (UPC) or bar code is currently the most widely adopted means for gathering information about products in the supply chain. When first implemented, bar codes had to be justified based on a cost-benefit analysis. The Grocery Industry Ad Hoc Committee, comprised of leaders in the industry, made an assessment of the hard savings in order to sell the technology. Formed in August 1970, the Committee was charged with the task of determining the economic potential of the UPC and anticipating possible roadblocks the grocery industry would encounter during implementation. The MIT Auto-ID Center is currently running through a similar set of tests in order to justify its vision and value in the marketplace.

## CONCLUSION

Auto-ID is a promising technology that will take identification and data capture to a new level of automation. Auto-ID overcomes some the restrictions of bar codes, which require human intervention and cause exposure to error. Auto-ID reduces the labor costs associated with reading the codes and automates many supply chain processes.

By using Auto-ID, companies will not only save on labor costs, but will also reduce errors and remove friction that results from manual processes. Removing friction points in the supply chain will allow CG manufacturers to better serve their customers with correct orders and faster delivery. Providing superior customer service creates loyalty on the part of customers and eventually contributes to profit and market share.

While Auto-ID is still in the early stages of development, we believe that selective commercial applications will begin to replace bar codes within five years. Long-term, perhaps in the next 10 years, Auto-ID technology will take conventional business processes to a higher level of automation than what current technologies permit. Early adopters can gain strategic advantage over competitors who are less willing to accept the risks of inevitable change.

The overall development of Auto-ID Technology is intertwined with industry adoption of open standards. In a move designed to promote open standards, MIT recently announced that all intellectual assets from the Auto-ID Center will be licensed to the UCC. With a strong record of achievement, the UCC will work to establish open standards for Auto-ID applications. This will accelerate the use of Auto-ID Technology in practice.

Additional information about the MIT Auto-ID Center, including research papers, can be found at http://www.autoidcenter.org/main.asp

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