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Auto-ID on Delivery: The Value of Auto-ID Technology in the Retail Supply Chain

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New "Smart", Silent Products Revolutionize the Retail Supply Chain

CHICAGO – The first major technology shift of the 21st century has arrived and it is having a dramatic impact on the retail supply chain. With the introduction of Auto-ID technology, consumer goods are arriving at stores in record time.

TargX has joined their trading partners in the use of revolutionary new "smart" tags – devices the size of a postage stamp. What makes this technology smart is the combination of a radio frequency (RF) transmitter along with an electronic product code (EPC)™. Developed by the Auto-ID Center, in conjunction with leading retailers, manufacturers and technology providers, EPC™ provides a unique identification number for every individual item that TargX orders, handles and sells.

TargX now knows the exact location of every unique item that it handles in real time. As a result, they can now move product to and from their distribution centers at record speed with nearly 100 percent accuracy – dramatic improvement over 20th century business practices. TargX Chief Supply Officer, Jan McMullen, describes their experience saying, "We've clearly become the market leader. Auto-ID technologies have helped us differentiate ourselves head and shoulders above the competition."

Accenture Silent Commerce
www.accenture.com/SilentCommerce

Auto-ID technology has left the lab and is out in the real world so it's not a matter of if, but when. Will you be ready to take advantage of the future scenario described above? Accenture has a vision for RFID and broader related technologies, called Silent Commerce. Silent Commerce creates unlimited new business opportunities by making objects intelligent and interactive. It is "silent" because communication and commerce can take place between objects such as cases of paper towels, dock doors and warehouse management systems. For several years we have been exploring the business potential of these innovative technologies at Accenture Technology Labs' Silent Commerce Centers located in Chicago, IL; Palo Alto, California; and Sophia Antipolis, France.

We have built working business applications and industry prototypes. We host hands-on workshops where companies can explore near- and long-term business and industry implications. This year in conjunction with the Auto-ID Center, we've collaborated with retail, consumer goods and freight transportation industry leaders to bring you a series of white papers, focused on this exciting new value creation opportunity. Auto-ID technology is an innovation that will revolutionize your business as you know it today. We invite you to explore the possibilities. Read on!

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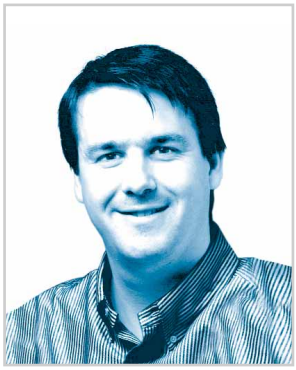
Biographies



Gavin Chappell
Partner

Gavin Chappell is a Partner in Accenture's Supply Chain Global Service Line. For over 13 years, Gavin has specialized in developing and implementing solutions to drive improvements in Supply Chain operations, specializing in physical distribution and inventory management. He has worked extensively in the UK Retail sector and across Europe for both Retail and consumer goods companies. He is leading Accenture's Supply Chain practice in the adoption and implementation of Auto-ID solutions. Gavin has an honors degree in Chemistry from the University of St. Andrews, Scotland.

David Durdan
Partner

David Durdan is a partner in the North America Retail & Consumer Goods industry group of Accenture. He is one of the organization's leading experts on RFID, wireless and ubiquitous technologies. In this role, David is responsible for architecting and delivering technology solutions with a focus on immediate value delivery. During his 14-year career with Accenture, he has brought leading-edge technology strategies and solutions to companies worldwide. He has worked with Sears, Roebuck and Co., Sainsbury's, Benetton Group, THOMSON multimedia, Sears Canada, Sony Corporation, Shoppers Drug Mart and The Black & Decker Corporation. He is a frequent technology spokesperson as well as a guest lecturer at Northwestern University's M.B.A. program and is quoted in a wide range of business and technology publications. Mr. Durdan attended Queen's University in Kingston, Ontario, Canada where he studied engineering physics.

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Greg Gilbert is a manager-Supply Chain Management in the North America Retail & Consumer industry group of Accenture. He specializes in applying RFID technology solutions to the extended supply chains of retail companies, leading to improved performance and reduced costs. Since joining Accenture in 1996, Mr. Gilbert has spent the majority of his career focused on business process reengineering, software application implementations, supply chain planning and systems execution. Mr. Gilbert received a bachelor of arts degree from the University of Alabama and a master of business administration degree from the University of Alabama Manderson Graduate School.

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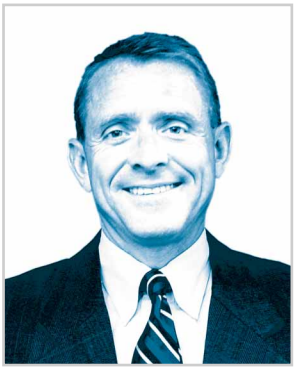
Biographies

Lyle Ginsburg
Partner

Lyle Ginsburg is the managing partner for technology innovation in Accenture's global Products Operating Group. With more than 20 years experience identifying new technology trends and bringing them to market, Lyle is now focused on finding the value of Silent Commerce for Accenture clients in Retail, Consumer Goods, Transportation, Hospitality, Pharmaceuticals, Life Sciences, Automotive and Industrial industries. Lyle has a Computer Science degree from Northern Illinois University.



Jeffrey Smith
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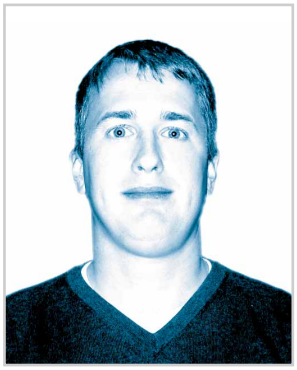
Jeff Smith serves as the managing partner for innovation in Accenture's Retail & Consumer Goods industry group. He is an internationally known specialist in technology innovation and ERP solutions, speaking regularly to retail, manufacturer and other industry trade groups in the Americas, Europe and Asia. Over his 23-year career, Jeff has specialized in strategic planning, data modeling, design and development of value-creating technology solutions for large retail and consumer goods companies, with a focus on customer/supplier collaboration processes and systems. Clients include Sara Lee, Meijer, Novartis Consumer Health, Nestle, Ahold USA and Wegmans. Jeff currently leads a research team assisting the Auto-ID Center in developing business cases for the commercial application of Auto-ID technology in the consumer industries. Jeff holds a Master of Business Administration in Organizational Behavior/Informational Systems and an AB in Economics from the University of Michigan at Ann Arbor.



Joseph Tobolski
Senior Manager

Joseph Tobolski is a senior manager in Accenture Technology Labs. His main areas of expertise are Silent Commerce, Content Management, Collaboration and Knowledge Management and technical architectures. Joseph serves as the director of Accenture's Silent Commerce Center, where he is investigating how emerging technologies such as RFID, sensors and actuators can enable inventory management, maintenance and logistics. Joseph received his M.S. in mechanical engineering and his B.S. in industrial engineering from the University of Illinois at Urbana-Champaign.

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1. EXECUTIVE SUMMARY

Radio Frequency Identification (RFID) and the Electronic Product Code (EPC)™ are poised to be some of the most exciting technologies to influence the retail industry over the next decade. Headlines like the one you read in the cover "article" will be a reality in the not-so-distant future. That is why leading retailers are fast learning what this new technology can do and how it can drive improved earnings in their businesses.

Auto-ID technologies will enable retailers to radically change the way they do business within the retail supply chain. Accenture research and analysis of this rapidly emerging technology uncovered the following key findings:

- Case-level tagging will bring the greatest number of benefits in the retail supply chain as most merchandise is handled in this fashion. Item-level tagging will bring about more benefits in operations that involve a large amount of unit-level handling or in sectors where inventory accuracy is suspect. Pallet-level tagging has benefits for companies that receive and handle large portions of single SKU pallets.

- Direct labor reductions related to the processes within the distribution center will range from 5 to 40 percent, depending on a company's current level of process automation, technology and the number of times items must be handled as they pass through the supply chain.

- Safety-stock reductions made possible by reducing delivery lead-times and lead-time variability creates the largest benefit in the transportation segments of the supply chain. The greater the current lead-time and lead-time variability, the greater the potential savings. Depending on current lead-times, this reduction may range from one to four days of supply.

While it is clear that Auto-ID applications are destined to unlock unprecedented value for retailers, the path to adoption will have its challenges. Rate of adoption, shifting cost projections and leading-edge technology make for an unpredictable mix. Yet for most retailers, the benefits will be worth the effort. The take-up of Auto-ID in the coming years has the potential to revolutionize the industry in a powerful, but silent way.

2. ACKNOWLEDGEMENTS

Accenture would like to acknowledge and thank the many companies, organizations and individuals whose insights proved invaluable to this paper, including the Auto-ID Center, CHEP, The Home Depot, Intermec, Matrics, Procter & Gamble, Savi Technology, Target Corporation, Unilever and Wal-Mart.

3. INTRODUCTION

Working in close collaboration with the Auto-ID Center and its members, Accenture has developed a series of white papers to help companies in various industries determine opportunities with the highest value in manufacturing, supply chain, demand planning, transportation and store operations. Our findings are based on extensive research, business and operations modeling, and financial analysis, including in-depth interviews with Auto-ID board member companies and experts from the Accenture Supply Chain Group and Accenture Technology Labs.

For a discussion of the impact on freight transportation companies or the consumer goods industry, please see the Accenture industry white papers, "Auto-ID on the Move: The Value of Auto-ID Technology in Freight Transportation" and "Auto-ID on Demand: The Value of Auto-ID Technology in Consumer Packaged Goods Demand Planning".

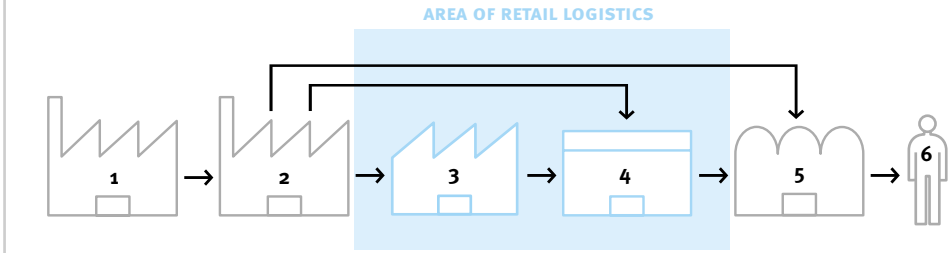
This paper is dedicated to the retail supply chain. It outlines the issues retailers face in this area and how Auto-ID can serve as a solution. For this paper, the retail supply chain will begin at the point where product leaves the vendor and ends when a shipment arrives at the store, not including the store receiving process.

Figure 1: illustrates the typical "core" of the supply chain

1. Supplier
2. Manufacturing
3. Finished Goods Distribution
4. Retailer/Distributor Distribution
5. Retail Store
6. Consumer

→ Transport

THE OVERALL SUPPLY CHAIN



– **Retail Distribution Center –** Encompasses the processes that occur in and around the four walls of a facility, which includes a wide range of activities from cross-docking to warehousing to merchandise preparation.

– **Transportation –** Deals with the processes of shipping product from the vendor to the retail distribution center or store and the processes of shipping product from the retail distribution center to the retail store.

Understandably, each retail supply chain will be unique in its makeup and use of different channels. These multiple channels and processes have been considered throughout the paper.

4. DISTRIBUTION

4.1. Introduction

As consumers demand higher levels of service with more competitive pricing, retail distribution becomes more complex. These demands are passed back through the supply chain and in many cases, the distribution centers shoulder a good deal of the responsibility. They must deliver product to the stores with lower costs, but with higher accuracy.

Retail distribution has two main goals:

1) to fill store orders accurately and completely and
2) to do it for the lowest possible cost.

Retailers face many issues in reaching these goals. The most common are:

[1] "Logistics Benchmarks for U.S. Retailers", Accenture Study, 2001"

– **Labor Costs –** Labor costs make up approximately 30 percent of overall supply chain costs.[1]

– **Inventory Accuracy –** Imprecise information about inventory levels hinders good decision making. Errors such as barcode no-reads and human factors such as not scanning barcodes or incorrectly counting product, contribute to inaccurate inventory information. For more insights into the use of Auto-ID in demand planning, please refer to "Auto-ID on Demand: The Value of Auto-ID Technology in CPG Demand Planning," Accenture, 2002. There are two levels of inventory accuracy that can be addressed. The first is aggregate accuracy, which answers the question, "Do we know how much of a particular item in the distribution center?". The other level is location accuracy, which deals with the question, "Do we know where the product is, in the distribution center?". High levels of inventory inaccuracy lead to low order fill rates and ultimately, to lower levels of customer service.

[2] "Logistics Benchmarks for U.S. Retailers", Accenture Study, 2001"

– **Order Fill Rate –** Not all orders from the distribution center are filled properly. "Did the distribution center ship the right amount of the right product to the right place?" This is a key measurement of the service the distribution center provides to the stores and in maintaining store in-stock levels. Four percent of the items that stores order are not filled correctly [2].

[3] "2002 Retail Survey Report", University of Florida, 2000.

– **Shrink –** Despite advances in shrink prevention, shrink is an issue that continues to plague most retailers. It occurs when product is misplaced, lost in the warehouse or stolen. Other times, picking or packing the wrong products causes the shrink and creates inventory imbalances. According to the National Retail Security survey,[3] shrink averages 1.71 percent of sales in the retail industry.

– **Inventory Velocity –** Low inventory velocity forces a retailer to maintain a higher amount of inventory to cover the lead-time.

4.2. Auto-ID in Distribution

Before discussing how Auto-ID technology will address these issues, it is helpful to first set the stage for what an Auto-ID-enabled distribution center might look like. In such a world, all products and assets will be tagged, enabling every item, case and pallet to be tracked. RFID readers will monitor the flow of inventory into and out of a building as well as where the inventory is located. These innovations will enhance the functions within the distribution center immensely. Several functions that will be affected are described in the following sections.

4.2.1. Receiving and Check-in

When cases and pallets tagged with Auto-ID (possibly containing items that are tagged) are brought into the distribution center, RFID portals will read the tags and update the inventory quantity. The received merchandise will be applied to the correct purchase order and any discrepancies will be systemically identified. The current labor-intensive quantity check-in process will be virtually eliminated as well as many of the clerical functions that are required to support the receiving process. These functions range from printing the receiving checklists and labels, to data entry for the receipt, to a detailed check against the purchase order. The quality check process would not be impacted by Auto-ID technologies until sensors are employed.

4.2.2. Putaway and Replenishment

Putaway drivers will be directed to the correct pick-up location. Drivers will be able to pick up and drop loads without stopping to scan a barcode identifier. When a load is dropped at a location, the inventory location system will be adjusted to reflect the quantity at the new location automatically.

Replenishment operators will never find themselves arriving at locations to look for loads that are not there. Once at a location, an operator will be able to remove the load without scanning the product or the location. When an operator drops the product at the stocking location, the product will be located without anyone having to perform scanning or verification. If product is stocked to the wrong location, alerts will be created.

4.2.3. Order Filling

Personnel will be directed to the picking location and then retrieve the cases or items as directed, placing them on the material-handling equipment as required. When the cases or items are removed from the location, the system will automatically verify that the correct quantity was removed and update the current inventory quantity and the store order information. The picker will be prompted if too many or too few cases or items are removed.

4.2.4. Shipping

Shipping operations can be highly automated with Auto-ID. Loaders will be able to convey cases and pallets directly onto the trailers without scanning merchandise. Shipping documents will be created systemically with fewer errors. Conveyors will run at higher speeds due to the increased read speed of RFID and decreased no-reads (and the labor that is entailed in correcting them), since line-of-sight requirements of laser scanned barcodes will have been eliminated.

4.3. The Benefits of Auto-ID in Distribution

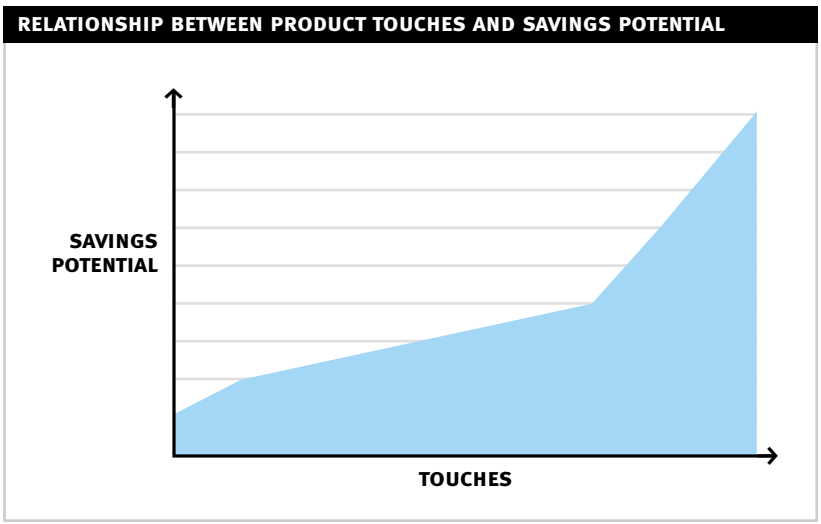
4.3.1. Benefit Factors

Accenture's analysis shows that two key elements will drive the degree of benefits retailers should expect when evaluating Auto-ID solutions: the mix of processing methods employed and a company's degree of process automation.

Processing methods determine how much product will be stored in the distribution center network and how many times each item must be handled before it leaves the distribution center. There is a direct relationship between the number of touches (defined as how many times the product must be handled before arriving at the store) and the savings potential, as illustrated in Figure 2. The more items that must be handled and the more times they must be handled, the greater the savings potential.

Figure 2

RELATIONSHIP BETWEEN PRODUCT TOUCHES AND SAVINGS POTENTIAL

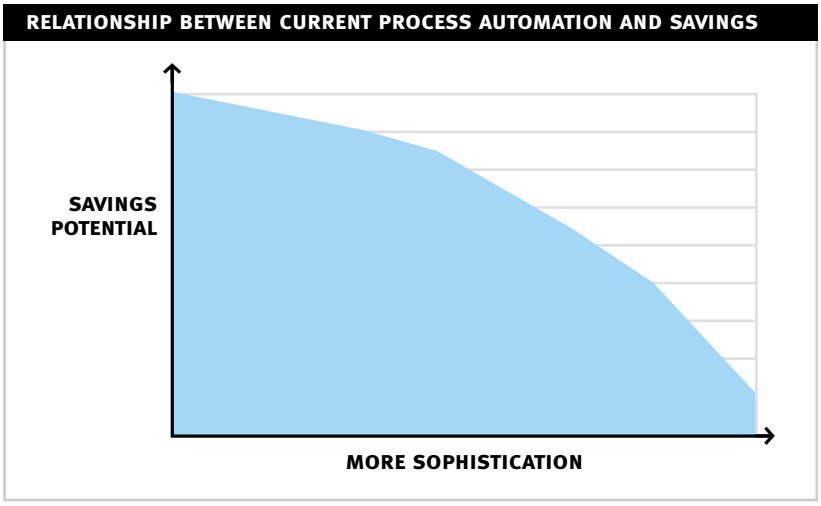


The mix of processing methods used in our analysis includes:

- **Direct Store Delivery (DSD)** – Product is delivered directly to the store.
- **Cross-Dock** – Cases (and sometimes pallets) are shipped to a retail facility but bypass storage and picking processes.
- **Case Pick** – Merchandise is shipped to the retail distribution center, where it is stored and held for processing at a later time. Full cases are shipped to the retail store.
- **Each Pick** – Merchandise is shipped to the retail distribution center, where it is stored and held for processing at a later time. Merchandise is shipped to stores in less-than-case quantities, requiring additional stocking and picking activities in the distribution center.

The second element is the degree of process automation and the sophistication of the systems currently in place. As shown in Figure 3, the greater the current degree of process automation, the lower the overall benefit.

Figure 3



The range of automation and systems evaluated included:

- **Manual or Paper Based** – An environment where few, if any, tasks are automated and inventory control systems are updated with manual clerical functions or by fixed terminal stations.
- **Stock Locator** – An environment where few tasks are automated and most systemic updates are performed at fixed stations. Some functions, such as stocking and putaway may be RF enabled.
- **Warehouse Management System (WMS) with Radio Frequency (RF) Functionality** An environment with advanced WMS technology where inventory is updated real time with RF handhelds in most functions.
- **WMS with RF and Electronic Data Interchange (EDI)/Advance Shipping Notice (ASN)** An environment much like standard WMS, but the application of EDI or ASN greatly speeds up the receiving process.

– **WMS with RF, EDI/ASN and Real-time Instructional Systems** – As above, but with additional systems, such as pick-to-light, picking carousels and replenishment conveyors in place to automate tasks.

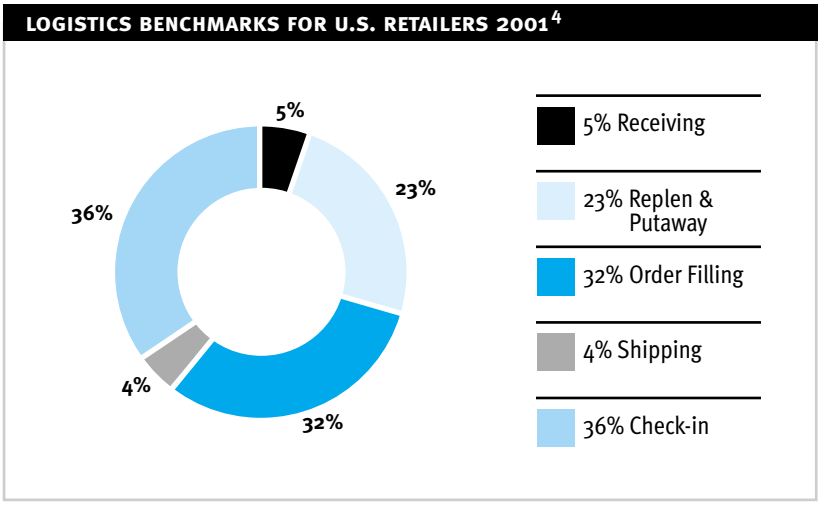
Using these variables, Accenture determined that retailers with manual or paper-based systems performing each- and case-pick operations will see the highest level of benefit, while companies with high levels of DSD and/or cross-dock and sophisticated automation systems should expect to realize comparatively fewer benefits. Some of the leading adopters of Auto ID are retailers particularly concerned with short shelf life products, where inventory accuracy and fast turnaround are key to successful execution.

4.3.2. Labor Costs

Auto-ID applications will have a major impact on distribution center processes that involve the scanning of product and/or location barcodes, as well as processes that require time-consuming auditing and confirmation steps. Multiple scenarios were simulated with the Accenture Silent Commerce Cost/Benefit Calculator fusing the retail industry averages seen in Figure 4 for the basis of costs. The findings revealed that Auto-ID technology efficiency gains would result in labor cost reductions between 5 and 40 percent.

Figure 4:

[4] "Logistics Benchmarks for U.S. Retailers," Accenture study, 2001.



4.3.3. Inventory Accuracy

With the ability to know the location of every case and/or item and the potential for human error greatly reduced e.g. not scanning bar codes, double scanning or manual counting, the integrity of the data pertaining to inventory will be significantly increased. This was reflected in our analysis as we determined that location inventory accuracy would approach 99 percent and that aggregate inventory errors would all but be eliminated in our future operation. The financial benefits in this area correspond to the cost of the annual physical counts or to the cost of maintaining a cycle count program. The physical count process can be eliminated, while 95 percent of the labor involved in the cycle count program will also be eliminated.

4.3.4. Order Fill Rate

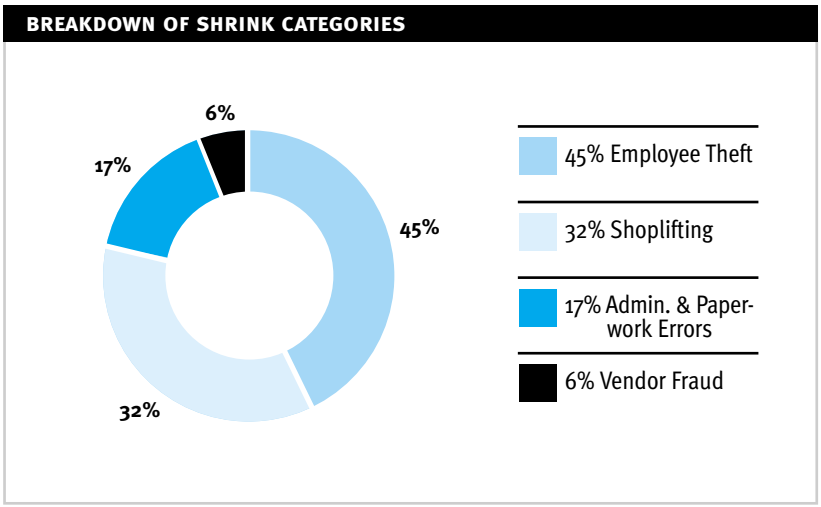
With systems capable of monitoring the completion of every picking task, the mis-pick rate for case-picking operations will be negligible with case-level tagging. In each-pick environments, the accuracy of inventory during the replenishment process will decrease mis-picks by approximately five percent. Item-level tagging has the potential to improve each-pick order accuracy to the point where errors are insignificant.

[5] "2000 Retail Survey Report", University of Florida, 2000

4.3.5. Shrink

Figure 5 details the breakdown of all the shrink categories.[5]

Figure 5



Vendor fraud and administrative and paperwork errors are the areas of shrink that are most common in the distribution segment, although a portion of employee theft occurs in the distribution center as well. Case-level tagging can eliminate shrink caused by vendor fraud, and will have some impact on shrink caused by administrative and paperwork errors, resulting in an average potential savings of .06 percent of sales. Case-level tagging will likely have little impact on employee theft.

4.3.6. Inventory Velocity

Due to the labor efficiencies Auto-ID provides, associates will be able to decrease the cycle time within the warehouse. This will reduce the overall lead-time for processing store orders. However, the benefits will vary by industry vertical and with the current order cycle time. Retailers operating on a one-day or less cycle time should expect lower benefits than retailers with extended cycle times. Retailers dealing with time sensitive products (chilled, pharmaceuticals, etc.) should also see benefits of increased velocity.

4.4. Illustrative Case Study of Auto-ID Technology in Distribution

Kitchens, Inc. is a specialty retailer in the United States home furnishings vertical industry. Its annual sales are $2 billion, with an average item-selling price of $5. The company operates 500 stores serviced by three distribution centers. The distribution centers are fairly modern, and activities are guided by a warehouse management system. The current labor budget in distribution is $48 million and vendor and paperwork shrink is $7.8 million. However, Kitchens Inc. has not been very aggressive in developing an EDI or ASN program with its vendors, resulting in a slow check-in process and shrink caused by vendor and paperwork errors.

To address these issues, Kitchens, Inc. implemented case-level Auto-ID solutions in its distribution centers using tags that were already attached to incoming cases of product by all of its vendors. Reader portals were installed on inbound doors to automate the receiving and check-in process as well as on material handling equipment and vehicles, to allow product locations to be recorded. The implementation costs were approximately $7.8 million per facility, including hardware, software and integration. Annual maintenance is expected to cost about $100,000 per installation.

Kitchens Inc. experienced a 35 percent improvement in direct labor productivity and an 88 percent improvement in vendor and paperwork shrink with annual savings of $16.7 million in labor expense and $6.9 million in shrink reduction. The cumulative cash flow analysis shows a positive NPV in less than four years, assuming an 8 percent internal rate of return. See Tables 1, 2 and 3 for details regarding savings and costs.

Table 1: Labor Savings by Area

FUNCTION	CURRENT BUDGET	% IMPROVEMENT	NEW BUDGET	SAVINGS
Receiving	$2,599,721	0%	$2,599,721	–
Check-in	$17,017,341	80%	$3,403,468	$13,613,873
Putaway & Replenishment	$15,760,272	15%	$13,396,231	$2,364,041
Order Filling	$10,667,587	7%	$9,920,856	$746,731
Shipping	$1,955,080	0%	$1,955,080	–
TOTAL	**$48,000,000**	**35%**	**$31,275,356**	**$16,724,644**

Table 2: Shrink Reductions by Area

AREA	CURRENT EXPENSE	% REDUCTION	NEW EXPENSE	SAVINGS
Administrative & Paperwork	$5,763,000	85%	$864,450	$4,898,550
Vendor	$2,034,000	100%	–	$2,034,000
Employee Theft	$15,255,000	0%	$15,255,000	–
Shoplifting	$10,848,000	0%	$10,848,000	–
TOTAL	**$33,900,000**	**–**	**$26,967,450**	**$6,932,550**

Table 3: Implementation Costs

CATEGORY	COSTS	UNITS	TOTAL
Readers	$500	100	$50,000
Reader Peripherals (Antenna, Multiplexers, etc)	$3,500	100	$350,000
Reader Installation	$1,000	100	$100,000
Controllers	$1,500	100	$150,000
Location Tags (Using Powered Tags)	$2.00	60,000	$120,000
Installing Location Tags	$50.00	60,000	$3,000,000
Data Management Software	$30,000	1	$30,000
Software Integration	$4,000,000	1	$4,000,000
TOTAL	**–**	**–**	**$7,800,000**

This illustrative case study demonstrates the overwhelming potential of Auto-ID within the distribution portion of the retail supply chain and provides insight into how Auto-ID will impact operations in the future. However, adoption of Auto-ID technologies throughout the value chain will likely take place over several years and retailers in different market verticals and different geographies will likely see different rates of adoption and areas of benefit. The potential benefits, therefore, must be factored to account for

this adoption curve. Accenture has run numerous scenarios using our Silent Commerce Cost/Benefit Calculator. Our conclusion? Retailers should begin implementing RFID solutions to address critical issues now, to prepare for the industry wide adoption ahead.

5. TRANSPORTATION

5.1. Introduction

Transportation is the segment of the supply chain that consumes the most resources (in the form of capital and expenses), takes the most amount of time for product to pass through and presents the greatest number of "surprises" along the way (higher risk that an unforeseen event will cause the product to spend more time than normal at that point). Additionally, retailers tend to shift much of the responsibility of managing this segment to someone else e.g. freight forwarders, carriers, and consolidators, reducing the amount of visibility they have to the product as it is in transit.

Common issues with the transportation segment of the supply chain are:

[6] "Logistics Benchmarks for U.S. Retailers," Accenture study, 2001.

- **Freight Costs** – Transportation is the largest cost in the supply chain at approximately 61 percent of total supply chain costs[6]. This includes the costs of carriers and consolidators.

- **Safety-Stock Inventory** – Transportation, specifically the inbound segment, represents the largest area of lead-time variability in the supply chain. This is due to the distances and time frames involved, the number of inter-company handoffs that occur and the lack of visibility to the process in general. Ultimately, unplanned lead-time variability forces the retailer to do one of two things: either maintain higher levels of safety stock or suffer stock-outs. Similarly, even when things go "as expected," it is not always as quickly as would be desired. Take, for example, clearing customs. One of the most common places where product sits idle is at the port of entry, where the product must be inspected and approved before moving to the next segment of the supply chain. Even though retailers plan for this time, this step increases lead-time and increases the amount of inventory a retailer must carry.

- **Detention and Demurrage** – Retailers rely on a large number of third-party assets (trailers, pallets and bins) to help them move and process merchandise. At peak times of year, returning these assets within the contracted time frame becomes challenging, and can result in incurring costly detention and demurrage charges. At times, retailers can lose track of these third-party assets and incur charges on them until they are located and returned.

- **Capacity Planning/Asset Utilization** – Some retailers operate (either own or lease) large fleets of trucks and trailers used in the delivery of merchandise to the retail store. Maximizing the use of these assets is critical to ensure that the asset pool, and its associated capital expense and depreciation charges, are minimized.

- **Asset Tracking** – Many retailers have a major investment in product handling and storage assets such as pallets, totes, trays, hanging racks and flats that are used in the delivery of product to stores. The expectation is that these assets will be returned and reused but retailers must continue to invest significant capital in these assets.

5.2. Auto-ID in Transportation

As with the distribution segment of the supply chain, Auto-ID technology holds tremendous potential to make a dramatic impact on the transportation segment. In the Auto-ID-enabled supply chain, both products and assets will be tagged. Reader portals will exist at critical points within the supply chain, including major supplier shipping docks, freight forwarders, consolidators, distribution centers and pool points.

Every time a tagged product or asset passes through a portal, a detailed and accurate record of the movement will be created and passed to product and asset tracking systems. From the time a shipment leaves a supplier until the time it shows up at the retailer's receiving dock, retailers will be able to track the progression of a shipment and its transporting vessel(s).

Product tracking systems will be configured to monitor the progress of shipments through the supply chain, creating alerts if a shipment remains at any node longer than expected. With this information, a transportation manager can contact freight companies to investigate the issue and facilitate on-time delivery.

Asset tracking systems will monitor the usage and last known location of each asset in the supply chain. This allows the utilization of every asset to be tracked over the long term. Assets that are underused can be removed or retired from service. Information about the last known location will assist in locating missing assets and allow loss prevention measures to be deployed to nodes with higher than average rates of "missing" assets.

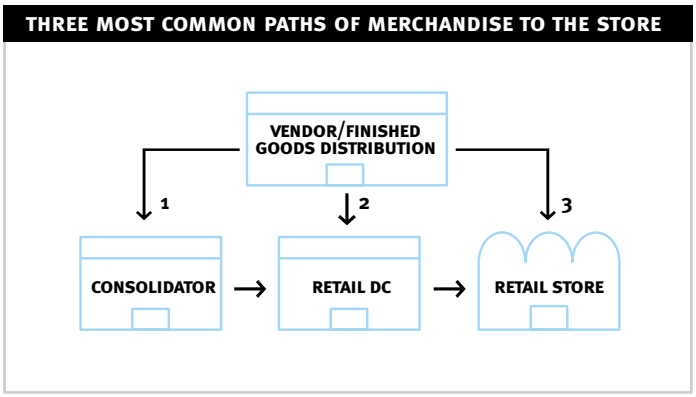
5.3. The Benefits of Auto-ID in Transportation

5.3.1. Benefit Factors

Accenture found that the benefits varied greatly depending on the flow path of the merchandise to the retail store, due to the differences in lead-time and lead-time variability. The three most common paths are consolidator, direct to distribution center and direct to store, as illustrated in Figure 6.

Figure 6:

1. Consolidator
2. Direct to Distribution Center
3. Direct to Store



1. Consolidator – Product is shipped from the vendor to a third-party consolidation point, where it is combined with other shipments (possibly from other vendors) prior to being shipped to the retailer's distribution center. This flow path has the greatest lead-time and lead-time variability.

2. Direct to Distribution Center – Merchandise is shipped directly from the vendor to the retail distribution center.

3. Direct to Store – Product is shipped directly from the vendor (either from the manufacturing plant or the finished goods distribution center) to the retail store. The lowest lead-time and lead-time variability are typically found in this flow path.

5.3.2. Freight Costs

Regardless of the flow path, Accenture does not see Auto-ID having a material impact on freight costs. While the increased degree of communication between carriers and the retailer should ease the administrative burden of the carrier, it is doubtful whether this would result in better rates. The more likely scenario would be that a retailer would concentrate its business with carriers that supported Auto-ID, which in turn, could lead to lower negotiated rates.

5.3.3. Safety-Stock Inventory

Detailed information on shipments coupled with defined processes to deal with exception situations will cause lead-time variability to decrease. Additionally, the immediate and accurate identification of product will allow it to move more quickly through handling and inspection points, as reliance on human labor is decreased. Both of these factors will lead to lower safety-stock inventory levels. In short, the more visibility a retailer has to product as it moves through the supply chain, the better equipped it will be to manage the process and deal with the exceptions.

A reduction in average lead-time with no increase in variability has a one-to-one relationship to the safety-stock quantity. In other works, if the average lead-time were reduced by one day, a retailer could maintain one less day of safety stock. Lead-time variability has a less direct relationship. A reduction in lead-time variability by two days will allow retailers to remove one day of inventory from the safety-stock calculation (assuming an even distribution in lead-time variability).

5.3.4. Detention and Demurrage

Auto-ID will provide "real-time" information about where third-party-owned assets are being held and how long they have been there, avoiding detention and demurrage charges. Determining the improvement potential because of Auto-ID is primarily based on when these charges are incurred. Those that are incurred during off-peak times of the year suggest the root cause is due to "invisibility" of these third-party assets. For this category of expense, Accenture believes Auto-ID can reduce detention and demurrage by 80 percent. Those that are incurred during peak times suggest the retailer physically has more merchandise than it can process within the given time frame. In this case, our analysis shows a 40 percent reduction due to the increased speed at which product can be received and the capacity constraints this removes.

5.3.5. Capacity Planning/Asset Utilization

Like a third-party's, assets owned by the retailer can be tracked and managed in detail. Asset utilization is typically about 80 percent. Analysis of Auto-ID asset tracking (totes, cylinders, pallets, dollies) suggests that utilization percent can reach 85 to 90 percent. A retailer with $20 million in inbound assets is taking an annual depreciation expense of around $3 million. Increasing utilization by 10 percent reduces asset needs by 10 percent, which translates to a $300,000 benefit per year.

For more details about benefits in this area, please refer to the Accenture white paper, "Auto-ID on the Move: The Value of Auto-ID Technology in Freight Transportation."[7]

[7] "Auto-ID on the Move: The Benefits of Auto-ID in Transportation," Accenture, 2002.

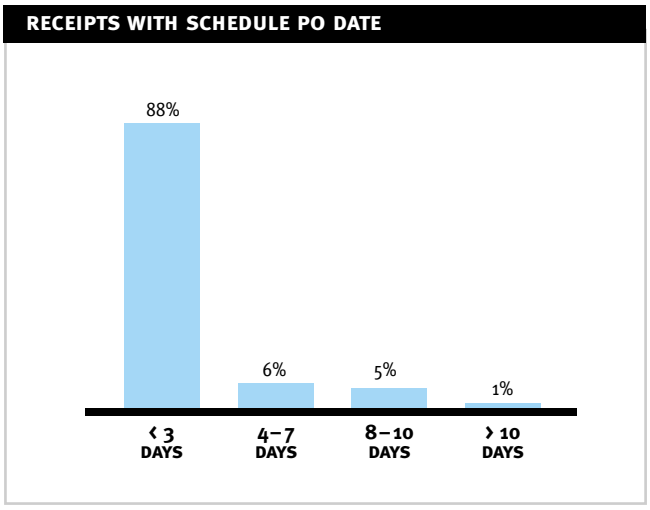
5.3.6. Asset Tracking

By tagging reusable assets and installing readers at transition points, retailers will be able to reduce the cost of replacing missing and lost items by 95 to 98 percent.

5.4. Illustrative Case Study of Auto-ID Technology in Transportation

Fast Lane is a retailer in the sports apparel segment with annual sales of $5 billion. It owns $20 million of assets used in the movement of product to the retail stores from its distribution centers. Thirty percent of its suppliers, responsible for 65 percent of the shipments, are located overseas. These shipments are routed through consolidators prior to arriving at the distribution center. Many of these shipments arrive well past the appointment date (see Figure 7).

Figure 7



Due to these delays, Fast Lane must maintain seven days of safety stock inventory. Due to the large effort it expends in trying to locate and track inbound shipments, it often misplaces trailers and incurs detention and demurrage charges on these assets.

Fast Lane began its Auto-ID project by implementing an asset-tracking system, providing a one-time benefit of $2.5 million in reduced assets due to improved planning capabilities with a corresponding annual benefit of $375,000 in depreciation charges. Fast Lane worked with its vendors and logistics providers to optimize the data sharing afforded by Auto-ID technology, allowing a four-day reduction in the required level of safety stock. This translated to a $58 million inventory reduction and $5.8 million of inventory carrying costs. Tracking inbound trailers with Auto-ID has resulted in $280,000 in reduced detention and demurrage charges. With a $1.35 million investment, Fast Lane experienced a positive cash flow in just over a year. See Tables 4, 5 and 6 for details on benefits and costs.

Table 4: Annual Transportation Savings by Area

AREA	CURRENT BUDGET	SAVINGS AMOUNT	NEW BUDGET	SAVINGS
Asset Depreciation	$3,750,000	10%	$3,375,000	$375,000
Inventory Carrying Costs for Safety Stock	$10,150,000	4 Days	$4,350,000	$5,800,000
Detention and Demurrage Charges	$711,000	65%	$430,769	$280,000
TOTAL	**$14,611,000**	**–**	**$8,155,769**	**$6,455,231**

Table 5: One-time Transportation Savings by Area

AREA	SAVINGS	SAVINGS
Asset Reduction	10%	$2,500,000
Safety Stock Reduction	4 Days	$58,000,000
TOTAL	–	**$60,500,000**

Table 6: Implementation Costs * (antenna, multiplexers, etc)

CATEGORY	COSTS	UNITS	TOTAL
Readers	$500	30	$15,000
Reader Peripherals*	$3,500	30	$105,000
Reader installation	$1,000	30	$30,000
Controllers	$1,500	30	$45,000
Installing Asset Tags	$2.00	60,000	$120,000
Data Management Software	$30,000	1	$30,000
Software Integration	$1,000,000	1	$1,000,000
TOTAL	–	–	**$1,345,000**

Like the case study for distribution, this example illustrates that potential Auto-ID solutions will deliver for transportation in the retail supply chain, once the technology has become widely adopted by vendors and freight providers. However, there are areas in transportation, such as asset tracking, that can be evaluated as stand-alone applications. By implementing such stand-alone solutions, retailers can begin to realize the benefits of Auto-ID, while gaining valuable experience with the new technology and by building the infrastructure to fully use Auto-ID as it becomes accepted as standard practice.

6. CONCLUSION

By implementing Auto-ID solutions, retailers have the potential to achieve tremendous benefits across the supply chain that will substantially impact the bottom line. The primary areas will be:

1. **Reduced Safety-Stock Inventory** – The need for safety-stock inventory will decline due to the reduced lead-time and reduced lead-time variability on both the inbound and outbound segments of the supply chain.

2. **Labor Reduction** – Labor costs will decline in the distribution segment through the automation of processes and the removal of many of the verification and auditing steps.

3. **Shrink** – Shrink will be reduced by decreased receiving and paperwork errors during both the distribution center receiving process and the vendor loading process.

4. **Visibility to All Assets** – Whether company owned, leased or provided by a third party, the associated assets and their utilization rates, will increase. This also increases the visibility to products as they move through the inbound and outbound segments.

The potential savings in each of these areas will be determined by the position of the variables and levers discussed in each section of this paper. For the distribution segment, the most important levers are the degree of utilization of each flow path and the sophistication of the current technology in place in the retail distribution center. The more product that is handled and the lower the level of the current technology in place, the greater the potential benefits.

In transportation, lead-time and lead-time variability are the key drivers. The benefits in these areas will be greater for retailers that have longer lead times and higher variability. Overall, the take-up of Auto-ID in the coming years has the potential to revolutionize the industry in a powerful, but silent way.

7. NEXT STEPS

In adopting Auto-ID technology, the potential benefits for each retailer will vary greatly with the unique mix of variables we have discussed. To determine specific potential benefits, each company should pursue several activities to determine the applications that will bring about the highest value in its own environment.

7.1. Value Targeting/Business Case Development

Using the levers Accenture has identified in this paper, retailers should evaluate every potential application. This step will require detailed financial and process analysis, as well as the development of a functional process/business model, using different inputs to generate a high-level business case.

Once the highest benefit areas are determined, the next step is to build these benefits into a time-phased model that will also allow the implementation costs to be considered. The result of this model will provide the retailer with the financial metrics (ROI, NPV, EVA) required to determine high value implementation areas.

7.2. Pilots/Proof-of-Concept

The results from the first phase will lead to detailed pilots that serve as the proof-of-concept for the application of Auto-ID, in the specific retailing environment. In the supply chain, this pilot might consist of processing a single vendor's products through a single Auto-ID-enabled distribution center, with the processing points in both the inbound and outbound segments having Auto-ID capabilities as well.

Pilots serve two purposes: 1) to validate the business cases and 2) to prepare the retailer for full-scale implementation and integration. A rigorous business case, validated by thorough piloting will position retailers for Auto-ID integration at scale as well as open system collaboration with trading partners across the extended value chain, once Auto-ID standards are in place.

7.3. Implementation

If the pilots are successful in realizing the projected benefits, the next step is to develop a detailed, time-phased rollout plan in conjunction with key suppliers and third-party transportation providers. Without the cooperation of these trading entities, the full scale of the benefits will never be achieved.

7.4. Managing the Unknown

While it is clear that Auto-ID applications will unlock unprecedented value in the future, the path to adoption and implementation will be a challenging one. Although many companies have implemented point solutions using Auto-ID technology, the scope and scale of the EPC™ evolution coupled with item-level tagging are unprecedented.

All the obstacles along the path to widespread Auto-ID adoption are unknown, but some of the known challenges are data storage requirements, network bandwidth and the accuracy of read rates. These issues will likely force adoption of case-level tagging applications, with a gradual transition to item-level tagging as issues are resolved. Managing this implementation process will require detailed planning and a deep familiarity with the industry.

Successful Auto-ID take-up will be comprised of several stages in an overall adoption journey. We recommend that you consider the following stages:

- Value Targeting/Business Case Development
- Pilots/Proof-of-Concept
- Implementation and integration with existing systems
- Implementation at scale and across trading partners - open systems
- Managing the Unknown

8. APPENDIX

8.1. Auto-ID Primer

Introduction

Auto-ID technology consists of several parts: eTag – an electronic tag, EPC™ – a unique identifier, Object Name Service (ONS), Savant™ Systems and Physical Markup Language (PML). By embedding the Electronic Product Code into products, intelligent and communicative objects result. This creates what Accenture refers to as a Virtual Double, where for every physical object there is an analogous data representation. In this sense, atoms and bits are aligned.

The Electronic Product Code

The first component of Auto-ID technology is the EPC™. It is a string of numbers that provides a unique identification. For instance, instead of referring to a class of products (as Universal Product Codes do), the EPC™ refers to a specific instance of a product (see Figure 8).

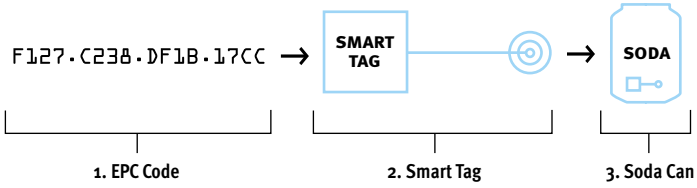
Figure 8:

1. EPC™ Code
Unique Number 96 bits long

2. Smart Tag
Made from a microchip with antenna – transmits EPC™ code

3. Soda Can
Typical Object becomes unique because of "Smart Tag"

INTRODUCTION TO AUTO-ID



To enable Auto-ID, the EPC™ is embedded in a memory chip contained within a smart tag on individual products. The chip is mated to an antenna. This allows for the smart tag to be scanned by a radio frequency "reader," which transmits the product's embedded identity code to a network, where the "real" information on the product is kept. That information is then communicated back from the network to provide whatever information is needed about that product. RFID is the basis for current Auto-ID technology. It is important to note that the baseline functionality of these tags provides read-only access to the EPC™. No information need be kept on the tag.

The Auto-ID Center standard does not preclude other tags with read-write functionality or even more advanced capabilities. However, as additional functions and capabilities increase, so will tag cost. Read-write tags also tend to be slower as well as shorter range than their read-only counterparts. Additionally, implementation of EPC™ does not depend on RFID technology; any way of being able to quickly and easily read a unique ID from a product will work. RFID is the most likely option today but technologies not yet commercialized (such as amorphous metal threads or ultra-wide band) may also play a part (see Figure 9).

The Object Name Service

The next step in the Auto-ID chain is the Object Name Service (ONS). The ONS tells computer systems where to find information about any object that carries an EPC™. ONS is based in part on the Internet's existing Domain Name System (DNS), which routes information to appropriate network interfaces. The ONS will likely be many times larger than the DNS, serving as a lightning fast "post office" that locates data for trillions of objects carrying an EPC™.

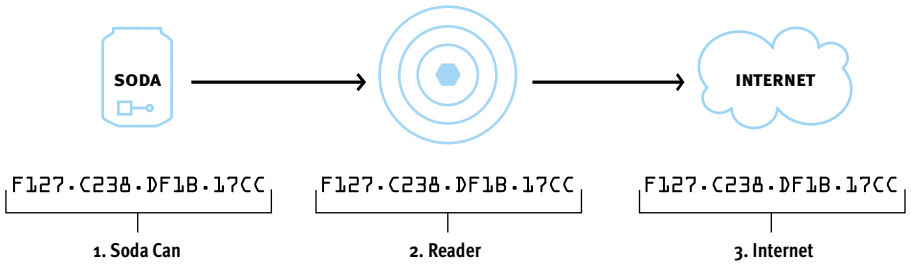
Figure 9:

1. Soda Can
Transmits EPC™ Code from embedded "Smart Tag" on side of can

2. Reader
Could be found in shelving, appliances, etc. Transmits EPC™ to Internet

3. Internet
Uses EPC™ to access unique object information

TRANSMITTING EPC™ CODE



The Physical Markup Language

Physical Markup Language (PML) is a new standard "language" for describing physical objects, in the same way that Hypertext Markup Language (HTML) is the common language on which most Internet web pages are based. Almost anything can be contained within the PML description of an object: its physical characteristics such as weight or caloric content, repair instructions and audit trails. PML will allow for manufacturers to specify and customize the information tracked on products. There will not be a vast repository of PML descriptions. Ultimate implementation of the PML descriptions will result in highly distributed data. Manufacturers, retailers and consumers will all have unique views to data. One probable outcome of Auto-ID technology is that in the same sense that product is shipped, so will access to information or the information itself.

Applications

Auto-ID applications are numerous. They include manufacturing process control (flexible manufacturing, outsourcing), inventory management (retail stocking, spare parts, and back room supplies), supply chain optimization (distribution center operations, transportation, ordering and replenishment), regulatory compliance (customs, security, tariffs), recall management and recycling.

In all these areas, Auto-ID offers the potential for significant savings, as well as new sources of incremental revenue. New services will start to emerge as objects start to become smart and interactive. As the technology becomes pervasive, benefits will extend throughout the entire value chain.

Auto-ID technology has the capability to redefine the global marketplace by embedding intelligence, identity and Internet connectivity into everyday objects. The EPC™ unites elements of the entire supply chain, making it an interactive, dynamic cycle from raw material and distribution to point-of-purchase and recycling, and back to raw material. Products equipped with smart tags will interact with manufacturers, their trading partners and each other to form an optimally efficient cycle of direct, real-time supply and demand.

8.2. Challenges

As with any revolutionary technology, there will be challenges to overcome in Auto-ID implementation. Some challenges are technological in nature, some economic, and some societal. The following topics outline these challenges and seek to address how to overcome them.

Accuracy
Readers cannot be guaranteed to be able to communicate with all tags in a volume 100% of the time. Environmental issues, the make-up of the products being tagged and the volumes of tags to be read all impact read accuracies. Nothing is foolproof. The degree of concern is proportional to how much an enterprise relies on absolute data.

RFID offers many advantages over manual or semi-automated data collection processes. Any shortcomings in accuracy can be mitigated through the use of redundant readers, information auditing and process redesign. If tagging at the pallet and/or case level, fewer tags will need to be read and accuracy will increase.

Interference
As readers proliferate, more occurrences of interference will be documented. Depending on the frequencies and powers used, devices such as phones, wireless handsets and industrial equipment may be affected. Since such a widespread penetration of RF technology has not been undertaken before, it is difficult to state explicitly what will be impacted. Good engineering and proper tuning will be important in overcoming this challenge.

The perceived health risks of this much RF may also come into play. While there is no evidence that there are any negative effects at the power and frequency levels associated with RFID, no one has rolled out such large-scale implementations yet. More research and monitoring will need to be conducted to address the public's concerns in this matter.

Performance
Smart objects will generate tremendous amounts of data. This much data will not be accessible if stored in a massive central repository, so some distributed data will be necessary. How will this distributed data be managed? Will it be accessible? How will it be accessed? The Auto-ID standard calls for read-only tags with a unique identifier. However, it is not hard to see mission critical applications where this is not a viable option. For instance, in field service, remote locations, or even on airport ground areas, speed of network access cannot be guaranteed, and it will be much more convenient to have data on the tag.

Speed of information access is important. Sub-second lookup times will be expected in many applications. Where data is kept, as well as the networking infrastructure and computing platform, will greatly influence this speed. Simply put, for EPCs™ to work, the data associated with a given EPC™ must be available on demand.

Frequency Availability
Since RFID uses unlicensed RF spectrum, the available spectra that is usable for RFID is an issue. Although there are some frequencies that are common, there is no universal standard. 13.56 MHz and 2.45 GHz are both worldwide standard Industrial, Scientific and Medical (ISM) frequencies. These are available in most parts of the world, albeit at slightly different restrictions. However, more useful in terms of read range and speeds are tags operating at roughly 915 MHz or ultra-high frequency (UHF). The UHF spectrum around 900 MHz is not universally available at the same frequency and power levels worldwide.

This will be addressed through two potential methods. The first alternative is multi-frequency readers. Overall RF system design (integration of antenna, readers and tags) is the most difficult part of the problem. The second is to select a common frequency. Obviously, since this involves millions of stakeholders, the lead-time on this will be considerable. This does not, however, deal with the fact that not all frequencies work well for every application (although some work well across virtually all applications).

Security
Security is paramount, and contains many levels. There is read security (or being able to read the tag), security of the data, and many other security issues. For users of the technology to feel comfortable, there will need to be assurances that no one will be able to "hack" into a smart object. As long as tags are read-only and are difficult to counterfeit, then security will be somewhat a given. Users of Auto-ID technology will also need to rely on the security of Auto-ID data on the network.

Data Ownership
Related to security, data ownership is an issue. Who "owns" the massive amounts of event information associated with an object? It is clear that the manufacturer owns the design specs and other PML type data for a given product. It is clear who owns captured data - the owner of the reader that read the tag. It is less clear, however, how information will be shared.

Many parties will be privy to and will update the data for an object as it passes though a supply chain. Will those collecting the data even want to share data (consider a shipper with less than stellar turn-around times – would they be interested in sharing item-level tracking information?). Does an end-user (consumer) ultimately "own" a product and its data, and if so, how does use of that data for process improvement or data mining impact privacy?

Lastly, although killing a tag when purchased has been discussed as an option, this method eliminates future recycling benefits, and also introduces the potential of tags being killed maliciously or by accident, before they should be.

Privacy
Finally, a large, mostly perceived risk in Auto-ID, falls within the area of privacy concerns. The idea of tracking products into the home is troubling to most concerned parties. Consumer fears in this area are sparked by a lack of understanding of the limitations of RFID. Education is the key here – as people learn about when and how the technology works and what exactly is stored on the tag, the privacy concerns may lessen. Also, as consumers see value in the technology, acceptance will increase. For instance, consider stored warranty information that can help a consumer if repairs are needed or recycling information that can earn them a credit for being environmentally conscious.

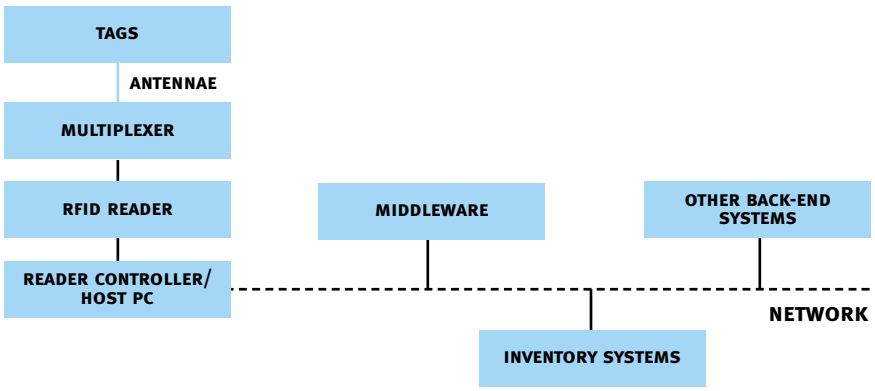
Even with education, there are some legitimate competitive issues. Retailers may see the technology as an aid to their competitors. For instance, since the EPCs™ will be global and unique, it may be possible to determine specific product information from the EPC™ given enough data. Imagine knowledge of your competitors' shelf assortment and inventory levels gained through a store walkthrough, accompanied with a hand-held reader. This information is available now. The technology simply makes it easier to obtain.

8.3. The Elements of Cost

The Basics of Cost
Radio frequency identification (RFID) tags are the most frequently cited cost component in Auto-ID implementations. This is not the whole story. Tags, readers, antennae, controllers, middleware, operations and maintenance all contribute to the total cost of ownership. Only by factoring in all of these components, tailored to a given situation, can costs be accurately estimated. Figure 10 gives a schematic of the various components of an Auto-ID system roll-out. This section outlines each of these components and offers recommendations to calculate the overall cost in a business case for Auto-ID.

Figure 10

REPRESENTATIVE AUTO-ID IMPLEMENTATION



Tag Costs

RFID **tags** are usually the first of the costs associated with an Auto-ID system. There are as many tag variants on the market, as there are potential applications. Changes in form factor, memory capacity, read or read-write capability, active or passive configurations and range, all impact the cost of tags. When calculating tag costs, the application requirements are the primary driver.

The target cost of an Auto-ID Center compliant tag is five cents i.e. read-only containing an EPC™. Note that this cost is a future "volume" target. By way of comparison, commercially available read-only tags in the UHF spectrum today cost approximately fifty cents per tag, in volume.

The cost of the tag is not the final figure. Conversion costs must also be factored in. Conversion in this case, means application of the tag to a product's packaging, to the product itself, or to cases or pallets. It also implies associating the EPC™ code with the actual product - known as "commissioning." Commissioning may mean writing the pre-assigned EPC™ to the tag (or programming) or alternatively, reading the predefined EPC™ value on the tag. Then the proper PML associated with that particular EPC™ should be updated.

The product being tagged will greatly influence conversion costs; will the tag require a standoff (in the case of metal mounts)? Will the tag need to be concealed? Will the tag antenna be printed or metal coil? These factors will increase the baseline tag cost. How much of an increase depends on the application. If the tag requires a printed label, then a label printer/RFID writer may also need to be purchased.

Reader Costs

Readers energize passive tags with energy, receive the results and very often, handle the low-level anti-collision algorithms that allow readers to read more than one tag at a time. Readers are generally controlled via application programming interfaces (APIs) that are provided by the reader manufacturer. Generally, the API also allows for configuring the reader's read cycle, power or other settings. The API for a given reader may have additional costs associated with it, although many providers bundle the software.

Reader costs vary as a function of range, speed, robustness, network readiness and antenna capability. The longer, faster or more hardened a reader is, the higher the cost. For readers at the lowest end, a PDA application may run $200 USD. For shelf or forklift installations, readers may reach $2,500 USD, and for high-speed conveyor or dock door applications, from $2500 up to $10,000 USD. These ranges are based on today's commercially available equipment, although they will drop as volume of readers produced increases.

Antennae and Multiplexers

Antennae are another component of the reader subsystem. Whether it is a shelf, mat, portal, wand or directional antenna, different antennae will be required for different applications. These can range in cost from $25 to $500 USD, depending on application and base operating frequency

Depending on how many antennae are required, one or many **multiplexers** may be necessary. A multiplexer allows many antennae to be physically connected to a reader. Expect to pay $500 to $2000 USD per multiplexer, depending on the number of ports. A configuration using multiplexers may also require an additional communications card such as an RS-485 (roughly $250 USD) on the controller.

Lastly: **cabling**. As in high-end audio, cables really do matter. Although there are generally fewer limits on the distance between reader and controller, there are signal degradation effects in the cables connecting readers and antennae. High-grade RF cables for this purpose can be expensive. Look to spend up to $10 USD per linear foot, keeping in mind distance limitations.

The entire reader antennae/multiplexer setup may be referred to as a "read point."

Installation

Installation is the next major cost. Physically mounting antennae, power supplies, multiplexers and readers can be costly, depending on the environment. Many readers will need to be installed in warehouse or industrial environments. Still others will be installed on equipment such as forklifts or various handling equipment. Retrofitting existing sites or material handling equipment can add to the cost.

Readers and antennae may need to be concealed if aesthetics are to be considered (such as in a retail environment). In the case of a warehouse or plant installation, equipment may need to be hardened to handle the environmental abuses that come with such locations. Power drops, often at union rates, must also be provided to the location of the readers. Depending on the environment (for instance, retail stores may not have power available at all merchandise locations) this cost may be considerable.

As with power, network capability may also be required. This is a "may" because the reader and controllers may utilize existing wireless LAN capability to communicate with other systems. Otherwise, some sort of connectivity will be required between the controller and the reader. This can be Ethernet (CAT-5) or other serial communication. This cabling must also be installed, shielded or concealed, depending on application.

Controller costs

For every reader or group of readers a **controller** will be required. A controller is simply a computer, running software to control the reader. Initial processing, event firing and some diagnostics run on this PC. The controller need not be a very high end PC unless it needs to be hardened for factory or other industrial applications. Approximate cost: $1000 to $3000 USD.

Tuning

Another cost in an RFID solution is the **tuning** phase. Every physical environment will interact with radio frequency waves in a different fashion. The RF field will need to be measured for dead spots and adjustments made. This cost is highly variable, given the expertise needed, selection of reader systems, and the vagaries of RF fields.

Software Costs

The next level up from the hardware is the controlling software, or **middleware**. This software translates tag reads into business events. Middleware is where much of the action takes place and is justifiably receiving a lot of attention.

The middleware will be a distributed system. At the very least, it will run on one or more servers plus the software running on controllers. All middleware serves pretty much the same function: it translates tag events into business events, aggregates data from item level actions to those used in current Enterprise Resource Planning (ERP) and Warehouse Management Systems (WMS), and provides publish and subscribe interfaces, so that applications may register interest in business events. The middleware will provide abstraction layers for connecting various types of readers and will provide for basic business rule engines. Furthermore, middleware should provide for read point monitoring and diagnostics.

However, it is important to realize that almost every implementation of middleware will be highly dependent on business rules, existing systems and the desired level of control. Commercial variants of middleware include the Savant™ from the Auto-ID Center, Accenture's Silent Commerce Infrastructure, ConnecTerra, SAP's Adaptive Networks and Savi's SmartChain and UDAP. These all vary in cost, from free (in the case of the Savant™) on up, however their capabilities also vary greatly.

Integration Costs

No matter what the middleware chosen, integration costs will be a large factor in an Auto-ID implementation. It will be in the order of magnitude of the cost of readers and installation combined, depending on the number of legacy systems affected. It goes beyond simple integration. Some systems may need to be replaced altogether if they are not capable of taking advantage of incrementally large volumes of real-time data from Auto-ID technology.

Maintenance

In addition to one-time costs, the ongoing **maintenance** and upkeep of an Auto-ID system should be factored into ROI calculations. Factors influencing maintenance include hardware upgrades, replacement of failed or damaged equipment, ongoing firmware and middleware upgrades and any software or licensing fees. Also, ongoing tag purchases and battery replacement (for active tags) should be factored into operations and maintenance costs. A standard software license and maintenance agreement usually runs approximately 10% per year. This is a good estimate for these systems. Finally, since so much physical infrastructure is involved, the depreciation of equipment must be factored in as a cost item.

Workflow

The last pieces of the puzzle are the **process** and human elements of Auto-ID. Many existing processes, especially inter-company processes, will need to be redesigned. Current batch, or paper-based processes will need to be eliminated and reinvented. Essentially, new workflows may need to be created.

When more information is available through Auto-ID, increasing peoples' ability to act on that information must also be enhanced. Training of personnel in new processes and technology should be added into overall implementation costs. Journey management will become a necessary discipline in order to fully address Auto-ID implementation at scale.

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