

## Applications of New RFID Tag Technology

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## TABLE OF CONTENTS

I.	List of Figures	2
II.	Introduction	3
III.	Technical Capabilities	
	a. Active vs. Passive	3
	b. Memory	3
	c. Speed	4
	d. Security	5
IV.	American Apparel Item Level Tagging	
	a. Application	6
	b. Technology	7
V.	Copenhagen Airport Passenger Tags	
	a. Application	8
	b. Technology	8
VI.	METRO Group's Real Future Store Keeps Meat Stocked and Fresh	
	a. Application	9
	b. Technology	10
VII.	Conclusion	10
VIII.	Sources	12

### I. List of Figures

<u>Figure #</u>	<u>Figure</u>	<u>Page #</u>
III.1	Memory Capacities of Varying Frequency Bands and System Types	4
III.2	Speeds of Varying Passive Standards	4
III.3	Security Features of Varying Frequency Bands and ISO Standards	5
IV.1	System Software Passenger Diagram	9

## **II. Introduction**

Radio-frequency identification (RFID) is a relatively young technology that is ever-changing everyday around the world. New advancements to its five main components of readers, antennae, management system, enterprise application software and transponders allow for the daily discovery of new applications. This report will focus mainly on the innovations made to the memory, speed and security of tags and how companies are using this new technology to increase efficiency as well as safety.

## **III. Technical Capabilities**

### **III.A Active vs. Passive**

The technical capabilities of a tag highly depend on if it is either an active or passive one. Active tags possess an internal battery while passive tags must reflect energy from the reader or absorb and temporarily store a small amount of energy from the reader's signal to generate a quick response. Active readers can generate low-level signals to the tags while the tags can generate back high-level ones. Passive tags require very strong signals from the reader and generate low ones back to the reader. Active tags also have longer communication ranges that go up to 100 meters while passive ones max out at 3 meters.

### **III.A. Memory**

Active transponders have large read/write data storage. They have sophisticated data search and access capabilities. Current active tags range in memory from 64 bits to 128K. Passive transponders have very small read/write data storage with no search capability or other data manipulation. Passive tags generally range in memory from 32 bits to 64K. In Figure III.1 below different memory capacities of varying frequency bands and system types are shown. The dark blue shaded boxes represent tags that are widely available, light blue for available ones and white for not available.

Frequency Band	System Type	Memory Capacity (Bytes)								
		16	64	256	512	1K	8K	16K	32K	128K
LF	Passive	Blue	Blue	Light Blue	Light Blue	Light Blue				
HF	ISO 14443	Blue	Blue	Blue	Blue	Blue	Blue	Light Blue	Light Blue	Light Blue
	ISO 15693	Blue	Blue	Blue	Light Blue					
UHF	Passive	Blue	Blue	Light Blue						
Microwave	Passive	Blue	Light Blue							

Table Provided by “RFID Technology, Hardware and Standards” Prabhu, UCLA-WINMEC

Figure III.1: Memory Capacities of Varying Frequency Bands and System Types

From Figure III.1 above one can see that in low, ultra and microwave frequency bands, which are all passive systems, the memory capacity maxes out at 1KB. For the two active systems in the high frequency band, the memory capacity is much higher reaching 128 KB.

### III.B. Speed

There are several speed characteristics of tags: read rate, data rate, collection rate, and also speed of a tag in motion in which it can still be read. Figure III.2 below displays the different speeds of four popular standards.

Standard	Speed	Read Rate	Data Rate
ISO 15693 (13.56 Mhz)	0.5 m/s	30 tags/sec	26-28 Kbps
ISO 11784/11785 (125, 134.5 KHz)	1 m/s		57 Kbps
EPC Class 0, 1 915 MHz	3.3 m/s	400 tags/sec	80 Kbps
EPC Class 1, Gen 2	3.3 m/s	1500/sec US (600/sec EU)	27-128 Kbps

Table Data from “RFID Technology, Hardware and Standards” Prabhu, UCLA-WINMEC

Figure III.2: Speeds of Varying Passive Standards

Although all standards above in Figure III.2 are passive RFID systems they still vary in speed performance. EPC Class 1 Gen 2, the most dominant and common standard in the market, have a speed of 3.3 m/s, a read rate of 1500/sec and data rate of 27-128 Kbps. These specifications compared to the earlier standard of EPC Class0, 1 show how quickly the technology is advancing.

### III.B. Security

Security for all RFID systems is an extremely vital aspect to the technology. There are many fears of security breaches that could lead to personal identification theft to counterfeiting. Luckily, there are five main security features that current RFID tags contain: write lock, password, authentication, stream encryption and crypto-processor. Each feature is a more secure advancement than the one listed before. These five security options are available for both active and passive systems. Write lock is a feature in which once a tag is written on it can only be read from there on out and is thus “locked” from further writing. The password feature necessitates the need for a password by the tag before it can be written on. Authentication prevents tags to be read by unwanted users by authenticating readers before allowing them to be read. Stream encryption along with crypto-processors use complicated algorithms in which their complexities depend on the key bit sizes. Most of these security features can be mixed and matched depending on one’s security needs.

Although it may seem like these five protection schemes are enough, since RFID technology is still developing, many of these features have not been fully tested as hack-proof. In fact, teams of hackers are proving that most can be beat with the right amount of knowledge of how the technology works.

Frequency Band	ISO Standard	Transponder Type	Security Features				
			Write Lock	Password	Authentic-ation	Stream Encryption	Crypto-Processor
LF		Memory	Dark Blue	Dark Blue	Light Blue	Light Blue	White
		Microcontroller	Dark Blue	Dark Blue	Light Blue	Light Blue	White
HF	14443	Memory	Dark Blue	Dark Blue	Dark Blue	Dark Blue	White
		Microcontroller	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue
	15693	Memory	Dark Blue	Light Blue	Light Blue	Light Blue	White
UHF	18000-6	Memory	Dark Blue	Light Blue	White	White	White
Microwave	18000-4, -5	Memory	Dark Blue	Light Blue	White	White	White

Table Provided by “RFID Technology, Hardware and Standards” Prabhu, UCLA-WINMEC  
 Figure III.3: Security Features of Varying Frequency Bands and ISO Standards

As with Figure III.1, the dark blue shaded regions stand for features that are widely available, light blue for available and white for not available. From Figure III.3 above, one can see that all

of the above frequency bands and ISO standards have write lock because it is so basic. As the security feature increases in complexity, less and less tags can implement them. The most advanced security feature is the crypto-processor which is only used by the high frequency ISO 14443 microcontroller.

## **IV. American Apparel Implements Item-Level Tagging**

### **IV.A. Application**

American Apparel, a clothing retailer operating more than 180 stores in 13 countries, began a pilot program at their Columbia University store implementing item-level RFID tagging in October 2007. The program implemented Vue's TrueVue software platform to manage Electronic Product Code (EPC) and inventory data. They used Motorola readers to collect the data and Avery Dennison tag inlays. The program is to help improve inventory accuracy along with having better-stocked sales floors. Almost instantly the company saw benefits from the technology. The weekly process of taking inventory of all items in the store went from requiring four workers and eight hours to just two workers in two hours. This extra time created allows for the employees to focus more on customer service as well as to carry out other duties.

What makes American Apparel stores unique is that they have one of every item on the floor; meaning they have one of every size, color and style out at all times to ensure each garment is fully represented. This means that when an item is purchased, that particular model, size and color is out of stock on the sales floor. Previously, employees would periodically take sales lists at the check outs and then make trips back to the stock room to restock the floor as long as the store's inventory showed it was in supply. With the new RFID program, each item's tag would be read by an interrogator at the point of sale upon purchase. The data is then transmitted to the Vue software which triggers an alert on the stock room computer informing stockers that that particular item was sold. As soon as the alert arrives, the worker finds that item and restocks it on the floor. As the employee leaves the stock room to enter the sales floor, they pass by a reader antenna that reads the item's tag and sends the data back to the software, which updates the stock's location to the sales floor. With the success of the pilot program at Columbia

University, American Apparel placed an initial order, lasting for 6 months, of 1 million tags to supply a 17-store rollout of all its New York stores.

#### **IV.B. Technology**

The stores will be utilizing Avery Dennison AD-220 EPC Class 1 Gen 2 passive inlays. For the pilot program the tags are attached to all items of clothing as they are received from the manufacturing center in Los Angeles. An EPC encoded to each item will be associated with that garment's style, size and color. Eventually, they will bring the tagging of items back to the point of manufacture. Once shipments leave the distribution center, fixed Motorola XR440 interrogators at the dock doors will read a hand-applied EPC Gen 2 shipping label attached to each case of items. These cases will then be associated with EPC's encoded to all items within that case. All of this data along with timestamps and locations will be transmitted to the TrueVue software platform. Upon arriving at the retail store, another Motorola XR440 fixed interrogator will collect the EPC data and send it to the store's Vue software, which will compare the received goods with the factory's advance shipment notice. The software will then add the items to the store's inventory. Workers will use Motorola MC9090-G RFID handheld readers in order to take periodic inventory of all items on the sales floor.

One last concern is what eventually happens with the RFID tags. During the pilot program, tags were removed from items at the point of purchase for reuse. At the new stores tags will remain on the sold items, since they will not be recollected and reused.

#### Avery Dennison AD-220 Inlays

The AD-220 is an Ultra High Frequency passive inlay. An inlay, which consists of an RFID chip and antennae, is only one component of a complete tag. They are compliant with the EPC Class 1 Gen 2 protocol. They possess 96 bit read/write memory while operating at frequencies ranging between 902-928 MHz. Their read range is from 6-8 feet. They are also 4 inches by 0.5 inches in size. The cost of these inlays when sold in bulk (by the millions) is about 8 cents each.

## **V. Copenhagen Airport Passenger Tags**

### **V.A Application**

Copenhagen Airport is testing a combined system of active RFID and Bluetooth technologies in order to create a detailed traveler flow map in the terminal to help reduce delays and to improve the overall layout. Approximately 4% of all flight delays are caused by passengers arriving late to their gates. The Gatecaller system will track passengers' locations within the terminal and alert them via cell phone if they are detected to be far from the gate as their flight begins boarding. It uses a credit-card sized active RFID tag that passengers receive at check-in and return when boarding. The system is being developed by a conglomerate that includes Lyngsoe Systems, Copenhagen Airport, the IT University of Copenhagen, Blip Systems, and the Riso National Laboratory. This three year project called SPOPOS (the Danish acronym for "tracking technology personal and operator services") is backed by a \$2.7 million grant from the Danish government.

Scandinavian Airlines (SAS) had a successful live trial with 106 passengers, all whom registered their names and cell phone numbers, from one its flights. The system will not only reduce stress for passengers but it will also further the airport's goal of being "silent"; without frequent calls for passengers over the public address system. The last benefit of this system is that passengers' locations will be known in real time so that staffing levels can be adjusted on the fly. They will know when they need increased manning at the security lines because they can see that there are a lot of people checking in who will be going through security within the next few minutes.

### **V.B Technology**

Lyngsoe RFID readers and Blip Systems Bluetooth transmitters are installed at 25 key "gateway" points throughout the terminal to track passengers passing by. Active RFID tags transmitting at a frequency of 433.92 MHz are used. Currently, passengers can only be tracked within a 100 square meter area that can increase in the future. The complementary RFID and

Bluetooth systems are calibrated against each other so that passengers can be 100% accurately tracked. The diagram below depicts how the software and system work.



Image taken from RFID Journal "Copenhagen Airport Pilots RFID Tags for Passengers"

Figure IV.1: System Software Passenger Tracking

Figure IV.1 shows a diagram of the airport terminal along with various colored dots that represent tracked passengers. Green dots represent passengers that are near the proper gate. Yellow dots (not pictured above) indicate passengers who are some distance away, but who will still be able to make the flight. The system calls or sends a text message warning them about the impending takeoff. Red passengers are too far to be able to reach the gate in time. With this knowledge, airline personnel can pull those customers' bags from the aircraft and begin rebooking them.

## **VI. METRO Group's Real Future Store Keeps Meat Stocked and Fresh**

### **VI.A Application**

Metro's Real Future Store in Toennisvorst, Germany is using RFID tags to track individual packages of meat, ensuring the store's display cases are well stocked, and that no customers

purchase expired products. The Avery Dennison tags are attached to the plastic foam trays that displays the fresh meat. Each meat tray is fitted with RFID labels containing a unique EPC number which links to data, such as expiration dates, about the product from the internal EPC Information Services database. The system, called “Smart Freezers”, contains 50 compartments that total around 35 meters in length, 1.4 meters in depth and 1.5 meters in width with three to four rows of meat stacked within each freezer. Each compartment also contains a reader and antennas to make sure that once a particular tray of meat is removed from the freezers a notification is sent to the butchers so they can replace the item immediately. Having the trays tracked in real time also allows the butchers to be notified if a product is close to its expiration date.

## **VI.B. Technology**

.Two challenges of meat packing is to ensure a hygienic environment so that the product does not come in contact with the tag electronics and also in making sure the tags can be read when meat-filled trays are stacked three deep in a refrigerator or freezer. The RFID tags chosen were Avery Dennison AD-222 passive inlays. They are UHF and EPC Gen 2 compliant. They had the right characteristics; readable from a variety of angles by both fixed and handheld interrogators. The 4 inch by 1.5 inch tags are placed to wrap around the corner of the foam tray and include a special adhesive with clear plastic laminate provided by Fasson Roll Materials Europe, a division of Avery Dennison. The laminate goes directly over the tag itself and provides a barrier between the meat and the electronics. The 50 compartments of the system each contain an Impinj Speedway reader and four antennas placed in each corner that capture real time tray ID numbers and send that information to the back-end system via a cabled connection.

## **VII. Conclusion**

The market use for RFID technology is on the rise around the globe. Applications requiring both active and/or passive tags range from retail, manufacturing, healthcare, airports, and even in sports. Although active tags have more technical capabilities, passive tags are

currently dominating the market in new applications mainly due to their much lower costs and discrete size. The American Apparel application was chosen because it was unique from other retailers, such as Wal-Mart, in implementing item-level tagging as opposed to just pallet and box tagging. The Copenhagen Airport passenger tracking system was chosen because it utilized and combined an active RFID system along with Bluetooth technology. The last application with Germany's Real Future store was chosen because of the growing idea of smart convenient and grocery stores and also because of the concern they had with tags not being read when in close contact with meat. Ultimately, these three RFID tag technology applications increased a company or entity's efficiency. RFID implemented on a global stage has the potential to make the world much more effective in helping everyone save both time and money.

## **VIII. Sources**

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