FREE IDTechEx White Paper

RFID Explained

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An Introduction to RFID and Tagging Technologies

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Radio Frequency Identification (RFID) is the use of radio frequencies to read information on a small device known as a tag. Currently, these tags may take many forms: for example, the microchip may be the tag because it has a tiny antenna on it, or the tag may look like banknote security ribbon.

Other RFID tags are applied to products and packaging in the form of a label, an example being the Texas Instruments Tag It label fitted to the packaging of 250,000 Xerox copiers shipped yearly in Europe, and attached behind the cloth labels on Goldwin Sportswear made in China – using one million yearly. It is important to note that some RFID tags have a microchip in them and some do not.

Over 20% of RFID applications do not replace anything. An example is the "ScripTalk" pharmaceutical label for the blind that makes a gadget held near it speak out the type of drug and dosage required. Other examples are several hundred million 'clickers' for car access that have been sold and the 50 million sold as entertaining features of the Hasbro Star Wars toy.

Choices

There are several different RFID technologies that all overlap to some extent, and have various pros and cons making them suitable for some applications and not others. Applications are so diverse that there is a place for most of these different technologies.

Definitions

RFID is a term used for any device that can be sensed at a distance by radio frequencies or thereabouts, with few problems from obstruction or mis-orientation. The origins of the term lie in the invention of tags that reflect or re-transmit a radio frequency signal. In its current usage, those working below 300 Hz and those working above 300 MHz, such as microwave (GHz) tags, are included. For example, one type of chipless tag works at 100 Hz and one recent type of battery-driven chip tag works across the range 5.7 – 7.0 GHz, rather than at one frequency. Higher frequencies such as visible and infrared devices are excluded as these systems have very different properties and are frequently sensitive to obscuration, heat, light, and orientation.

The term "tag" is used to describe any small device – shapes vary from pendants to beads, nails, labels or microwires and fibres – that can be incorporated into paper and even special printed inks on, for example, paper.

Low Cost RFID

In the past few years, the term "low cost RFID" has begun to be used, and this may seem an artificial distinction at first sight. However, low cost RFID tags, typically taken as those costing less than one dollar each for up to 1 metre range and less than $5 above that, are different from conventional tags in several important respects. These differences mean that low cost RFID tags can be applied in very different, new applications and interest very different groups of suppliers and end users. This alternative to the barcode, magnetic stripe or printed label has advantages that include tolerance of mis-orientation and obscuration, lower cost over life and ability to "read". Most importantly, they are usually cheap enough to be disposable and thin enough to go in new locations, even inside sheets of paper in some cases, so all flat versions, including smart tickets and laminates, are usually called smart labels.

Almost all conventional RFID devices contain a transistor circuit employing a microchip. By contrast, the potential in low cost RFID is split between chip-based technologies and "chipless" tags. Chipless tags can still be interrogated through a brick wall and hold data but most are cheaper and more primitive in electronic performance than chip tags.

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Passive RFID Type	Conventional	Low Cost
Typical application	Cows, gas cylinders, beer barrels	Laundry, library, conveyances, vehicles
Typical mode of use	Re-used or on something expensive for life	Disposable and many tags read at one time.; longer range sometimes
Typical shape	Pendants, nails, boxes of electronics, contactless smart cards, glass beads	Labels, laminates, tickets
Typical frequencies	Low (125-135 KHz) to keep system cost low where there are few tags per reader	High (13.56 MHz near 900 MHz ("UHF"), 2.45 GHz) to keep system cost low where there are many tags per reader
Typical end users and uses of the system	Manufacturers, heavy logistics (e.g. brewers), farming, car keys, financial cards	Airlines (baggage), laundry, toys, libraries, passports
Typical payback	Greater security, better flow	Reduced losses, entertainment, automation, anti-counterfeiting

Significance of EAS

Some RF tags contain no information. They are not RFID because they are simply there or not there – call it 'one bit' of information. Because these are usually used as anti-theft devices in shops and libraries, this category is called Electronic Article Surveillance (EAS). About six billion are used every year. None have a silicon chip in them. Some new forms of RFID perform EAS functions as well, obviating the need for a separate device, and adding more value to the tag. In addition all the main three EAS technologies have been developed into RFID versions, albeit with rather higher costs. An EAS tag costs 1 to 6 cents. RFID tags usually cost more, depending mainly on range and data capacity. Longer range usually means a larger tag whether chip or chipless, or the addition of a battery.

Data Types

In RFID systems, there are two extremes of data storage. At one extreme, the interrogatory electronics simply sense something unique about the product, such as the random orientation of magnetic fibres in it – a pattern highly unlikely to ever be repeated. For this to be useful the computers in the system must have had prior notice of what the unique feature relates to, and this identity must be transmitted to all locations where the tag may need to be interrogated. This is known as Unique Signature, and even though it results in very cheap tags, it is very limiting.

At the other extreme, the tag is capable of storing digital information to agreed rules, so that readers can retrieve information directly from the tag without needing to refer to a centralised database. Digitally-encoded tags are more expensive, but much more useful because they do not require great amounts of processing power, time and unrealistic communications, as unique signature tags do.

Range

The range of tags varies widely, and for all types, the greater the range required, the more expensive the tag. RFID tags with a range of just a few millimetres can be embedded in banknotes and vouchers for high speed sorting and authentication, but for logistics often a range of up to 3 metres or more is required, with the ability to read many tags quickly. Other applications, for instance, road tolling and the location of items in real time, such as cars in a depot, require read ranges of up to hundreds of metres.

Cost

Cost is probably the most crucial issue at the moment. When we are talking about billions of these devices yearly in one application, the

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use of smart labels is only affordable if the labels are very cheap because they form a large part of the total system cost. To reach the ultra-low cost required, smart labels need to be stripped of unnecessary functions that add cost, and a healthy race is developing for new, faster and cheaper processes for smart labels and new designs. In contrast to the way in which the Internet and computers are evolving upwards in size and complexity, smart labels are going in the opposite direction for highest volume use.

As noted, RFID is much more than a barcode replacement. The same tag may obviate the need for a separate anti-theft EAS device, it may be used to prove ownership of goods, provide covert authentication, speed up shopping, remove the need for tills and floor space, and ultimately decrease the amount of time items take to go through the whole supply chain because of the better flow of information between each link. Product recalls can be more effective and auditable. Error prevention can be automated. These benefits can result in huge cost savings and brand protection.

Identifying that most players in the supply chain plus the users at the end will benefit, may be easy. Persuading one or all of them to pay the upfront cost of RFID can be problematic, even with paybacks as rapid as one year or less.

At item level, replacing a barcode is no easy feat, since barcodes cost next to nothing, therefore supermarkets and FMCG manufacturers say that most barcodes would need to be replaced by a device costing $0.01 or less. However, for a smart label, with the necessary data, range etc, reaching this cost will take at least three years. By contrast, in many instances, vehicle and freight barcodes have been replaced already with RFID devices costing $1

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Low Cost Digital RFID Technologies

Chip	Electric antenna UHF, 2.45GHz	Chip and (typically) printed dipole antenna
	Inductive antenna 125-134KHz, 13.56MHz	Chip and etched antenna wire or coil antenna
	Capacitative antenna (~130KHz)	Chip and thick film Printed antenna
Chipless	Remote magnetic	Thin films, wire or fibres
	Simple transistor - less circuits	Printed or bonded inductors, capacitors, diodes Surface Acoustic Wave SAW
	Transistor circuits	Plastic or silicon thin films - not yet available

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each because so many benefits accrue. Reading at high speed, tolerance of mis-orientation and far fewer false or failed reads are among them. Tagging cartons, pallets etc is proceeding apace at 10 cents to $1 now that the larger component here – the cost of the system – has come down. For this application, tag cost will drop to 5 cents for the largest orders and sales of 10 billion tags will be made yearly by 2007.

Tag price is only critical when very large numbers are used, particularly where there are large numbers per reader. The most extreme case is the dream of The Internet of Things where trillions of one-cent tags will be used yearly, notably on fast-moving consumer goods. Then again, a payback of less than a year may be achieved with a $100 tag if its sophistication is needed.

The Internet of Things, backed by EPC Global, is sometimes called The Product Internet or T2T (Thing to Thing). The vision is to have trillions of things communicating with each other without human intervention. It would be low cost because most of the time it would involve smart labels costing less than 5 cents and preferably 1 cent, and the existing Internet would be used as appropriate, yet each tag would have a unique electronic identity number.

The aim is to go far beyond a mere equivalent of the barcode and to create a chain where items can be read more reliably and individual items can be identified. Supply chain parameters may be improved by 90% and retail sales increased; there is talk of cradle-to-grave tracking, plus items electronically telling the freezer to restock; the microwave oven to cook correctly; and finally, the recycler to separate the materials correctly, all without human intervention. MIT talk of the medicine chest in the home that will not dispense contra-indicated medicines (not their best idea in our opinion), and all manner of anti-theft, anti-tampering and product diversion procedures that take place automatically.

Both chip and chipless (eg Surface

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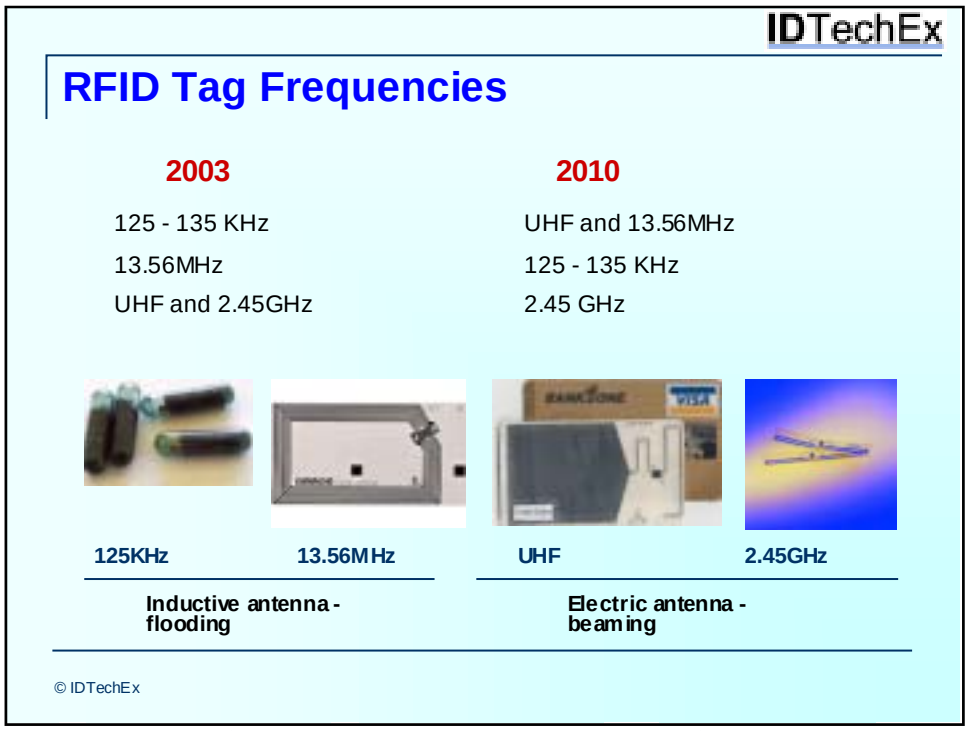

Acoustic Wave – SAW) smart label technologies are contenders for The Internet of Things which is getting under way in any case with various higher-cost tags. For example, low-cost, short-range smart labels can permit boxes of pharmaceuticals to be monitored and that wireless network could then talk to a more expensive, longer-range network that monitors whether a truckload so much as enters a lay-by. These systems exist today. The ultra-low-cost smart label uniquely identifying every blister pack, pot or vial can come later and we shall have networks within networks within networks and so on.

Commercial Success

In the past 50 years, only one billion passive RFID tags and about 500 million active (with battery) ones have been sold. The passive ones have generally taken the form of contactless smart cards for transport and tags for tracking. The active ones have mostly been car 'clickers' on key rings.

Only 50 million or so smart label versions had been sold by early 2004, chiefly to libraries, to hospitals for error prevention, as a feature of toys etc.

Now we have lift off with passive RFID smart labels as retailers and the US military have compelled suppliers to put them on conveyances such as cases and pallets to save costs. Up to one billion will be delivered in 2004 alone and many billions thereafter, with a possibility of one trillion being delivered in 2015 if they appear on most clothing in shops and then on most items in the supermarket. Active tag sales are also growing, but more gently.

The use of smart labels today is incredibly varied, and the potential is stunning. IDTechEx provides services to help you assemble and digest this information, and in particular, our reports (listed on the next page) cover in great depth the technologies involved, the markets, applications and so on. Further, our regular conferences are the largest in the world on the subject and provide an ideal opportunity to network with others and to hear the newest advancements from the industry leaders.

For more information, see:

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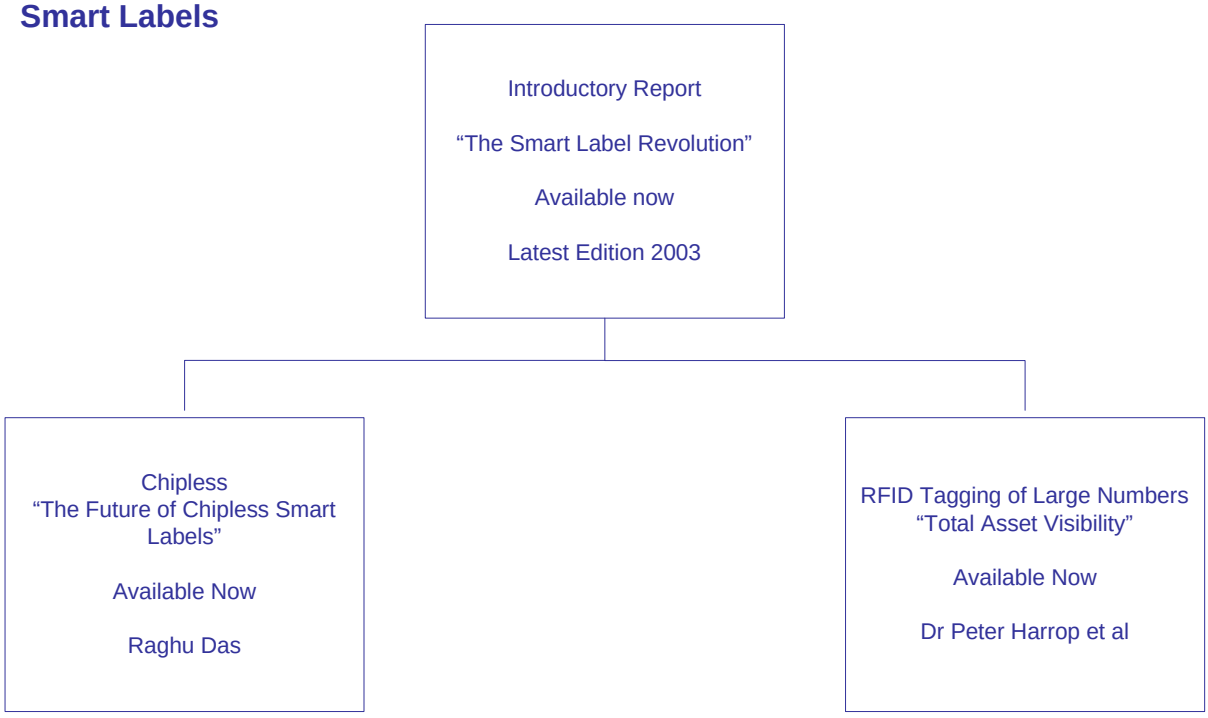
Let us know if there are any areas you would like to learn more about

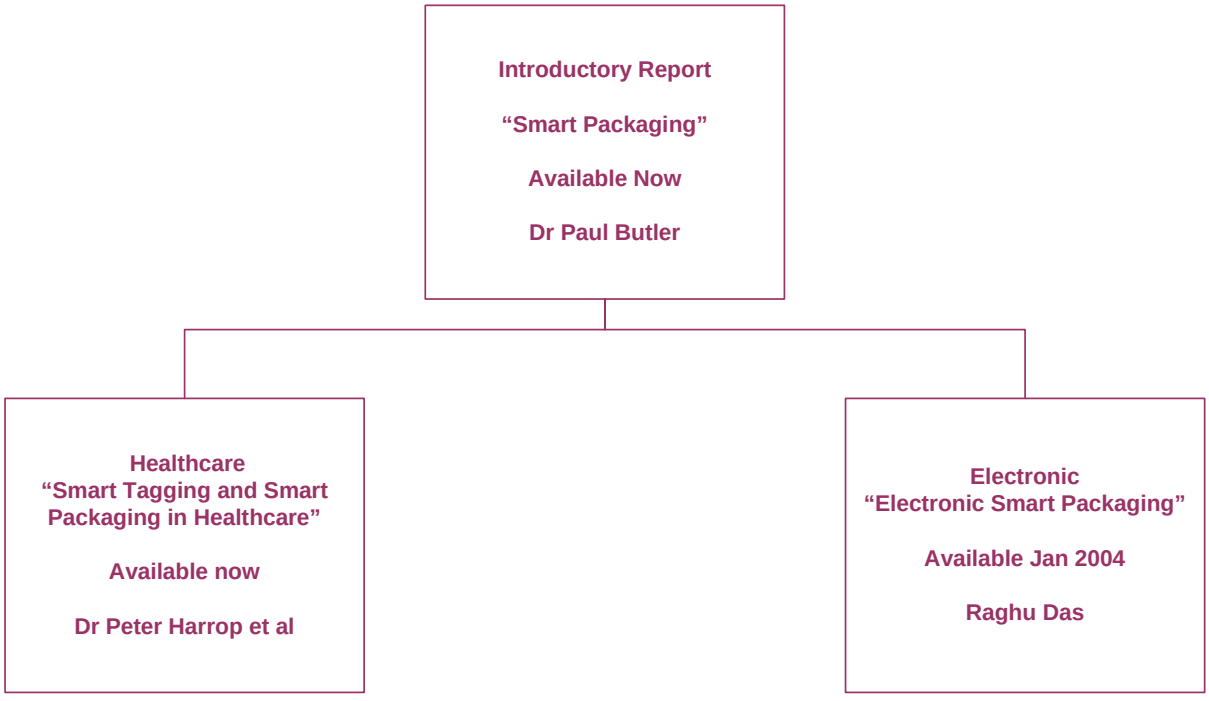
IDTechEx is the world's leading expert on the development and application of low cost RFID technologies.

The IDTechEx Report Program on Smart Labels and Smart Packaging

Smart Labels



Smart Packaging



There's more information about the IDTechEx Publications on the following page

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IDTechEx Publications

Strategic ten-year forecasts & company intelligence profiles
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This report analyses how smart technologies will be used to resolve the enormous challenges in the healthcare industry. RFID, printed electronics and smart responsive materials can be used to reduce costs, errors, crime, deaths and sickness, and provide new earning streams, intellectual property, brand enhancements and market intelligence in healthcare. The report provides a detailed breakdown of enabling technologies, where and how they can (and are) being used and the potential and forecasts of their use in healthcare.

The World's First Major Independent Report on Achieving
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Total Asset Visibility is the ultimate state of efficiency, automation and item information.

The Complete Introductory Report in low-cost RFID and beyond
The Smart Label Revolution
By Dr Peter Harrop and Raghu Das, IDTechEx

International case histories and company profiles Technologies evaluated 252 pages Over 90 detailed tables and figures Forecasts by technology etc to 2010 Sales leads

The one stop guide to chip and chipless technologies, markets, standards, statistics, trends, lessons of success and failures, future opportunities, and the RFID movers, makers and shakers. Your business needs this knowledge to get ahead, whether you wish to make, install, or use these revolutionary devices. This 252 page report is illustrated with over 90 detailed tables and diagrams.

Over 60 international case histories and company profiles from: Australia, China, Japan, Eastern Europe, Singapore, South Africa, USA and Western Europe

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In Depth on Chipless
The Future of Chipless Smart Labels: Markets, Players and Forecasts
By Dr Peter Harrop and Raghu Das, IDTechEx

Forecasts by technology etc to 2010 Latest new products and inventions
271 pages Over 105 detailed tables and figures Extensive sales leads

This report expands on The Smart Label Revolution, by looking in far more detail at chipless tags, including a much wider range of technologies. These have enormous market potential. They are usually ultra low-cost from 0.1 to 10 cents each, even in modest quantities. This second report also analyses how the silicon chip and even batteries in conventional RFID will become printed, to lower cost and improve ruggedness so eventually most forms of low cost RFID become "chipless".

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