RFID ITEM LEVEL TAGGING

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Summary: Item level tagging (ILT) has proven to be as controversial as it is exciting. Some industry experts contend that it will be become the largest sub-sector of the RFID market. It is exciting because of the business benefits of tagging all high value items individually on an assembly line, in a research or manufacturing facility, or even in a retail environment. It is controversial because there are many unanswered questions about its feasibility, its costs, and the appropriate frequencies for ILT. Then there are privacy, security, and regulatory concerns that are critically important to adjudicate before making large investments into this technology. Another consideration is that item level tagging has special requirements. In many cases, the tags need to be quite small, have high read accuracy, and be compatible with multi-tag reading. There are questions about whether new air protocol standards need to be established to meet the requirements of item level tagging.

Key words: Radio frequency identification, tag, item level tagging (ILT), retailer, frequency band

Anotace: Značenie na úrovni položiek (ILT) sa preukázalo byť kontroverzné a vzrušujúce zároveň. Fundovaní priemyselní odborníci tvrdia, že táto úroveň má potenciál stať sa najväčším podsektorom v rámci RFID trhu. Vzrušujúce z titulu obchodných úžitkov indivuduálneho značenia akýchkoľvek položiek s vysokou pridanou hodnotou na montážnej linke, pri sledovaní alebo vo výrobnom procese, resp. na úrovni maloobchodu. Kontroverzné z hľadiska mnohých nezodpovedaných otázok ohľadom realizovateľnosti projektu, výšky nákladov, či vhodných frekvencií pre ILT. Zároveň je potrebné definovať charakteristiky týkajúce sa bezpečnosti, ochrany súkromia, či regulácie, ktoré sú dôležité pre zhodnotenie, či je vhodné investovať prostriedky do takýchto technológií.

Klíčové slová: Rádio frekvenčná identifikácia, tag, značenie na úrovni položky (ILT), obchodník, frekvenčné pásmo

1. PREFACE

Initial large RFID deployments focused on compliance-oriented supply in applications. It was primarily 'slap and ship' for suppliers to the large U.S. retailers. Most suppliers were so focused on meeting the requirements of the mandate that they spent precious little time viewing how to integrate RFID into their total operation, which would have allowed them to realize the true promise of RFID. Nevertheless, any exciting applications that go well beyond the basic EPC mandates are now emerging, especially in the item level tagging arena.

Item level tagging (ILT) has proven to be as controversial as it is exciting. Some industry experts contend that it will be become the largest sub-sector of the RFID market. It is exciting because of the business benefits of tagging all high value items individually on an

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assembly line, in a research or manufacturing facility, or even in a retail environment. It is controversial because there are many unanswered questions about its feasibility, its costs, and the appropriate frequencies for ILT. Then there are privacy, security, and regulatory concerns that are critically important to adjudicate before making large investments into this technology. Item level tagging significantly increases the number of tags employed, raising the overall tagging costs. Of course, one could argue that there are higher opportunity costs in not embracing item level tagging. Another consideration is that item level tagging has special requirements. In many cases, the tags need to be quite small, have high read accurancy, and be compatible with multi-tag reading. There are questions about whether new air protocol standards need to be established to meet the requirements of item level tagging.

What appears definite about ILT is that it is poised for significant growth over the next decade. RFID consultancy and research analyst firm has projected substantial growth for ILT. With a 2008 base of 200 milion tags, IDTechEx has projected that worldwide RFID tag market of $26 billion. Unlike the RFID adoption in the past few years, compelled by large retailer and government mandates, IDTechEx points out that those who adopt ILT will do so willingly to take advantage of its benefits and that ILT will quickly become the largest market for RFID.

2. THE PROMISE OF ILT

RFID tags enable the automatic identity and accounting of objects, computers can track, monitor, and perform actions on those objects. Therefore, item level tagging refers to tags placed on individual items of clothing; or on each book; or upon each letter tray, bag, or package at the postal office; or on each manufactured part. ILT is expected to dwarf in number and in dollar value the tag volume currently used by consumer goods companies.

ILT is growing faster than many realize - with estimates of 200 million or more ILT tags in 2006. This is occurring despite the industry mantra that item level tagging will make sense only when the tag prices approach 1.05 per tag. The average price for an ILT tag in 2006 was $.35. As with other industries, value always trumps price. If an ILT application provides the appropriate level of value to a given organization, then the ice of the tag isn't an issue. Still, with the exception of Marks & Spencer the UK, few ILT applications are happening in retail despite the high profile of that industry as a result of the RFID mandates. Instead, pharmaceuticals, books, laundries, event ticketing, and high value items such as ladies' hand-bags, engineered precision parts, and tires are leading the way.

RFID is the tagging of discrete objects to convey information over a short distance. But in using the power and availability of the Internet, RFID systems can convey data over very large distances in a seamless system for tracking goods. RFID holds real promise in tightly integrating the physical world with existing computer systems. Conceptually, organizations can use RFID tags to identify items anywhere in the world. When objects are tagged with unique electronic identifiers, they can be linked to a variety of online data. Once these objects are online, Internet of Things can truly begin to evolve. Of course, the Internet today does not extend beyond the electronic world. Object hyperlinking aims to extend the Internet to the real world by attaching tags tied to URLs to tangible objects. These tags can then be read by a

mobile device, and information about objects can be retrieved and displayed. As RFID migrates to an open, Web-enabled platform, users can tag, update content, and share information regarding the digital existence of their objects.

ILT CHALLENGES

ILT creates a new set of challenges that are somewhat dissimilar from other RFID applications. Some of the characteristics of ILT include:

- Tagged items must be suitable for mass serialization
- The tags must be very small, but the form factor of the tag can vary significantly
- Exceptionally high read accuracy is required
- The tags must either be disposable or must survive through the product lifecycle
- The cost of item level tags should be less than 1% of the value of the product to which it is affixed
- Tag volume will eventually reach the trillions

Many of the obstacles of ILT are financial, including the cost of tags and the cost of multiple readers and the reader network infrastructure. Tagging cases and pallets of goods is one thing, but tagging each and every item or component of a complex item can be daunting and expensive.

There are also a number of technological and operational obstacles, including the use of multiple readers which may interfere with each other and the high volume of data that must be distilled and assimilated by middleware systems that are not yet mature. After all, ILT provides a highly granular viewpoint, and the data derived from ILT applications can overwhelm some RFID systems. Picking, packing, and shipping activities; tracking expiration dates of inventoried items; and product tracking for recalls creates data. In some cases, tags must be read in conditions where the products are clustered close together in large groups. And then there are the issues of metal and liquids, especially water - even glass and plastic can impede to some extent, depending on the tags and the ambient noise conditions in the reader environment.

There is also a huge range of applications with differing requirements. The technical requirements for tracking mission critical aircraft or automotive parts tend to be particularly challenging and require hardening of the tags and may require battery-powered solutions. For these applications, tag prices are almost a non-issue; it is all about achieving the technical specifications. On the other extreme, tagging of individual consumer items is more of a financial matter.

Operation issues include the need to tag the items far back in the manufacturing process and to choose the correct type of tag, including size, placement, frequency, air protocol, spatial offset from contents, etc. The size of the tag is another huge issue. UHF tag size is not a concern when its tags are affixed to large cases and pallets. However, inconspicuous tags on DVDs, access tickets, or small machine parts are another matter altogether. Privacy issues must be considered and addressed, particularly in the retail environment where their veiy

existence might convey the perception of tracking individuals' buying choices with no voluntary consent or opt-in.

As a result of these challenges, many companies which champion ILT solutions are focused on the more lucrative opportunities first. There tend to be applications where a given enterprise has a severe problem that RFID can cost effectively resolve. Meanwhile, the market continues to grow and widen with new applications for ILT emerging daily.

3. EPC AND ILT

The opportunity for ILT is so large that EPCglobal has been exploring potential applications for RFID at the item level for some tune-EPCglobal has created an Item Level Tagging Joint Requirements Group to address tag performance as well as security and privacy issues. They identified seven critical scenarios that use RFID at the item level. These scenarios are markedly different than the supply chain's pallets and cases. The tags originate further back in the manufacturing process and go further in retail operations. EPCglobal held a 2-day technology event in March 2006, participated in by 23 RFID technology vendors using passive tags at LF (125 KHz), HF (13.56MHz), and UHF (902 to 928 MHz) frequency bands to demonstrate seven ITL scenarios. EPCglobal was trying to determine which frequency bands were best suited for ILT and whether it should produce new air-protocol standards to meet ILT requirements. The tagged items included clothing, DVDs, and drug containers. EPCglobal was reticent in not declaring which frequency band performed best. It simply stated its determination to analyze the results and develop any additional air protocol standards, as needed.

3.1. HF Versus UHF

There is a growing debate among proponents of RFID technology regarding which frequency band is best for item level tracking. Most of the debate has centered on HF and UHF. HF proponents got there first with a technically feasible solution; Wal-Mart and other UHF proponents naturally want the solution to tilt to EPC UHF, providing them for the convenience of one radio frequency and air protocol.

The debate is about performance variability. UHF clearly has an advantage in read range, but the tags just don't work well around water and metal or very close to each other. That is generally true when UHF uses its normal far field communications (FFC). With UHF, radio waves can bounce off objects further away. Other concerns include: the UHF tags are larger, too big for some items; the UHF readers are relatively more expensive; UHF has too great a range for some ILT applications; and UHF is more susceptible to noise. On the other hand, HF tags use inductive coupling and are operating in the near field which means that the tag is within one wavelength of the reader. Moreover, HF tags demonstrate less performance variability around water and metals, and they penetrate other materials better than UHF. HF is the more mature RFID technology, and it has demonstrated higher read rates and accuracy than UHF - so far. However, even HF does not attain 100% read rates.

3.2. The Other ILT Frequencies

One of the criteria for some item level tracking applications is employment of a very small tag; and none is smaller than the Hitachi μ-chip, which operates in the 2.45 GHz (microwave) frequency. Because antenna length is inversely proportional to the frequency, the passive 2.45 GHz μ-chip tag has a very small 2-inch antenna length. There are a number of applications where the form factor of the tag, including its size and simplicity is the determining factor for selecting the RFID tag solution. In application, the chip might be affixed within the paper-based item itself or within a very small label. Low cost is a factor as well. The μ-chip tag, for example, was designed as a disposable, low-cost authentication solution for high value items. Today, it costs nearly half of the average ILT HF tag cost, and costs will continue to decrease with higher volume production. Some tags such as the μ-chip tag are impervious to typical gamma ray levels used for sterilization. That opens the door to ILT markets in which items are subjected to gamma radiation and to a number of specialized applications in industry. The powerful nature of gamma rays has made them useful in the sterilization of medical equipment by killing bacteria and viruses. They are also used to kill bacteria and insects in foodstuffs, particularly meat, spices, marshmallows, pie, eggs, and vegetables in order to maintain freshness. Aside from medical sterilization applications, there is movement to require routine gamma ray imaging of cargo containers at arrival ports to capture contraband cargos and improve cargo security. Most RFID tags and the data written to them cannot survive gamma radiation; however, the 2.45 GHz μ-chip tag does.

3.3. Surface Acoustic Wave Transponders

A surface acoustic wave (SAW) is an acoustic wave that travels along the surface of a material that is somewhat flexible (e.g., elastic). Electronic devices employing SAWs normally utilize one or more inter-digital transducers, which are basically components that convert the acoustic waves to electrical signals and vice versa. SAW devices are used mainly as filtering devices and are used extensively in cell phones, but they have promise as an alternative to silicon-based RFID transponders.

SAW technology is commonly used in the electronic circuitry of everyday appliances, such as mobile phones and televisions, where the waves are used to filter frequencies. SAW RFID technology provides a way to solve problems facing companies that have been unsuccessful in deploying common RFID technology to identify, track, and catalog tagged items in harsh environments or where long read ranges are required. In addition, SAW tags can report temperature, which is especially important in the harsh environments of manufacturing. High temperature antenna SAW tags have been used to read real time temperature within 1° F.

SAW tags use piezoelectric crystals with "reflectors" at predetermined intervals to represent their data (which can be read by variations in amplitude, time, phase, or other variables). When the incoming radio energy is transduced to a sound wave, propagating along the surface of the tag, each location reflects part of the signal back. The spacing of these reflections (or echoes) indicates the location and relative position of each reflector. The position of each reflector can then be calculated and translated into a data representation.

SAW transponders are constructed as "read only" devices whereby the properties of the transponders provide for the "physical" encoding of a unique number that can be anywhere between 16 and 32 bits in length. The encoded data cannot be changed and is essentially a factory programmed device. While SAW devices may not be affected by the materials that they are affixed to (e.g., water bottles), the productization for an alternative to RFID is yet to be taken on by manufacturers of the technology.

For many ILT applications, microwave RFID will not challenge HF or UHF RFID solutions. However, there are many other ILT applications where tag size does matter, and the HF and UHF tags simply cannot match the versatile form factors of microwave RFID. In those scenarios where size is the paramount determinant of the RFID solution, microwave tags are the natural choice. Microwave may well mount the biggest challenge to the HF domination in some market niches.

There are some notable LF ILT applications, but most indications are that LF is highly specialized for returnable asset ILT for several reasons, which include cost and tag form factor. In order to achieve distance, the inductive coil of an LF tag is generally more expensive than HF or UHF tags, and the tag form factor does not approach the thin flexible form factor needed by some applications. LF tags are best suited to applications such as beer kegs, compressed gas cylinders, and lost pets.

4. CONCLUSION

As has been discussed, most ILT systems today make use of HF technology. The reality is that, except for the United States, most countries do not allow an adequate level of UHF power or RF bandwidth to support various ILT applications. Even in the United States, far field UHF has not been highly successful for ILT. Near field UHF has promise, but is far from realized.

What is likely is that there will be a technology shift in the next 7 to 10 years. HF, near field UHF, and microwave systems will all thrive in the ILT market as the traditional silicon chip solutions. Additionally, there will be an eventual rise in very low-cost, non-silicon chip solutions. At the same time, some mission-critical specialized tags, such as surface acoustic wave (SAW) tags, will evolve to meet the highly sophisticated specifications required in such industries as aerospace and the military at price points that are not yet available today. In between these extremes, fueled by continued technology advances and newly emerging applications, mass adoption of ILT will surely occur.

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