AUTO-ID CENTER

WHITE PAPER

Prediction, Detection, and Proof:
An Integrated Auto-ID Solution to Retail Theft

Robin Koh, Edmund W. Schuster, Nhat-So Lam, Mark Dinning

ABSTRACT

Theft is a serious problem in North America costing retailers and manufacturers at least $25 Billion per year. For the past ten years, there has been no change in the rate of theft. This lack of improvement traces in part to current technologies that are not fully integrated. Auto-ID lays the foundation for developing applications to predict, prevent, detect and resolve theft within the supply chain; providing a comprehensive solution. Practical applications of the technology will occur within the next five years. These first steps will lead to other applications of Auto-ID including efficient transfers between companies and the reduction of diversion.

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Biographies

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Robin Koh has over 12 years of supply chain industry experience in North America, Europe and Asia. He has held Director positions at Arrow Electronics and Pepsi-Cola International. He has a Bachelors in Industrial Engineering and Operations Research from the University of Massachusetts at Amherst, an MBA from the Tuck School of Business at Dartmouth College and a Masters in Engineering from the Massachusetts Institute of Technology.

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Edmund W. Schuster has held the appointment of director of the Affiliates Program in Logistics at the Massachusetts Institute of Technology and is currently working on MIT Auto-ID projects. Before MIT, Ed spent 20 years in the food industry working for Welch's and Oscar Mayer in various corporate logistics and operations management positions. He has a Bachelors of Science in food technology from the Ohio State university and a Master of Public Administration, emphasis in management science, from Gannon University. Ed is a fellow of the American Production and Inventory Control Society.

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Biographies

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Mark Dinning

Mark Dinning is in the Supply Chain Engineering Group at Dell Inc. He has a Masters of Engineering in Logistics from MIT and his undergraduate degree in Business Economics from UCLA. Prior to Dell Inc. and MIT, Mark was one of the original employees at Tickets.com. He began his career at Deloitte & Touche and is a Certified Public Accountant.

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1. INTRODUCTION

Theft is a serious problem for North American retailers and manufacturers. It costs at least $25.0 Billion per year (see Appendix A). Theft levels have remained constant at about 1.1% of sales during the past decade. This ongoing cost directly reduces net income dollar for dollar. For every stolen item with a profit margin of 10%, revenues must increase by 10 times the amount of the theft to recover the net income lost (Albrecht 2001). Few firms can ever hope to recover these losses through higher sales volumes or price increases. The Retail Industry needs an effective solution to this continuing problem.

Theft is part of the broader category of shrinkage and it is hard to quantify. Firms routinely collect information on total shrinkage through careful measurement of inventory adjustments. This provides some insight into the extent of theft. However, inventory adjustments also include other losses resulting from process failures, spoilage, accounting errors, and vender fraud. Few firms know precisely the amount of theft that occurs within the supply chain. Consensus estimates put theft as high as 75% of total shrinkage.

2. RESEARCH PURPOSE

This paper analyzes both internal and external theft within the supply chain in addition to technological methods for controlling theft. The discussion concentrates on the implementation of Auto-ID technology as a means of predicting, preventing, detecting, and providing proof of theft. High value items that are compact in size, easy to conceal, not immediately perishable and with high resale value are the focus of this paper. Examples include videos, CD's and DVD's, cigarettes, health and personal care products, electronic equipment, alcoholic beverages, books, and clothing.

Besides direct monetary loss, theft affects firms in other more subtle ways. The next section highlights a few of these affects.

3. THE INDIRECT IMPACT OF THEFT ON INDUSTRY

3.1. Physical and Perpetual Inventory Synchronization

When theft occurs, perpetual inventory systems get out of synchronization with physical counts. Inventory records are inflated because there is no accounting transaction for goods improperly removed from manufacturing plants, warehouses, or stores. This is particularly important because many Enterprise Resource Planning (ERP) systems use a perpetual inventory method called "back flushing." With this technique, inventories are adjusted based on a transaction. Comprehensive physical counts occur only once or twice per year to verify the calculated inventory level.

Given this type of system, theft causes inaccurate inventory records that may be in error for many months. The cumulative effects are devastating to customer service because many stores and warehouses depend on continuous replenishment systems, and accurate inventories, to maintain stock levels for thousands of items (Raman 2001). Out-of-stocks are a particular concern to retailers. According to a recent study, nearly 23% of consumers leave a store immediately in response to an out-of-stock (Zinn and Liu 2001). No retailer can afford this loss of business.

3.2. Pushing Responsibility Downstream

Retailers are requesting development and manufacture of "theft proof" items. This may involve expensive packaging modifications to make stealing more difficult. Many retailers also ask that manufacturers make investments in store fixtures such as locked cabinets in an effort to reduce theft.

This is consistent with the gradual trend in industry toward supply chain integration. Retailers are shifting more responsibility for many aspects of store operations downstream to the suppliers, including such practices as vendor managed inventory and category management. Theft reduction follows this trend.

For example, manufacturers often attach electronic article surveillance (EAS) tags to products and packaging during production (source tagging). Each retailer currently uses proprietary systems for EAS tags. Since no universal standards exist, source tagging results in an exponential increase in Stock Keeping Units (SKU) adding considerable complexity, and cost, to managing inventory.

Finally, a recent trend exists toward consignment sales where manufacturers receive payment from retailers upon scanning at checkout. In this situation, the manufacturer will absorb all retail theft losses occurring in warehouses or stores prior to actual purchase by consumers. With no integrated program for theft control, the policy of consignment sales has substantial and immediate negative impact on the profit margins for manufacturers.

For all these reasons, understanding and controlling theft across the entire supply chain will become important for manufacturers and retailers alike.

3.3. Defensive Merchandising

Besides operational impacts such as inventory accuracy and consignment sales, theft also causes indirect constraints to merchandising. Retailers often limit the number of items on display to control theft. This practice is termed "defensive" merchandising. Some retailers go farther and do "restrictive merchandising" by placing goods behind counters or using locked display booths. In this case, retailers will leave a dummy package or sign on the shelf directing customers to the sales counter for eventual purchase. While these two policies prove effective in reducing shelf stock loss from theft, each method also limits sales because customers must request assistance to make a purchase.

Theft is not just an issue of financial loss but often the tactics involved in controlling theft place burdensome constraints on business operations. Retailers cannot ignore the huge positive impacts of removing specific constraints such as restrictive access or defensive merchandising.

4. CHARACTERISTICS OF AUTO-ID TECHNOLOGY

In developing an approach to combat theft, it is important to highlight a few characteristics of Auto-ID technology that provide unique anti-theft capabilities. For specific detail on the various components of Auto-ID, please refer to Engels et al. (2002).
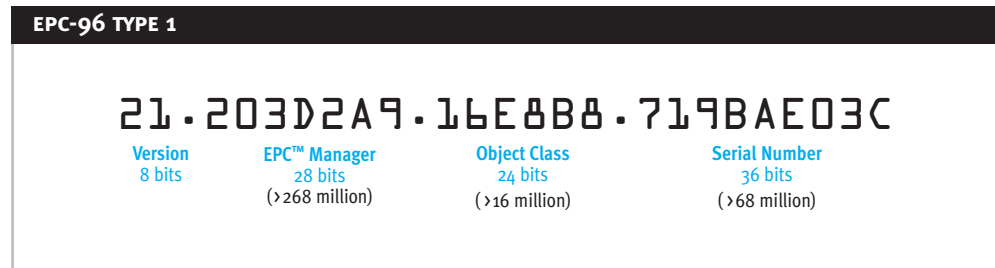
4.1. No Line Of Sight Identification

One of the primary advantages of Radio Frequency Identification (RFID) technology is that it does not require a direct line of sight between the reader and the tag. The RFID reader is capable of communicating with a tag through optically inert mediums such as the package containing the product or even the product itself. This is in contrast to barcodes that require unobstructed alignment with a reader.

4.2. Mass Serialization

The Electronic Product Code (EPC™) permits the assignment of unique serial numbers to identify discrete manufactured objects and object aggregates (e.g. secondary packaging, pallets etc.).

There are seven standard versions of the EPC™. The 96-bit version is the most frequently discussed in the RFID literature. Below is an example the EPC-96 Type 1 in hexadecimal format:

Figure 1

EPC-96 TYPE 1

21.203D2A9.16E8B8.719BAE03C

Version	EPC™ Manager	Object Class	Serial Number
8 bits	28 bits	24 bits	36 bits
	(>268 million)	(>16 million)	(>68 million)

Regardless of the EPC™ version employed, the primary goal of this new numbering system is to ensure that any manufactured object can have a unique identifier. The identifier is very important. It not only provides ubiquitous unique identity to the item but is also a key to access data on a network about the object.

4.3. Real-Time Visibility

EPC™ Tags along with the Auto-ID information infrastructure provide the capability to monitor objects moving through the supply chain in real time. This enables companies to account for inventory at all locations. As a result of open standards, Auto-ID is designed to integrate with other technologies, such as closed circuit television (CCTV) and motion detectors, to provide security staff with information as crimes transpire.

4.4. Track

Together, Auto-ID capabilities such as mass serialization and real-time visibility allow detailed tracking within the entire supply chain. Tracking is defined as maintaining control on a particular object going forward in time. An example of maintaining control is the process of pre-positioning information during the execution of a transaction like the Advanced Shipment Notice. The EPCs™ of a shipment can be sent in advance to the receiving company. When the goods arrive, the EPCs™ are checked off the advance list. Missing, different, or excess EPCs™ are then investigated.

4.5. Trace

Besides tracking, Auto-ID also provides unique capability to do tracing within the entire supply chain. Traceability, used interchangeably with the term "pedigree," is the ability to build the supply chain history for a uniquely identified object, i.e. location, ownership, telemetry etc. This may involve accessing data in distributed databases across a number of companies. The PML Service/Server is an important component of this tracing capability.

The following table summarizes the various characteristics of Auto-ID that pertain to anti-theft applications and the components of Auto-ID that enable these characteristics:

Table 1: Relevant Characteristics of Auto-ID for Anti-Theft Solutions

	TAG/READER	EPC	ONS	SAVANT	PML	PML SERVER
No Line-of-Sight Identification	✓					
Mass Serialization		✓				
Real-Time Visibility	✓			✓		
Track		✓	✓	✓	✓	✓
Trace		✓	✓			✓

5. A CONCEPTUAL MODEL FOR THE ANALYSIS OF THEFT

The advantages of Auto-ID technology open many possibilities for anti-theft applications in retail stores and manufacturing firms. However, before exploring specific Auto-ID applications, a conceptual model of the process of theft is needed to guide thinking about the appropriate use of the technology.

5.1. Before Theft

For a number of safety and legal reasons, it is best to detect, predict, and deter theft as oppose to dealing with theft when it is already in progress. Detection occurs through a combination of human intervention, such as store personal on the floor, in addition to various detection and monitoring technologies, like closed circuit televisions (CCTVs) and Auto-ID technology. Auto-ID shows great predictive potential through the ability to monitor the sudden disappearance of a number of tags from the reader field and the ability to flag unusual patterns of product movement.

Prediction of theft allows the option of enabling deterrence measures. This might be in the form of a Light Emitting Diode (LED) display that acknowledges the person and the quantity they have taken from the shelf/location. This can act as reinforcement to posted signs, directed at potential thieves, that warn of a closely monitored shelf.

Auto-ID is most effective as a theft predictive and deterrence measure when combined with other anti-theft sensing devices. The various components of the technology provide a dynamic platform to integrate different measures over time. The changing nature of the application will make it more difficult for thieves to game the system.

5.2. During Theft

When theft is in progress, detection can occur through a combination of human observation and the use of technologies like Electronic Article Surveillance (EAS), CCTV, and Auto-ID. Auto-ID's shelf monitoring capabilities could trigger attention to monitor suspicious activity through CCTV or possibly dispatching store personnel to a potential theft in progress. In most cases, conclusive detection of theft takes place only after departure through a checkout counter or exit.

5.3. After Theft

In spite of comprehensive security measures, there are situations where thieves will succeed in stealing items. At this stage, Auto-ID's EPC™ and trace capabilities help law enforcement authorities to prove the pedigree of a particular item that might be sold in secondary or black markets. This helps in proving if an item was legally purchased, including status – returned, recalled etc. This ability to determine the status of a particular item could potentially lead to the disruption of the goods to cash conversion cycle for stolen merchandise. Over time, this should reduce the incentive for professional thieves.

The following diagram summarizes the three stages of theft:

Figure 2

THREE STAGES OF THEFT
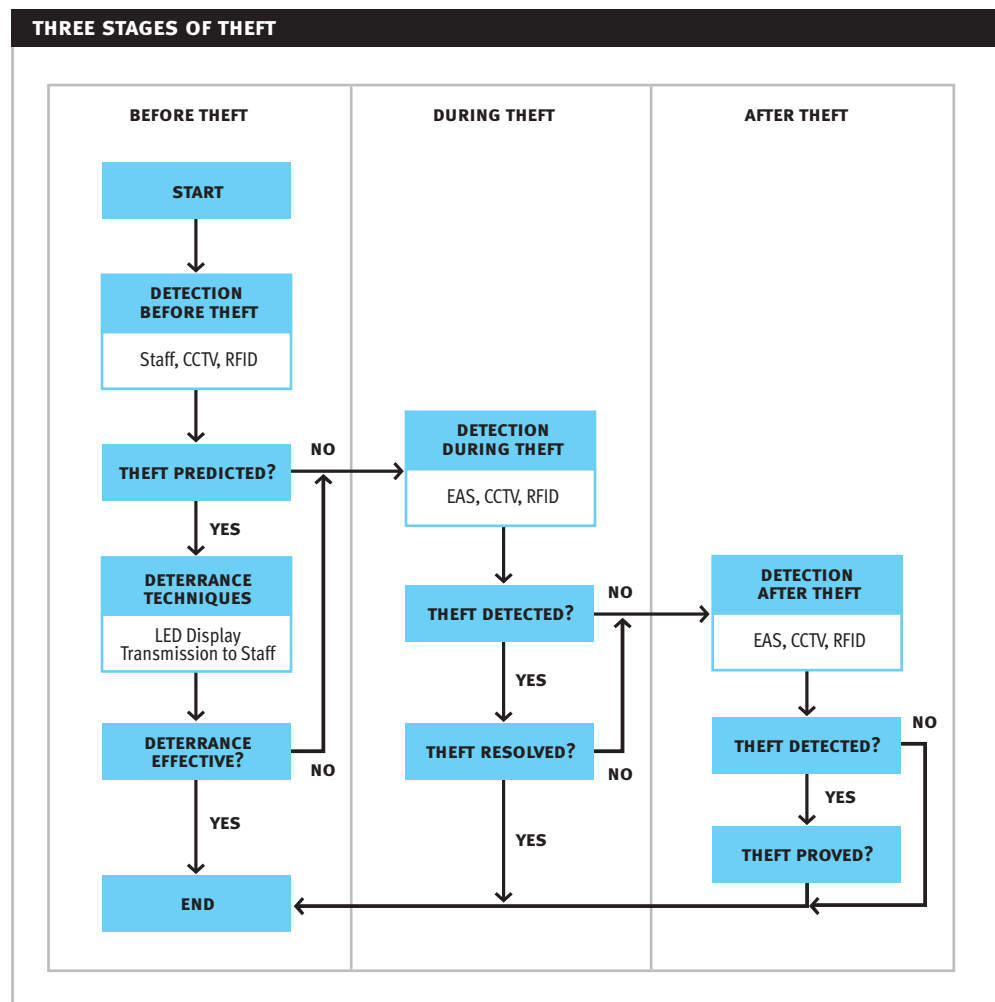
6. AUTO-ID AND DIFFERENT TYPES OF THEFT

According to a previously published study, eight percent of all store customers shoplift merchandise while over 50 percent of employees at retailers steal from their employers (Baumer and Rosenbaum 1984). In spite of these statistics, local police often consider shoplifting and internal theft soft crimes. Typically, theft from stores or warehouses is non-violent, in contrast to other crimes such armed robbery. With scarce resources, law enforcement authorities place a higher priority on solving crimes that are more serious. For this reason, the control of shoplifting and internal theft is by default the direct responsibility of retailers and manufacturers (French 1979).

Few firms employ an integrated solution for theft reduction that includes real-time information on movement of goods through their entire supply chain. A recent study states, "at best company information on this problem (theft) is partial and incomplete and at worst, it is non-existent (Beck 2001)."

To reduce theft it is necessary to have information about the scope and size of the problem. Auto-ID provides granular data to help determine 1) where along the supply chain theft occurs, 2) when it occurs and 3) how it occurs. This is an important first step in identifying the scope of the problem.

The remaining subsections study the applicability of Auto-ID to prevent specific types of theft. Each known type of theft fits in the classification model appearing in Figure 1.

6.1. Prediction (Before Theft)

Theft Prediction is possible with Auto-ID because it uses RFID in conjunction with the Savant™ to recognize patterns in real time and trigger deterrence measures. To be effective at theft prediction, the readers have to communicate with the EPC™ tags, feeding a constant stream of real time data to the Savant™. This type of monitoring is effective in combating three important types of theft.

6.1.1. Open Pack Thefts
Open pack theft occurs when thieves remove primary packaging from items before taking the item from the facility – e.g. retail floor, backroom, or warehouse. Theft prediction is possible at the shelf if the thief removes tagged items from the reader field, and the Savant™ senses the disappearances. Package design plays a fundamental role in enabling Auto-ID to sense this type of theft. Designs currently exist making it impossible to remove packaging without disabling the antenna, causing the signal to be lost. Another method to combat this form of theft is to mount the EPC™ tag on the item itself as oppose to the primary packaging. This ensures that the tag can be read all the way to the checkout area.

6.1.2. Sweep Theft
This type of theft occurs when a thief "sweeps" a shelf, taking large quantities of products at once. By placing readers on shelves, Auto-ID can detect abnormal item activity. With real time detection, Auto-ID can electronically alert the appropriate personnel within the store or facility whenever large numbers of items disappear simultaneously. On the retail floor, the Savant™ can be used to trigger an information display so that the would-be thief would know that their actions are being monitored.

6.1.3. Disabling Tags
Thieves employ several methods to disable anti-theft tags, including the application of a strong magnetic field close to the tags or by shielding items in a metal of aluminum foil-lined bag.

Smart Auto-ID retail shelves can combat this shoplifting method by constantly monitoring the items and detecting suspicious activity through the sudden absence of tag signals.

Another disincentive for thieves to destroy Auto-ID tags is the removal of the item's legal identity. Like the destruction of a person's Social Security number in the United States, this will mean the item cannot be re-sold in the legal retail supply chain thus diminishing its value. Essentially, the item becomes "counterfeit."

6.2. Detection (During Theft)

In the event that predictive and deterrence, measures are ineffective, Auto-ID is able to enhance detection of theft. For detection, all components of Auto-ID, including RFID, EPC™, ONS, Savant™ , PML, and PML Servers, are required.

6.2.1. Concealment
Concealment occurs when a thief hides an item under a jacket or in a bag. Since Auto-ID does not require direct line-of-sight, detection of unpaid items can still occur even when the object is not visible. During checkout, most retailers will either deactivate the tag or set the appropriate payment flag for the item. Therefore, if facility designers place sufficient distance between payment counters and exit doors, with appropriately positioned readers, store staff can identify un paid items and take appropriate action. Similarly, warehouse security staff can tell if unauthorized goods are leaving the facility.

6.2.2. Barcode Switch
A common theft technique involves switching bar-coded pricing tags by taking a tag with a lower price and attaching it to a more expensive item. Retailers have tried to fight this practice by putting two bar codes on a single item. Even if the cashier notices a switched bar code, the thief can claim it was the fault of the store. "If you do not conceal anything and are ready to pay for the article, it is hard to prove felonious intent (Caime and Ghone 1996)."

A similar technique involves thieves removing price tags and claiming the item was theirs. Unless security observes the individual removing the tag, it is difficult to counter the thief's assertion.

Since the EPC™ is unique to the item, all relevant information on the particular item can be pulled from the network to determine proof of payment, price and status of the item. This will help eliminate the uncertainty associated with mixed tags. If a false EPC™ tag is used as a substitute, and the number cannot be verified against the retailer's database, the EPC™ can also be queried in manufacturer's database to understand if the number is valid. If the item number is not verified in either database, then it is a potential counterfeit and should be handed over to law enforcement authorities.

6.2.3. Collusion
Collusion occurs when internal employees work with outside individuals to commit theft. For example, cashiers might register a product of lesser value, or not register the product at all by hiding the barcode with their hand while sweeping the product through the scanner. In the warehouse, a dockworker might collude with a trucker to load extra goods onto a pallet.

At registers, Auto-ID benefits by not requiring line of sight reads thereby reducing the possibility of a false read. Consequently, it will be much harder to violate the integrity of the checkout process. In the warehouse, items can be tracked in real-time, as they are loaded into vehicles.

If employees carry radio frequency identity cards, an association of missing item to employee can be recorded and, over time, patterns can be established.

6.2.4. Intentional Undercount

During physical inventories, employees can underreport the actual number of goods, and then return to take the "lost items" after the accounting adjustments for shrinkage. In this case, there is no discrepancy after theft because computer inventory records exactly match physical counts. The intentional undercount might appear when reconciling the receipt of goods versus sales and deliveries, but usually these discrepancies would be included in the overall shrinkage account - an example of why internal theft is sometimes difficult to measure.

RFID and Savant™ are used by Auto-ID to detect the movement of goods in real time while the EPC™ provides a method of accounting for transactions executed on an object-by-object basis. A result of this granular real time accountability is the constant synchronization of material and information system data. There is less opportunity for physical and perpetual inventories to be not synchronized. Even if they are not synchronized, the reconciliation can be made on an item-by-item basis and a trace can be placed on every unaccounted item.

6.2.4. Trash

One of the more unusual methods of stealing from a facility is to put items into trash for pick up latter when it is in the dumpster. RFID readers near the disposal area will help detect items that should not be in the trash and the Savant™ can then send the appropriate warnings to relevant personnel.

6.3. Proof (After Theft)

Depriving thieves of the ability to convert goods to cash, helps deter thieves from stealing in the first place. In the event that items are stolen, the ability to find out where they come from and when they disappeared from the supply chain will not only provide retailers and manufacturers with valuable data as to weak points in their supply chain but give law enforcement the opportunity to take action against the contraband.

6.3.1. Burglary

It is very difficult for a technological system to protect against forced entry or armed robbery. In many of these situations, thieves convert stolen goods into cash through "black" or "gray" markets. An investigator could trawl for the EPCs™ of goods in these markets and identify where and when they came from. This provides legal and corporate authorities with information to fight against the unlawful sale of their products through unauthorized markets.

6.3.2. Grab and Run

Brazen shoplifters will take items and rush out the door. They rely on speed to escape security. The list of methods also includes using emergency exits, ruining the anti-theft gates, and simply walking innocently out the store (Caime and Ghone 1996).

The overall ability of Auto-ID to prevent this shoplifting technique is minimal. With regard to resolution, the unique EPC™ could potentially help Law enforcement officials in determining the history of a suspect product if the items turned up in 'black' and 'gray' markets.

6.3.3. Fraudulent Refund

This technique involves a thief entering a store, taking something and proceeding straight to the returns counter. The idea is to create the impression that the thief came into the store with the item. While trying to return the particular item, the thief pretends to have lost the sales receipt or implies it is a gift. Store employees presently have almost no way to determine whether the item was part of a legal purchase.

A variation of this technique involves stores that have a "no refund without receipt" policy. In this case, the thief visits the returns desk asking for a refund. When the clerk denies the request because of the lack of a sales receipt, the thief then walks out the door with the item completing the theft.

In both these circumstances, the ability for the returns clerk to trace the history of the particular item by using the unique EPC™ will help reduce the uncertainty.

6.3.4. Fraudulent Receipts

Shoplifters sometimes create a fake receipt and use it as evidence of a purchase if security or store staff approaches them. The thief enters the store with the receipt, goes to the shelf, and takes the corresponding item. Alternatively, the thief can purchase the desired item, leave the store, and then return to steal the same item repeatedly. If caught, the individual will use the receipt acquired earlier as proof of purchase.

The EPC's™ ability to uniquely identity the item means it can be matched against the financial transaction (and receipt) used to purchase the item. This level of granularity will help eliminate any uncertainty between the physical product and the accompanying receipt.

The following table summarizes the capabilities of Auto-ID that we believe are most useful in dealing with different types of theft.

Table 2

USEFUL CHARACTERISTICS TECHNIQUE	NO LINE OF SIGHT	MASS SERIAL.	REAL TIME	TRACK	TRACE
THEFT PREDICTION					
Open Pack	✓		✓		
Sweep Theft	✓	✓	✓		✓
Disabling Tags	✓	✓	✓		
DETECTION DURING THEFT					
Concealment	✓		✓		
Barcode Switch	✓	✓	✓		
Collusion	✓		✓	✓	✓
Intentional Undercount	✓	✓	✓	✓	✓
Trash	✓	✓	✓	✓	✓
PROOF AFTER THEFT					
Burglary		✓			✓
Grab & Run		✓			✓
Fraudulent Refunds		✓			✓
Fraudulent Receipts		✓			✓

7. A HOLISTIC SOLUTION TO THEFT

Auto-ID offers a complete solution through a hardware/software infrastructure based on open standards. This is in contrast to current anti-theft applications that work independently using proprietary systems. As such, Auto-ID is a flexible approach that can be adapted to meet the changing requirements of manu-facturers and retailers. Summarized below are three additional technical attributes that make Auto-ID an appropriate comprehensive solution. Each attribute plays an important role in thwarting the different types of theft.

7.1. Embedding RFID Tags into the Product or Packaging

Tags embedded as part of the item or ingrained in the packaging will make it difficult for thieves to quickly identify and remove the security tag. The embedded tag also prevents attempts to remove or switch price tags because thieves would have to remove the packaging to do so. Tampering with packaging is cumbersome, draws attention, and reduces the resale value of the item in secondary markets.

7.2. Expanded Scope of Coverage

With reader costs expected to drop to the $100 - $200 range, firms can place readers in shelves, isles, shopping carts and at exits and entrances. With the expanded coverage, internal thieves will have difficulty colluding with outside parties to steal from warehouses or by using backrooms and emergency exits to remove goods. Shoplifters will not be able to conceal merchandise and escape detection while leaving the store.

7.3. Reduced Human Involvement

Overall, the Auto-ID system provides a dynamic platform for addressing different stages of theft. As applications that are more sophisticated are developed at the Predictive and Deterrence stages, there will be an opportunity to reduce the need for human intervention in the resolution of theft. This will not only make for a system less prone to human judgment, but will help contribute to a safer and less confrontational environment for employees.

8. ADDITIONAL BENEFITS

Besides the immediate impact of reducing both internal and external theft, Auto-ID technology provides several important long-term benefits.

8.1. Product Display and Store Layout

With Auto-ID, managers can feel comfortable about open access to merchandise on the floor. About 40 percent of all purchase decisions rely on impulse buying, so allowing consumers to touch items will increase sales (Klein 1991). In addition, stores can optimize the display of goods for maximum merchandising impact.

8.2. Greater Control of Theft Prone Items

Hot products are items most desired by thieves (Beck 2001). "In many stores, 10% of the inventory yields as much as 40% of the total store shrinkage (Mullen 1999)." Currently, security personnel develop hot products lists based upon perceived theft potential. Auto-ID technology provides the necessary data to pinpoint the products vulnerable to theft and identify patterns if the hot products change.

8.3. Source Tagging

There are numerous vendors of anti-theft tagging systems, each with proprietary standards. Manufactures must tag the goods in accordance with anti-theft systems used by individual retailers. In addition, retailers request several tagging configurations including dual tagging, tagging every other item, and no tag.

With Auto-ID, there is a single open standard. This is a tag that will be applied as an Automatic Identification and Data Capture (AIDC) technology. It is a bonus that this AIDC tag is also able to perform anti-theft and a variety of other applications. This multi-functionality has the potential to reduce the requirement to have specific SKUs and this will have an impact on inventory levels.

8.4. Dynamic System

Internal and professional thieves rely on the fact that current security solutions are static. Though cameras, complicated packaging, and inaccessible items serve to deter thieves, all of these measures can eventually be defeated (Hayes 1996). Once thieves learn the vulnerabilities, they are free to exploit these deficiencies at will. With no real time information about theft, it takes many months for manufacturers and retailers to realize if theft control methods have been compromised. Retailers must suspect any anti-theft strategy that has remained the same for a long time (Hollinger and Hayes 2001).

Auto-ID, however, is a real time system that can constantly be adapted to meet changing needs. By receiving immediate feedback on theft patterns, the pace of theft, and the place of theft, security officials can find weaknesses and make changes.

9. CONCLUSION

Auto-ID has great potential to reduce internal and external theft within the supply chain by providing real-time information to security managers. Through hardware and information infrastructure, both based on open standards, Auto-ID will be the future global solution for theft prevention.

The technology also offers additional potential for cost savings. Auto-ID will increase supply chain effectiveness by improving hand-offs between businesses (Dinning and Schuster 2003). Improper practices of diversion will be limited (Dahmen 2002). With shelf monitoring systems, dynamic pricing schemes become possible and the shelf-life limitations for foods and pharmaceuticals will receive more attention. All these benefits are possible by taking first step in applying Auto-ID to prevent theft.

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APPENDIX A
MAGNITUDE OF THE THEFT PROBLEM

Two studies attempt to identify the amount of theft as a percentage of total shrinkage (National Retail Security Survey; Efficient Consumer Response report). Both surveys poll loss prevention managers, however, responses are subjective because retailers seldom gather data on the amount of theft. Table 1 shows responses of both studies.

Table 1: Quantifying Theft Losses

	US	EUROPE
TOTAL SHRINKAGE COSTS (RETAILERS)	**$33.2 BILLION**	**€13.4 BILLION**
Percentage of Sales	1.80%	1.75%
Shoplifting	31%	37%
Internal Theft	46%	24%
TOTAL % ATTRIBUTED TO THEFT	**77%**	**61%**
THE TOTAL COST OF THEFT	**$25.6 BILLION**	**€8.17 BILLION**