postnote

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RADIO FREQUENCY IDENTIFICATION (RFID)

Radio frequency identification (RFID) technology provides a means of automatic identification. It is already widely used in animal tagging and electronic payment, such as Transport for London 'Oyster Cards'. Many other potential applications such as improving supply chain efficiency and reducing crime are being investigated. This note provides an overview of the technology, its current and prospective uses, and outlines the factors limiting its uptake. It then discusses measures being taken to address growing concerns over privacy.

Background

RFID tagging is a form of Automatic Identification and Data Capture (AIDC) technology where data stored on a tag is transferred via a radio frequency link. A RFID reader communicates with the tag to infer the identity of the object to which the tag is attached. The principle is similar to the more familiar bar code, where data are transferred optically. However, RFID has advantages over bar codes, such as the ability to store large amounts of data and to read many tags simultaneously (box 1).

RFID technology

RFID technology emerged in the 1940s as a way of remotely identifying aircraft for military purposes, and has since been used widely in civil aviation. However, recent technological advances have reduced the cost and the size of RFID tags, opening up a wider range of uses.

The tags themselves consist of an electronic circuit, which stores data, and an antenna which communicates the data via radio waves. A RFID reader interrogates the tags to obtain the information stored. When the reader broadcasts radio waves, all the tags within range will communicate. Software is required to control the reader and to collect and filter the information.

Box 1 Automatic Identification and Data Capture (AIDC) technologies
There are three main types of AIDC technologies:
- Optical – bar codes etc.
- Magnetic – magnetic stripe travel cards etc.
- Electronic – RFID tags, smart cards, sim cards etc.

RFID tags are often considered to be the next generation of bar codes, over which they have significant advantages:
- Ease of use – information from the RFID tag is transferred via radio waves and therefore, unlike bar codes, a line-of-sight between the tag and reader is not required. Many RFID tags can be read in a very short time and without handling the product.
- Information stored – tags that store 96 bits of data can store a manufacturer's name, a product name and a unique product code. Higher and lower capacity tags are available. RFID tags can be used to identify uniquely a specific item, whereas bar codes can only identify the type of product.
- Security – unlike bar codes, it is extremely difficult to copy RFID tags. As no line-of-sight is required they could be made to trigger security alarms, and help reduce theft, especially if incorporated into products.

Bar codes are very cheap to print and to attach to products, whereas RFID tags cost at least 20 pence each. However, this cost will fall as production rises and as novel ways of producing chips and antennae are developed.

There is a range of different types of RFID system available, for example, tags can be either 'active' or 'passive'. Active tags contain an onboard battery to drive the internal circuitry and to generate radio waves. They can broadcast even in the absence of a RFID reader. Passive tags are powered using the energy of the radio wave transmitted by the reader and do not have their own power supply. Also, tags can be 'read-only' or 'read-write'. Read-only tags are much cheaper to produce and

are used in most current applications. Read-write tags are useful when information needs to be updated.

Properties of RFID systems
The properties of a given RFID system depend on several key parameters such as frequency (box 2) and power:

- The **range** of a RFID system depends on the frequency, power of the reader, and the material between the tag and the reader. The presence of metal and liquids reduces the range of the ultra high frequency RFID systems. The range can be up to a few metres for passive systems but in excess of 100 m for active systems due to the onboard battery that facilitates increased radio transmitter power.
- The tag **size** increases at lower frequencies (LF), since the tag incorporates the antenna, and larger antennae are needed to transmit lower frequencies. The chip can be as small as 1 mm^2, but the antenna is much larger (of the order of centimetres). The antennae for LF tags are metal wire coils, but for higher frequencies they can be printed onto paper using conductive inks.
- As the frequency increases, the **read rate,** and thus the amount of data that can be transferred in a given time, increases. This is important when many tagged goods need to be read in a short time.
- The **cost** of tags tends to decrease as the frequency increases, although active tags cost much more than passive tags, irrespective of frequency. Also, the longer the range required and the more information stored, then the more costly the tag.

Box 2 Frequencies
Radio frequency waves are electromagnetic (em) waves ranging from ~ 30 kHz to 300 GHz. Only certain frequency bands within this range (listed below) are available for licence-free RFID systems. Certain frequencies are more suitable for specific applications:

- 125-134 kHz – Low frequency (LF) tags are used in animal tracking, car immobilisers etc. LF tags are commonly used where there are liquids or metals present and when a fast read rate is not required.
- 13.56 MHz – High frequency (HF) tags are the most commonly used, due mainly to the relatively wide adoption of smart cards based on RFID technology.
- 860-960 MHz – Ultra high frequency (UHF) tags are anticipated as being the most practical for item-level tracking as they offer a good balance between range (typically less than a few metres) and the ability to read multiple tags at speed.
- 2.45 GHz – Microwave frequency tags are used for electronic toll collection. This band is also used by many other systems e.g. Bluetooth and WiFi systems.

Current uses
RFID technology is already well established in a number of areas such as electronic payment, supply chain management and livestock tracking, as well as previously unforeseen areas, such as data conveying.

Electronic payment
Around the world, smart cards based on RFID technology are becoming more common in transport. Hong Kong introduced the 'Octopus' system in 1997, which is now used by over 95% of the population. The Oyster card, a Transport for London (TfL) contactless ticketing scheme, is a smart card. TfL estimates that 1 million fewer transactions per week are made at ticket offices and that there is a 30% improvement in the speed of passengers passing through the ticket gates. It is more difficult to copy Oyster cards than the magnetic stripe cards and, as each card contains a unique ID number, it can be immediately cancelled if the card is reported lost or stolen.

Supply chain management
Large retail companies are driving for widespread adoption of RFID tagging as a way of achieving complete supply chain visibility. They see such technology as a way of preventing 'out-of-stock' occurrences, the over-stocking of products in warehouses, and the theft or loss of goods, all of which are highly costly to retailers. For instance, the total cost of crime, including crime prevention, for UK retailers was £2.25 billion in 2002.[1]

Marks&Spencer (M&S) tagged 3.5 million returnable food produce delivery trays in 2002. This is among the largest supply chain operations involving RFID in the world. The tagged trays are filled with individual food items at the supplier, carried by the distributor to the shop, emptied and then returned. The information on the tagged trays is read at each distribution point, resulting in improved food delivery logistics and fresher food in stores.

Animal tracking
Most applications of animal tagging are in livestock tracking. This is becoming increasingly important following BSE outbreaks across the world. A mandatory RFID-based scheme was implemented in Australia in 2002, and a similar scheme is being set up in Europe.

Data conveying in hostile environments
Obtaining information from oil wells is problematic because of the high temperatures and pressures, and the narrow diameter and large depth of wells. Generally, a hydraulic line is used to convey messages to equipment in the well, but this is difficult and costly, especially if the line breaks. RFID tags can be dropped into the well to convey messages to equipment, for example to change the position of a valve. As worldwide oil reserves deplete, accurate and efficient methods of conveying data to and from the bottom of oil wells are increasingly important.

Future developments
Retail, healthcare and commercial services industries are predicted to be the fastest-growing RFID sectors. Some examples of recent or planned trials are given below, and Government funded initiatives to encourage wider use of RFID are described in box 3. In addition, some novel applications have been proposed, including 'smart' washing machines which alert users to mismatched clothing, and 'smart' fridges capable of warning when perishable goods are kept at the wrong temperature.

Preventing counterfeit drugs
The World Health Organisation estimates that up to 10% of medicines worldwide may be counterfeit. An initiative

planned for autumn 2004 by PA Consulting Group to tag pharmaceuticals, will involve a number of pharmacies, hospitals and dispensing doctors across the UK. Drug packaging will be tagged by the manufacturer and the product authenticated at the dispensing stage. This also allows for an extra check on the expiry date, whether the batch has been subject to a recall and up-to-date changes in product information. This trial aims to show how the tagging of pharmaceuticals could not only stop counterfeits and other fraudulently supplied products reaching patients, but also reduce dispensing errors.

Individual consumer product tagging
Retailers are already looking at the tagging of individual products to allow for better control of product recalls, and better targeted marketing campaigns. Tesco undertook a RFID trial at one store in 2003, which involved tagging individual DVDs. RFID readers were built into the store shelves to monitor each item. Not only was the stockroom alerted when a shelf needed re-stocking, but staff were alerted when browsing customers replaced a DVD in the wrong section. Tesco report that this improved stock visibility and customer service.

Box 3 Government initiatives
Government has focused on trials of RFID technology to reduce crime and to improve retail supply chain efficiency. Recent initiatives are described below.

The **Chipping of Goods** initiative was launched in March 2000 for 4 years. £5.5 million was allocated by the Home Office and was more than matched by industry to establish 8 'demonstrator projects'. The aim of these was to illustrate the effectiveness of tagged goods in combating crime, and also to accelerate the uptake of RFID-based systems. For instance, the 'laptop demonstrator project', which was a collaboration between Dell and BT, showed that RFID tags located in a Dell laptop could help to reduce laptop theft. In the first year no tagged laptops were stolen.

The **Next Wave Technologies and Markets Programme,** was launched in 2001 by the Department of Trade and Industry (DTI). The 'Centre for Information on the Move Systems' is part of this programme and its focus is on researching, developing and demonstrating information systems for linking inventory, vehicles, assets and people either in fixed locations or 'on the move', and aims to provide opportunities for industry and academia to collaborate.

Factors limiting the uptake of RFID
Industry and Government both acknowledge that the use of RFID could bring many potential benefits, but there are many factors that limit the uptake of the technology.

Universal standards
All retailers are able to read bar codes because there exist global standards, including a numbering system. However, with RFID, there is no numbering system in place. Moreover there are many different types of tag and different methods of communication. The absence of any standards in RFID technology has been an obstacle to its widespread adoption. Several organisations are working to improve this situation, including ISO (International Organization for Standardization), made up of national standards institutes worldwide, and EPCglobal, comprised of leading firms and industries.

Available frequencies and power for operation
Historically national governments have been responsible for 'spectrum allocation' – the assignment of frequencies and the power at which they may be transmitted. There is thus international variation in the frequencies and powers available for RFID systems, so a system produced in one country may not work in another. The main differences are in the UHF band (box 2). The European Commission is consulting on draft legislation that would increase the compatibility of this band with that of North America. Once the legislation is in place, tags produced at the North American frequency will work in the EU, albeit with a read range reduced by up to 10%.

Cost
The hardware (tags and readers) for implementing a RFID system is expensive to produce. Item-level tagging will not be widely cost effective until tags are less than a few pence per tag (tags currently cost at least 20 pence). However, results from a recent survey for the packaging industry[2] showed that, in addition to the hardware costs, a major concern is the cost of installing and integrating RFID systems into existing setups.

Industry awareness
According to e.centre, a not-for-profit UK business association, the UK is leading Europe in RFID trials and in the development of RFID systems, but their survey showed that 85% of UK businesses were not considering implementing RFID. The DTI is actively involved with many not-for-profit organisations such as AIM UK in promoting the benefits of RFID to industry.

Public attitudes
Privacy concerns
Originally RFID tags were used in closed systems, such as in the supply chain of individual companies. However, as the cost of tags decreases and worldwide industry-accepted standards become available, individual item tagging will become more widespread. This has led some consumer[3] and civil liberties groups to raise privacy issues. The main concerns are:
- use of the data by a third party,
- an increase in targeted direct marketing,
- the ability to track individuals.

Even if tags contain only a number and not personal data, they can still be linked to personal information, e.g. through the use of loyalty cards. Privacy groups argue that although linking personal data to products is already possible with bar codes, there is increased potential for direct marketing with item-level tagging, as consumers could be recognised on entering a store and their habits in-store monitored. Concern over whether this is covered by existing legislation is discussed on page 4.

Technologists state that tracking of individuals through RFID is difficult because of the large amount of power that would be required to read RFID tags at a distance.

The statutory limitations on power are fixed on safety grounds. However privacy groups point out that technological developments may increase the potential for privacy infringements in the future, for example by placing readers in floor tiles or in mobile phones. It is unclear whether legislation, such as the Human Rights Act, would protect individual privacy in these cases.

Technological solutions
Technological solutions, for example metal shields, blocker tags and 'blowing' of fusible links in the tag (which would render it inoperative), may help to mitigate concerns over privacy. However, these solutions are not user verifiable; that is, individuals are unaware whether RFID tags in their possession are disabled or unreadable. Privacy groups fear that these solutions would create a two-tier society: the technologically aware and unaware. They prefer user-verifiable solutions, such as removing the tags at the checkout (box 4).

Legislation versus self-regulation
If RFID tags are used to link items to personal data, then they are subject to the Data Protection Act, as is the case with bar codes. To collect these data, retailers must obtain written consent from the consumer. The Information Commissioner's Office (ICO) is aware of some applications that may involve personal data, such as the TfL Oyster card, and they are *'not aware of any retail applications that currently involve the use of personal data'*. The ICO is keeping 'a watching brief' and is collaborating with colleagues in the European data protection and privacy fields.

The DTI is not currently pursuing additional legislation or regulation. It favours self-regulation, but states that it is *'constantly checking regulation as the technology emerges and develops'*, and that if there is evidence of infringement of the Data Protection Act it will pursue legislation or regulation to control the use of RFID technology. Various initiatives are underway within industry to address privacy concerns (box 4). However, many consumer and civil liberties groups are sceptical about the effectiveness of self-regulation.

A voluntary moratorium?
Over 40 organisations have signed a position statement (November 2003) requesting that manufacturers and retailers *'agree to a voluntary moratorium on the item-level RFID tagging of consumer items until a formal technology assessment process involving all stakeholders, including consumers, can take place'*.[4] Although this statement identifies acceptable uses of RFID technology, e.g. the tracking of pharmaceuticals, it recommends that some practices, such as the tracking of individuals, should be prohibited.

Public awareness
In spite of privacy concerns, surveys indicate that the majority of the population is still unfamiliar with RFID technology. For example, an online survey of 1,000 consumers showed that less than 25% of North American consumers have heard of it.[3]

Box 4 Measures taken by industry to address privacy concerns
- e.centre is leading a UK RFID council in drawing up a UK code-of-conduct for the industry. This will involve discussions between industry, government and consumer organisations. The code of conduct will include notifying consumers of the presence of RFID tags, education about the technology, and adherence to current laws on the collection and storing of data.
- When M&S undertook a trial involving tagging individual items of clothing for stock-taking purposes, there was no possibility that any customer data could be associated with the tags because M&S avoided reading the tags at the checkout. As the tags are incorporated into paper labels they can be easily removed at the checkout if requested by the customer.

Most respondents were unaware that existing RFID applications, such as US highway toll devices, already used RFID technology. The National Consumer Council (NCC, an independent consumer policy organisation) has stated that *'consumers were not aware of RFID technology and certainly did not understand the extent to which their privacy may be jeopardised by its use'*.[5] Following a recent NCC summit on RFID, several recommendations were made, including calls for the DTI to fund research into consumer perceptions.

Overview
- RFID technology is a well developed technology and already used in asset tracking and electronic payment.
- Widespread implementation in an increased number of areas is expected to occur in the next 5 to 10 years as the cost of tags decreases and worldwide industry-accepted standards become available.
- There are potentially large benefits from RFID, both in the commercial sector and in public services.
- However, consumer and civil liberties groups state that there are privacy issues that must be addressed prior to the large scale implementation of item-level tagging, and that the risk of abuse must be reduced.
- Currently, there are no moves towards new legislation, but Government and industry are taking other measures, including drawing up a code-of-conduct for implementation of RFID technology. Some groups are sceptical about the effectiveness of self-regulation.

Endnotes
1 British Retail Consortium, *10th Annual Retail Crime Survey 2002*, June 2003
2 Packaging Strategies/CapGemini Ernst & Young Survey, March 2004
3 Cap Gemini Ernst & Young (CGEY), *RFID and Consumers – Understanding Their Mindset*, February 2004
4 http://www.privacyrights.org/ar/RFIDposition.htm
5 National Consumer Council, *calling in the chips?*, February 2004