White Paper

RFID: Construction

Potential of RFID in the Construction Sector

This white paper describes for C-level executives and line-of-business managers the opportunities and business benefits of RFID in the construction sector. It looks at various scenarios and provides answers to the questions:

- What are some of the potential uses of RFID technology in the construction industry?
- What are some of the critical issues with RFID in construction applications?
- How can individual companies leverage collective industry efforts to understand and implement these technologies?

Highlights of this white paper include:

- Using RFID for maintenance
  - Plant machinery, smart metering, servicing
- RFID track and trace capabilities:
  - Supply chain, utility pipe work
- Authentication scenarios:
  - People, products
- The potential of RFID in health and safety
- RFID in compliance

Executive Summary

RFID, short for Radio Frequency Identification, is a rapidly evolving technology that can dramatically improve operational efficiencies and customer service. RFID will fundamentally transform the way information about products, equipment, animals and even people is gathered and analysed in real time, providing new business opportunities. Implementing RFID is about far more than simply upgrading technology.

To see RFID purely as an IT issue would overlook the major impact that RFID can have on the revenues, business processes and working practices of an organisation. RFID has a place in commercial construction because it provides the industry with potential to improve construction productivity, quality, safety and economy, cutting labour and material costs and enhancing project schedules. This means that RFID brings both challenges and opportunities, and dealing with these needs direction from the top leadership team - 'boardroom buy-in'.

RFID systems throw out huge amounts of data, and where organisations are working in partnership with others, for example in a supply chain, there are immense challenges of data synchronisation, standardisation, general management and overall ownership. Where RFID tags are active, data is also streaming in constantly, adding another dimension to the problem. Data management is a real issue.

The UK

UK Construction Marketplace

The UK construction industry consists of 192,404 firms employing 2.1 million people in a multitude of roles. Of this total, 164,000 construction firms have less than 24 employees and just 56 firms have more than 1,200 employees. The sector is defined as one which embraces various sub-sectors: construction materials and products; suppliers and producers; building services manufacturers, providers and installers; contractors; sub-contractors; professionals; advisors; construction clients, and those organisations that are relevant to the design, build, operation and refurbishment of buildings.

The UK construction output is the second largest in the EU and contributes 8.2% of the nation's GVA (Gross Value Added). One in 10 people employed in the UK works in construction and 1.68 million work for contractors whilst 1.05 million are employees. UK designers, civil engineers, contractors, and component and product manufacturers have a worldwide reputation and working overseas provide high-tech solutions to environmental, transport and building projects. Figures compiled by the research body Construction Forecasting and Research estimate that construction's black economy is worth £10 billion and the DIY (products) economy is worth an estimated £5 billion.

International construction is worth over £10 billion to the UK economy and 500 construction firms work abroad. Therefore as a sector it is hugely important to the British economy.

Definition: "Construction Industry" is widely defined covering all sectors involved in construction and maintenance of buildings from production of raw materials through component manufacture, logistics, transportation, construction process, management and maintenance of buildings to their demolition and disposal. This also includes the 'Do-it-yourself' mar-ket and that part of the assortment for sale in large supermarkets and department stores.

Danish Technology Institute

Figure 1: UK Construction Industry Vital Statistics

Type of firms	Number firms	Contribution	Employees
Contractors	192,404	52%	1,665,000
Quarrying firms	2,248	2%	23,900
Products producers	20,863	15%	382,000
Builders' merchants etc	81,997	15%	591,000
Professional services	57,636	16%	308,000

Source: Annual Business Inquiry 2003

Components of Construction's Output

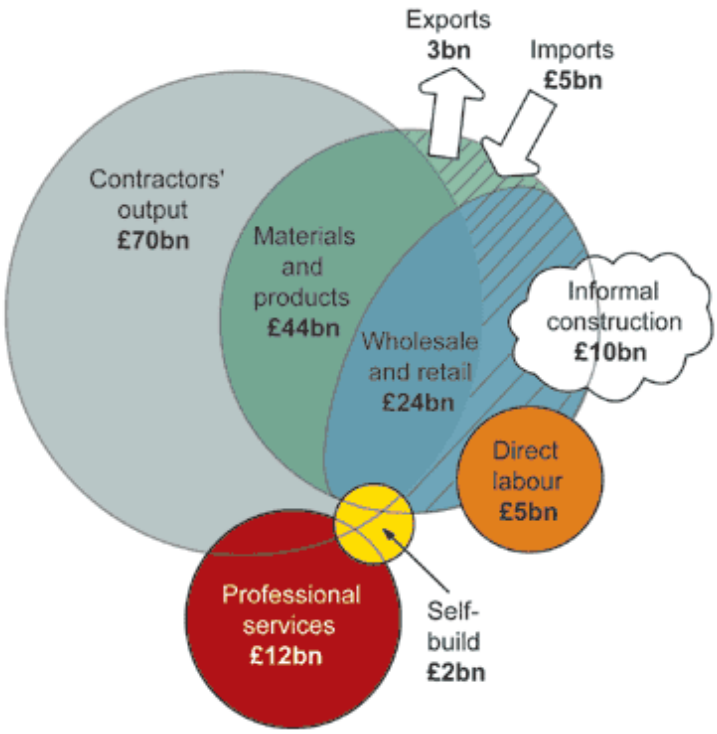
The various components of construction's output are broadly defined in Figure 2 below. Where an industry sub-sector contributes to output in another sub-sector the circles overlap.

Contractors' output is far and away the biggest slice of the industry.

The informal or black economy is represented by a cloud because of the uncertainty surrounding its actual size and value.

The reason its size is not known is because it goes purposely or accidentally unrecorded – in other words it is illegal – so how it contributes to the UK's gross domestic product (GDP) is unclear.

Figure 2: The Overall Gross Output of the UK Construction Industry



Source: Information Supplied by Construction Industry Research and Innovation Strategy Panel

The Overall Gross Output of the UK Construction Industry

Figures published in a Construction Products Association forecast (September 2006) show output fell by 1% in 2005 ending 11 years of uninterrupted growth. This was due to higher energy costs, a weaker private sector and a fall in Government spending, however the Association is predicting a 1% pick-up in overall output in 2006, largely driven by fresh Government investment. In the long term, work is expected to grow at around 3% a year in 2007 and 2008 as a result of economic growth in the private sector and sustained Government investment.

Construction was hit by higher energy and raw material costs in 2005, weaker private sector activity and a 3% fall in Government investment, according to the Chief Executive of the Construction Products Association, Michael Ankers.

The products body has predicted that spending on home improvement work is expected to fall by 1% in 2006 before recovering in 2007 and 2008, and office development work is likely to recover over the next three years, while retail and entertainment spending will decline further.

Following three years of decline, road spending is expected to stage the biggest recovery through the delivery of the Highways Agency's investment programme, with output increasing by 8% this year and 10% in 2007.

UK Competitiveness

The Department of Trade and Industry (DTI) asked Experian Business Strategies (EBS) and University College London, in conjunction with the consultants Davis Langdon (UCL/DL) to analyse the international competitiveness of the UK construction industry. The two reports commissioned in 2004 investigated the relative position - in terms of labour productivity and total factor productivity - of the UK construction industry compared to the construction industries of France, Germany and the USA. The UCL/DL report also compares the productivity of the UK construction industry with the UK's vehicle production and repair industry. EBS's estimates of relative productivity in construction were:

- The US is about 25%-35% ahead of the UK and Germany in terms of average labour productivity (ALP).
- The UK is ahead of Germany in ALP on an output per worker basis, but not on an output per hour worked basis (this is due to Germans working fewer hours per week on average).

It is important to understand the issues in The Construction Industry in order to be able to see where RFID can provide business benefit. The main issues can be summarised under 2 headings: Projects; and Sustainability.

Major Issues in the Construction Industry

Some typical issues experienced in the construction sector include:

- Productivity of the labour effort.
- Complex operations scheduling.
- Processing of contractors onto site.
- Locating spares, equipment and personnel.
- Shrinkage of materials.
- Late deliveries and high cost expediting.
- Verification of work completion.
- Compliance to health, safety and environment laws.

Construction Projects

A construction project is one of the most demanding information environments and is often underestimated.

Commerce on a site is as diverse as commerce in general industry. Elements of service, process and commodity abound and as such no one IT solution will fit all. A commercial transaction under the following forms, in essence, the detail the life of an individual contract (commitment to supply to predefined terms) contains:

- Specification.
- Tender.
- Purchase order.
- Delivery.
- Invoice.
- Payment.

In processing the contract, traceability is beneficial to many parties for different reasons, e.g. information on a delivery is useful to the project manager, trades, supplier, accounts and end user.

Sometimes traceability is useful down to item level, such as a boiler, i.e.:

- Where it is installed.
- When it was delivered.
- Who it was commissioned by.
- When it is due for service.
- When it is due for repair.
- Who owns it if it is stolen.

What parts are required if it is to be repaired, etc.

It is thus useful to trace:

- Paperwork and transaction
- Individual Items

An ideal solution would be a common method without any programming requirements. Unfortunately there is not a single identification technology that would suit all solutions. For example, a bar code printed on a delivery note which identifies that piece of paper at the same time as printing is not suitable for a pump that is going to get wet, painted or scratched.

The recording of an action does stay the same:

- Who performed the task against the paper / item.
- What the paper / item is.
- When this action took place.
- Why this action took place.
- Also, where and how this action took place are often useful but feature less often than the above.

The most basic components to achieve traceability are:

- Unique identification.
- Time.

The unique identification provides the key to accessing a broader scope of information, and time informs us when these things happen. By using hierarchies (directory like structures) it can be shown that any combination of information can be constructed from a series of unique IDs and times.

Sustainability

Sustainable construction is high on the government's agenda. The UK Government strategy "Building a better quality of life" was launched in 2000, with a report on progress published in 2002. Sustainability will take on the biggest issues facing the construction industry to date, highlighting the latest thinking on energy efficiency, green design, renewables and environmental legislation. Sir Neville Simms, CEO, Carillion stated that “Sustainability underpins future profits”.

It was announced in July 2004 that a code for sustainable homes would be developed. The consultation for the code was launched in December 2005 and closed in March 2006. The code is a voluntary initiative, by government and industry, to actively promote the transformation of the building industry towards more sustainable practices by requiring buildings that use:

- Energy resources more efficiently.
- Water resources more efficiently.
- Material resources more efficiently.
- Practices and materials designed to safeguard occupants' health and well being.

Social responsibility is about recognising and addressing the needs of all groups affected by the activities of an organisation (not just customers and shareholders). Importantly, it is not only about complying with existing legislative requirements but also adopting a voluntary approach to meeting the needs of different stakeholders. Engage-construct defines social responsibility as a commitment by organisations to integrate socially responsible principles and concerns of stakeholders in their operations in a manner that fulfils and exceeds current legal and commercial expectations. There are many different definitions of sustainable development and corporate social responsibility (CSR). The two definitions below are amongst the most prominent ones:

- ‘Sustainable development is meeting the needs of the present without compromising the ability of future generations to meet their own needs.’ (The Brundtland Report, 1987)
- Corporate social responsibility is the business community's response to the sustainable development agenda.

Social responsibility issues will vary from project to project and according to the different stakeholders involved. As a rule, the way to find out what issues should be addressed is through stakeholder engagement. However, there is a list of core social responsibility issues which tend to be important for every type of construction project and are related to the construction process or the end product.

Construction sites can be dangerous places, which is why health and safety is of great importance. A poor health and safety record affects the reputation of a business and could put staff at risk. It is also bad for the image of construction as a whole. On 24 February 2006 the UK Government held the industry's second safety summit in Westminster, central London. The then construction minister Nigel Griffiths called for the industry to commit to zero tolerance of accidents on sites. Mr Griffiths told employers and union officials that the message sent out to the public by an industry that needs to recruit 80,000 people a year cannot be that deaths and serious injuries are acceptable. The CITB-Construction Skills Health and Safety Test is the industry standard, taken by over 300,000 people every year. It is designed to ensure everybody working in construction has a minimum level of health and safety awareness. Passing the test is an essential part of qualifying for the major card schemes such as CSCS and affiliated schemes. The Site Management Safety Training Scheme (SMSTS) is one of the most highly regarded construction courses available for site managers and supervisors, and is taken by more than 10,000 people each year. It helps site managers (and anyone wanting to become

a site manager) to develop a better understanding of the legal, moral and social responsibilities of their role, and to manage health and safety on site in accordance with current legal provisions.

Intelligent Buildings

The field of intelligent buildings, intelligent homes and building management systems (BMS) encompasses an enormous variety of technologies across commercial, industrial, institutional and domestic buildings, including energy management systems and building controls.

The idea of the intelligent building has been with us for quarter of a century. The term was first coined in the USA in the early 1980s as a combined real estate / telecommunications business proposition. There are many definitions of intelligent buildings, which have evolved as a result of: push from information technology developments; better understanding by vendors and suppliers seeking business opportunities; clients' demands for productivity, and reduced 'cost of ownership' drivers.

> "……there has never been greater need in the world to have more control over our homes and businesses — especially when it comes to reducing energy consumption."
>
> Bob Heile, chairman of the ZigBee Alliance

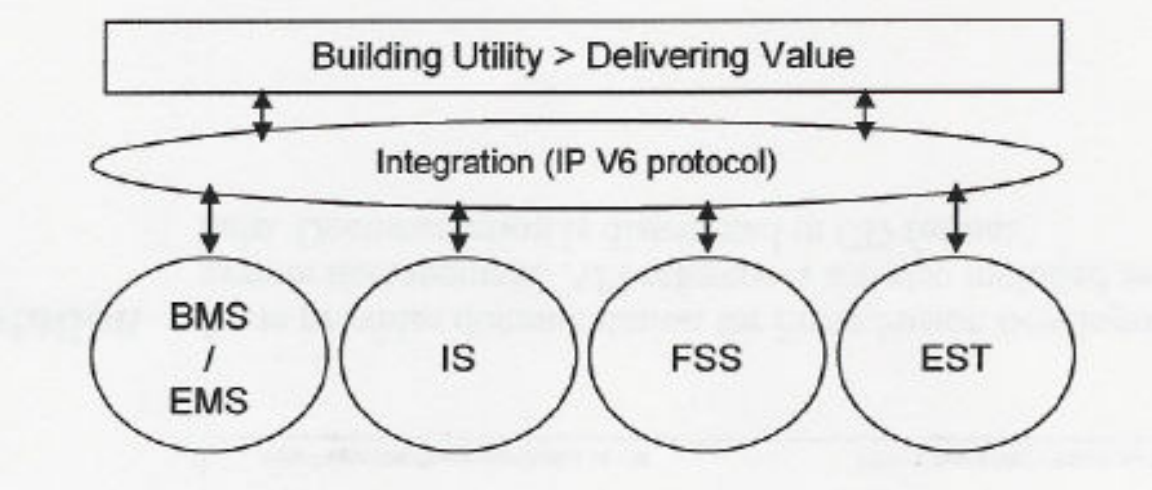
Intelligent buildings are meant to be sustainable, healthy and technologically aware. They should meet the changing needs of the occupants and business and are flexible and adaptable to deal with this change. This means that the design, construction and facilities management are all equally important to the long term success of intelligent buildings.

The challenge for intelligent buildings, therefore, is to deliver integrated systems that deliver value for money and address the issues of sustainability, such as energy efficiency and accountability, use of renewable energy and water conservation. They should also provide a healthy environment for people, while meeting the performance criteria for the occupants and owners. This challenge is most likely to be met successfully through a better understanding and exploitation of the integration of buildings fabrics, space, services, sustainability, smart materials, sensors and detectors, control systems, building automation and information systems that is defining the nature of intelligent buildings. This will also need to be supported by developments of 'whole life value' models for clients to demonstrate lower cost of ownership.

The intelligent buildings concepts cover the convergence in:

- Building management systems (BMS)
- Energy management systems (EMS)
- Information systems (IS)
- Buildings fire and security systems (FSS)
- Emerging sensor technologies, e.g. tags (EST)

Figure 3: Components of Intelligent Building Concept



Sources: BRE Intelligent Buildings, Invitation to Develop the Intelligent Buildings Strategy, July 2005

The intelligent building concept then involves delivering these concepts across a single common infrastructure or platform. This converged view of information systems means they can be regarded as the fourth utility - as essential to the everyday activities and operation of an organisation as the more traditional utilities, such as water and electricity.

At the implementation phase, the use of a common shared infrastructure means just that: a single system is installed once but is then utilised many times over. Since it is using internationally recognised standards-based technology rather than the proprietary systems which have been such a feature of the property sector in the past, new applications and solutions can quickly and easily be run across the existing infrastructure.

Benefits of Intelligent Buildings

The key benefit is that for any building there is a single point of control for all digital services.

The primary benefits of intelligent building solutions include their operational responsiveness and flexibility. So called integrated systems break down the traditional silo solution culture, and can provide an integrated, single point control of:

Information and communications networks including data transfer and telephony.

- The building environment: HVAC, lighting and electrical equipment.
- Energy management: integrated energy management across buildings, estates and campuses.
- Security systems: CCTV, access control and intrusion detection.
- Critical systems: building safety and protection of building occupants.
- Asset management: tracking and monitoring of physical assets and personnel.

The significant benefits of integrated building service and asset management operations are much enhanced by the ability to manage systems locally and remotely - often using TCP/IP and the Internet. This can significantly reduce operational management costs, adding to the whole life performance benefits of integrated services.

Application of intelligent building solutions brings other significant benefits that cannot be readily realised, if at all, with traditional technologies - for example the ability to rezone areas of a building to redistribute service delivery without relocating hardware, wiring and the associated disruption and cost.

This responsiveness is not limited to cost effective control of buildings. Intelligent buildings can respond quickly to changing business demands and environmental requirements, or whatever demands are placed on them.

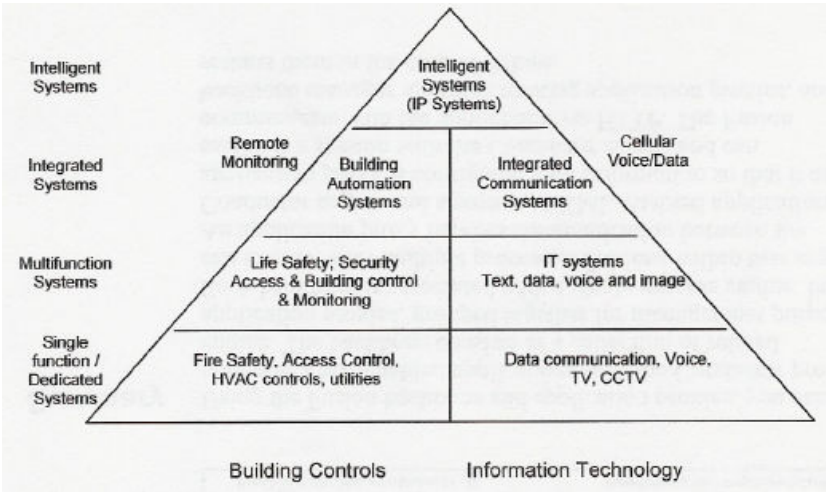
When it comes to operational benefits, intelligent building systems - because of their integration - are inherently flexible and capable of delivering much improved functionality compared with disparate, standalone systems. Adds, moves and changes are extremely simple and can be undertaken in-house, rather than having to contact the original supplier of the system. Maintenance and support costs are also dramatically reduced, allowing resources to be employed in a more targeted and thus more efficient manner.

Intelligent Building Opportunities

The driving force has been the growth of communications and information services alongside those building management systems.

Intelligent buildings offer significant opportunities for the industry. Research by BRE has revealed that the driving force behind the intelligent buildings concepts has been the implementation of information and communication technologies and subsequent integration of building automation systems, suggesting that it is currently a technology push that is creating possibilities through systems integration. Furthermore, it is apparent that an absence of good advice or even the provision of poor advice to owners and end-users is inhibiting greater deployment of intelligent systems in buildings.

Figure 4: The Intelligent Buildings Pyramid Shown Below Depicts a Short History of Technology Progress Towards the Intelligent Buildings Concept.



Sources: BRE Intelligent Buildings, Invitation to Develop the Intelligent Buildings Strategy, July 2005

In this technical intelligent buildings vision, it is the bringing of advanced information technology systems and building controls systems that provide adaptive functional capabilities to deliver the broader vision. In reality, you simply have to observe various buildings around you. It is easily apparent there is a vast difference in the quality of buildings. The majority of buildings are still operated using basic proprietary systems working in isolation, and while some more advanced new build and refurbished buildings often deploy multifunctional systems very few take advantage of integrated, i.e. intelligent, systems.

In order for an intelligent buildings vision[1] to be realised, several issues need to be considered. Some of these are:

- Comprehensive testing and certification of products compliant with integrated standard protocols (e.g. IP, LonTalk, BACnet and KNX) and provision of certified integrated intelligent systems based on these products that support the delivery of business and / or building user's objectives.
- Development of common architecture between different subsystems, e.g. life safety, control, security and information systems.
- Development of new architecture and delivery of new value added services, using intelligent low-level sensors, e.g. tags etc.
- Demonstration and, more importantly, quantification of the 'cost of ownership' to the construction organisations in order to promote the availability of an embed technology infrastructure within new build and refurbishment of buildings programmes.
- Demonstration and quantification of real-life benefits.
- Demonstration of best practice methods of procurement for the selection of specification, installation and commissioning of intelligent building systems.
- Demonstration of best practice methods for optimal operations and management of integrated solutions.

Intelligent Building Issues

The intelligent buildings concept introduces new issues, not only for new builds but also in terms of retrofitting to existing building stock.

Intelligent building solutions are appropriate for many different types of development, including: retail centres, multi-tenant office locations, business and science parks, hospitals, and education establishments. Although individual applications will vary according to the property, a typical intelligent building solution will contain the elements illustrated in this schematic.

Whilst the ability to reduce costs and potentially identify new sources of revenue is attractive, there are considerable challenges which need to be overcome in order to reap these benefits.

New build

If an intelligent building solution is to be implemented as part of the main contract, rather than a subsequent add-on, the IP network must be installed before the property is completed. This is a radical concept for more traditionally minded developers and it can cause considerable anxiety about technical challenges, costs and where responsibility for each aspect of the project lies.

Whilst procurement routes for building management systems, telephony and other services are all well-established and have been in operation for decades, the decision to implement an intelligent building system will change this completely. And the situation is further complicated. It is impossible (at present) to go to a single source for a complete intelligent building solution: it has to be obtained from a number of different suppliers or partners, which again adds to the complexity of the procurement phase.

Retro fit

Putting an intelligent building solution into an existing development raises a new set of challenges. There will inevitably be both physical and operational disruption. In the face of this, it may be necessary to overcome opposition from tenants who resent any change, regardless of the benefits that it will deliver in the future.

Different approaches to funding the introduction of an intelligent building solution may have to be considered. This demands a comprehensive understanding of the innovative new services which can be delivered once it is installed.

Every intelligent building solution will naturally vary, but early indications suggest that it is usually between one and a half and two and a half years from the installation when organisations start to see a revenue return on their investment. Strong growth in revenues after this period is complemented by decreasing and levelling off costs relating to the implementation.

[1] BRE Intelligent Buildings, Invitation to develop the Intelligent Buildings Strategy, July 2005

However, achieving substantial revenue streams takes effort and imagination and needs commitment from the landlord and their team.

Intelligent Business Services

Here are just some of the services which will be enabled with the implementation of an intelligent building solution:

- GSM/3G
- Wireless applications
- Advertising
- Virtual Tenants
- Loyalty systems
- Video conferencing
- IP CCTV
- IP voice managed switchboards
- Footfall counting
- Intelligent car park management
- Meter reading
- Content distribution
- Internet access

Wireless hotspot access will deliver operational efficiencies for internal teams within the development. Providing point of sale and marketing access for consumers will generate substantial revenue streams.

RFID has the potential to be a "killer application", providing great opportunities for both operational and tenant-based solutions. For retailers, the information gathered from RFID loyalty-based solutions will be worth its weight in gold. This important new application should be incorporated into all intelligent building solutions for retail centres.

Integrated mobile: if the property has well-structured secure wireless hotspots, the mobile operators will pay handsomely for the opportunity to provide telephony access. The supply of integrated data wireless solutions is destined to be a huge market.

Integrated point of sale: RFID is a key technology here. It supports a till-less environment and a number of other queue-busting solutions for innovative retailers.

On request marketing: for landlords, on request marketing provides the ability to both track and communicate with the purchasing public. This is an extremely valuable resource (provided that it is used responsibly).

The Issues for RFID in Construction

RFID technologies, e.g. bar codes, have been used for many years in multi-national logistics operations and retail outlets. However, the nature of these operations is very different from a construction project. In a retail or logistics environment there may be a narrow range of problems to be solved or information to be stored by one bar code or RF tag, using internally generated software. In a construction project, the environment is quite different. A vast number of different aspects need to be addressed, ranging from manufacture, transport and medical care to accounting, security and catering.

> Oscar peeled a strip of tape from a yellow spool and wrapped the tape around a cinder block. He swept a hand-scanner over the block, activating the tape... "I'm a cornerstone," the cinder block announced.
>
> "Good for you," Oscar grunted.
>
> "I'm a cornerstone. Carry me five steps to your left." The construction system was smart enough to manage a limited and specific vocabulary.
>
> Distraction, Bruce Sterling, 1998

In its 2000 review, the Construction Industry Institute[2] identified a number of potential application areas for RFID technology in the sector. These included component tracking, inventory management and equipment monitoring. Suggested applications for the future include guided control of equipment, tags that can communicate fatigue or excessive stress in concrete and steel members, and concepts for safety management.

The key players in the construction process have many different skill sets and personalities and their companies, different objectives and interests. These players may be:

- Clients.
- Project management professionals
- Quantity surveyors.
- Construction manager and operatives.
- Facilities management staff.
- Health and safety professionals.
- Contractors and sub-contractors.
- Manufacturers and suppliers.

The construction environment is not like a retail or logistics environment. A large number of aspects have to be addressed.

In addition, the key players see the various spaces or objects that are involved in a construction project (e.g. rooms, equipment, sites, parts, containers) in a different way from each other. For example an operating theatre may be seen as a room to a maintenance person, but as a sterile zone to a health and safety professional; a silo may be seen as a source of product for a contractor, but simply a location for a security guard.

A tag that carries information about a space or object overcomes some significant problems, the differing perceptions of use being one of them. Also, the ability to recall information, such as that obtained from inspections of equipment can avoid having to carry around a laptop with large databases whose contents may be out-of-date. Of all the components, fittings and other objects that go into a building, hundreds of thousands need inspecting and maintaining through the construction process and later during the life of the building. By storing key information about the item on a tag, rapid access to relevant data can be obtained through a simple hand-held device and updates initiated, speeding up the process of on-the-spot auditing. Allowing a number of people to access data will assist traceability whereas restricting access will allow suppliers to maintain confidential records on site.

Flexibility in reading from and writing to a tag is also necessary. The sort of information carried on a tag today will be different from that required on the tag tomorrow, particularly if it is to keep up-to-date with changing regulations and compliance demands. Any RFID system must cope with this and, in many cases, do so with a very small amount of storage capacity.

[2] Lake, C. and Jaselskis, E. (2000). RFID Applications for Owners and Contractors, *Proc. Construction Industry Institute Annual Conf.*, Nashville, Tennessee, pp.7-24.

A data collection solution for the construction industry[3] must be flexible and, to have any long term value, must be able to adapt to the changing demands and interests of different users. The main users are likely to have the following requirements:

- Management: reliable up-to-date information readily available.
- Contractors: a system that is simple to use, robust and if they are to buy equipment, cheap.
- Health and safety: a system that is fully featured with mobile accessibility.
- Facilities management: adaptability and long life.
- Suppliers: a system that is cheap and simple to incorporate into existing systems.
- Client: traceability and accessibility.

Given these differing interests it would be impossible to design one technology, packaging, software suite or data collector to suit them all. Any solution must be able to demonstrate its ability to adapt and expand in the future without major programming.

Using RFID to Solve Current Business Issues

Production and Supply Chain Visibility

Today's consumers are becoming increasingly demanding and this is causing supply chains to have to adapt into demand chains. At the same time there is increased complexity with scope for new problems. Out of stock is a major concern with lack of visibility in the supply chain and increased pressure through lean manufacturing of less inventory / stock being held. Construction companies want to know:

"Effective supply-chain management reduces the risk of regulatory delays or failure and creates shareholder value."

Dr Val Tate, Chief Executive, BioValue Ltd,

- Visibility of shipment in the supply chain.
- JIT deliveries reduce shrinkage.
- Anti-counterfeiting and compliance.
- Manufacturing origin.
- Marshalling onto site.
- Condition on arrival (to specification).
- Inventory management.
- Onsite transport management.

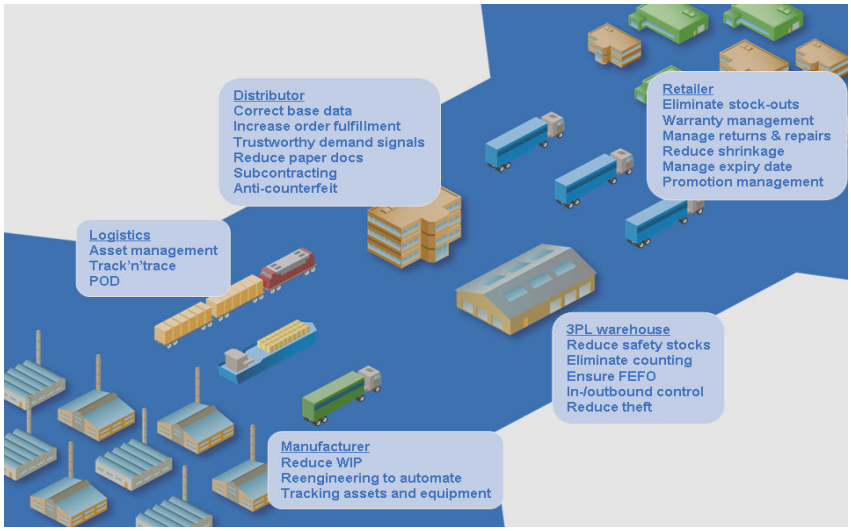
The construction demand chain is a complex one and where time is key to cost reduction, the need for visibility is great.

As they are familiar with the user friendly environment they get from using Amazon, DHL and others, there are more participants in the supply chain, which is leading to more shrinkage, counterfeiting, copying, damage and tampering. Most organisations see that these issues lie outside of their boundaries - with their suppliers or logistics companies. However in practice it has been found that these issues also lie inside organisational boundaries, particularly where there is plant-to-plant movement or where a plant covers a large area. Therefore production visibility is just as important to get real data for management as visibility in the supply chain.

Modern warehouses have complex requirements. Fast product cycles, the need to decrease inventory and increase the flow of goods through the supply chain mean that warehouses cannot remain static. Virtual real time data must match the supply to demand. Furthermore, many light manufacturing operations such as final assembly, customised packing, labelling and engraving, have been moved from shop floors to warehouses and distribution centres (DC).

[3] Read/write (RFID) tagging technologies in construction, Ron C Manning, TechnologyWatch for the UK Construction Industry

Figure 5: Supply Chains are Complex Networks



Source: Microsoft Corp

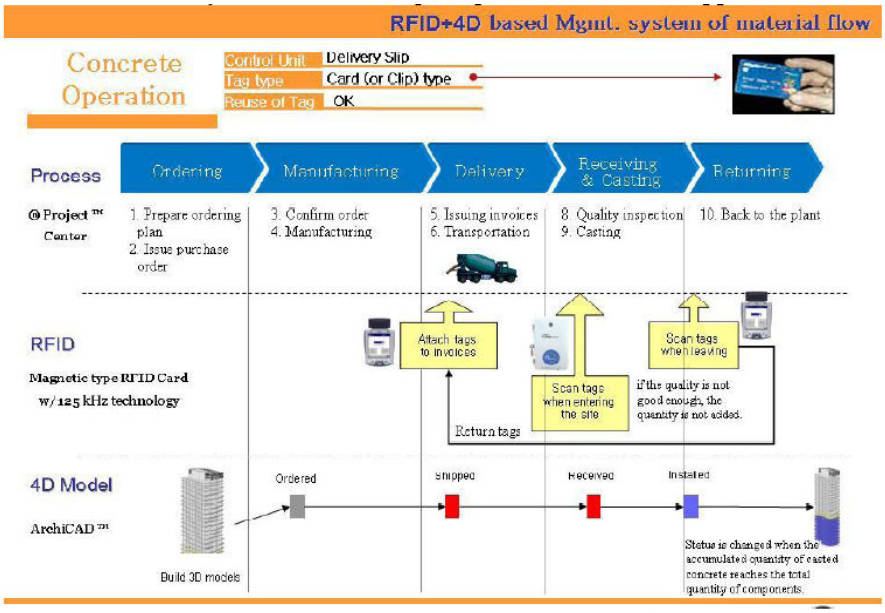
Javed Sikander, Microsoft's Director of Industry Architecture, in an article[4] on MSDN stated that "Businesses strive to make their supply chains more efficient by improving the information sharing throughout the supply chain. At each node in the supply chain, forecast and actual sales from the next node are collected, and planning may be done on what and how much to make, which drives what and how much to buy from the previous node. Today large demands are placed on manufacturers, distributors and retailers along the chain to maximize efficiency, minimize cost, and provide the best value to the end-customer."

"With a supply chain that numbers millions and involves complex co-ordination and tracking of labour, materials and plant movement, the construction industry can really benefit from RFID.

Davendra Patel. CICA

Figure 6 shows a supply chain of the future where construction materials (i.e. steel beams) will have RFID tags so that manufacturing, transporting, storing and installation of materials is monitored by construction engineers. This will have a great benefit in reducing field overhead costs which account for the major portion of project expenses.

Figure 6: RFID for Construction Project Management

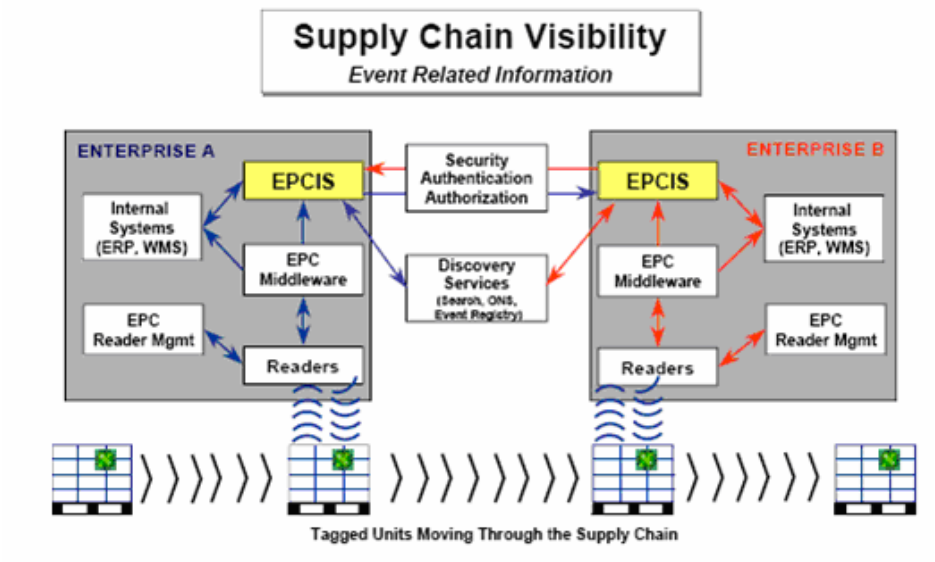


Source: Construction Supply Chain Management Based on RFID Technology, Chul Kim

4 RFID Enabled Retail Supply Chain, Javed Sikander, Microsoft Corporation, April 2005

EPCglobal's stance is that RFID provided the mechanism to provide the visibility necessary in today's complex supply chains. It envisages a sharing of information between companies.

Figure 7: EPCglobal Network



Source: EPCglobal

But to handle this network effectively, you have to tackle the biggest issue: that during the supply chain the same product may be referred to by different product codes. The benefits of synchronised data are far-reaching, both from an internal and an external perspective. The sharing of data between trading partners is now one of the most important supply chain processes as the integrity of the information is critical for the uninterrupted flow of goods. The term used to describe this phenomenon is Global Data Synchronisation (GDS).

Equipment Tracking

The need to keep track of expensive moveable assets as they move from supplier to site and on site is critical to cost control.

A number of devices are starting to emerge that combine mobile phone technologies with location equipment. By adding digital and analogue inputs, not only is it possible to show where an item is, but it is also possible to trigger alarms and control using direct dial or SMS techniques. Vehicle usage, mobile pump monitoring, tracking and recovery of stolen vehicles permit return on investments directly accountable to reduction in losses and penalties when the technology is missing.

By associating a unique identification with a GPS coordinate it is possible to allow appropriate maintenance to take place on items that have no visible form of uniqueness. A GPS coordinate may take you to within 3 metres of a unit or less than 1 metre with more sophisticated equipment, but with bar code or RFIDs absolute certainty of action is possible with anything anywhere on the surface of the planet.

Cemex Rail Products produces 100,000 linear metres of concrete bearers and railway sleepers each year. Although all concrete blocks appear to be the same, they are all unique items, tracked through the factory. The sleepers are individually set, drilled, fasteners attached and quality confirmed. Cemex already uses ERS systems for order tracking and delivery, but wanted to use RFID to fully track the sleepers during the manufacturing process. A key issue was the choice of tags, as they would need to withstand being set when casting. A small scale system to demonstrate proof of concept to support the automation of quality check against delivery schedule was set up.

"Construction companies are continually challenged with ensuring that expensive assets are secure and have maximum utilisation. Construction sites, with their multiple contractors and ever-changing environments, pose multiple risks including theft, misplacement, and unauthorised use of equipment. After the successful demonstration of this trial we are now in discussions to enable roll-out of the solution later in 2006."

Keith Dobson, CEO of OxLoc

Figure 8: Cemex Rail Sleepers being Quality Checked

Source: BRE Projects with RFID in Construction, Karim Esmail, 2006

The benefits from this pilot were evident. Tags can be embedded in concrete with steel re-enforcement. It was easy to track concrete blocks in the yard. The pilot also showed that there were opportunities for asset whole life costing as tracking covered:

(US) Construction industry loss estimates up to one billion dollars annually, according to a 2003 National Equipment Register study

- Improved specification
- Manufacturing schedule
- Delivery
- Options feasible for operating cost structure
- Concrete loading
- The ability for concrete block to be leased if tracked

Manchester Housing Association has over 1500 boilers to maintain on a paper-based Corgi service system. The boilers have been fitted with bar codes, but these bar codes are often removed by vandals. The tenants complained about the inaccuracy in service history. Based on these issues the Housing Association, in conjunction with BRE developed a ROI case for RFID. BRE developed a tagging system for maintaining boiler assets which integrated with existing maintenance and HA/LA asset management systems. The tags were applied to both the boilers and the doors. Besides the boiler identification number, the tags contained embedded health and safety notes and inspection notes. The engineers were able to download information from the central systems as well as upload data. A pre-emptive maintenance schedule was used to monitor service engineers.

In the US, Allaura provides the construction industry with RFID technology for tool management, tracking and anti-theft applications. It allows companies to retrofit tools of all sizes that have item information coded onto passive RFID (short range), semi-passive RFID (long range) and active (extreme long range) tags secured onto the tools. The service also provides RFID compatible tool tracking software, corresponding mobile scanning hardware, and a list of corresponding serial and product numbers for products in inventory. The tags meet ISO standards. The RFID software technology provides accountability for who used the tool last, where the tool was last seen, whether the tool is in inventory order, and sends a real time alarm when a tool is misappropriated and found to pass through a gate or door. RFID tool tracking system is able to tag all tools, from small items such as hammers and screw drivers to larger ones - power tools, compressors and fork lifts. These include demolition and breaker hammers, combination hammers, cordless and corded rotary hammers, small and large angle grinders, cutoff machines, cordless and corded construction saws, cordless multi-tool combo kits, corded and cordless reciprocating saws and cordless drill / drivers.

Remote Monitoring

Remote monitoring of fuel, temperature and utility metres provides a way of reducing costs and manual intervention.

Remote monitoring allows a user to manage and monitor systems over a network without manual intervention. It can provide automatic alarms and warnings.

Tank monitoring

When do customers need more gas? For thousands of companies and individuals around the globe, liquefied petroleum gas (LPG) is a critical source of power and heat, but often supply can be disrupted because there is low visibility in the final stage of the supply chain and at the customer site. Because there is no visibility of how much is left, trucks may return from the day's rounds half full - or conversely be empty by mid-day. Customers can run out, often during out-of-hours, and this can cause the potential loss of the customer to another supplier. Using RFID, BP is able to remotely monitor canisters and, in effect, provide preventative maintenance in order to ensure supply continuance. The benefits are enormous. Delivery efficiency has shown an improvement of 34%. The drop-size, i.e. the amount dropped at each customer per trip has increased by a mammoth 50%, and customer service has risen strongly, resulting in 70% less customer queries. Whilst this story is about LPG, it provides an indicator for other industrial uses where remote asset diagnostics is required.

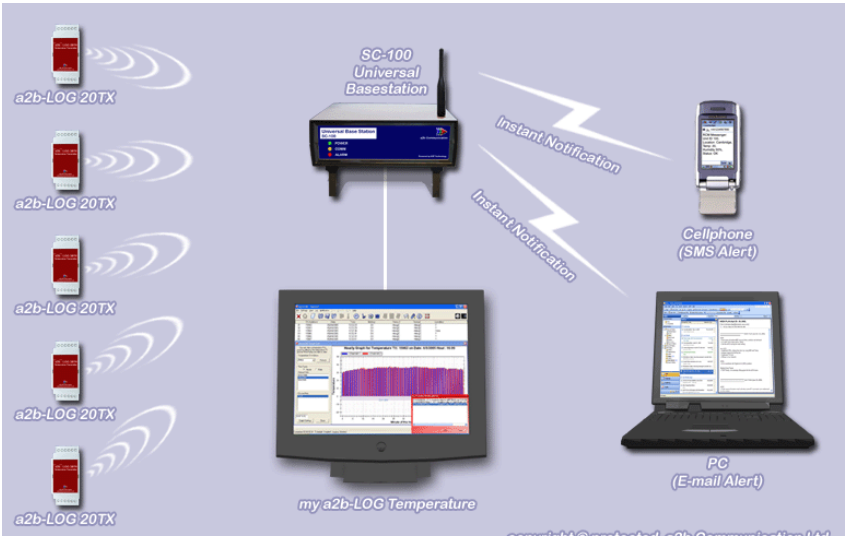
Temperature monitoring

One of the cornerstones of automatic temperature monitoring success is the ability to automate all temperature reading irrespective of distance, location and environment. Remote sensors need to read and monitor temperature without human intervention 24 hours a day, seven days a week and 365 days a year. Data is then processed in real-time and a report is sent to the customer automatically (daily or weekly). In the event a temperature alarm has occurred the system must automatically notify the customer for immediate action to be taken. Eliminating the need for manual temperature measurement and storage, the wireless temperature monitoring systems use sophisticated software to manage historical data, analysis and risk assessments for verification, and print reports for on demand inspection. Alarm management functions allow immediate notification through several mobile phones or email addresses. There is also a pop-up alarm window with audible sound to notify personnel of alarms, location, time, date and temperature reading.

Temperatures are read automatically at a pre-defined period such as real time, every 30 minutes, every hour, every six hours, every 12 hours or once a day, therefore site visits for temperature reading are no longer necessary, except for routine maintenance. Using dedicated software, temperature readings are collected remotely, processed, presented in easy tabulated and graphical format for the user to review, and then eventually archived. All the user has to do is watch new temperature readings from all the remote sites / points as they come in, review temperature trends and if a site has a problem such as the temperature value exceeding normal conditions, the user will be informed by an audible alarm, receive a text message and an email alert.

Automatic temperature monitoring over Ethernet is simple and straightforward, allowing direct connection to your existing LAN/WAN, providing safe and cost effective meter reading solutions for companies and organisations.

Figure 9: RFID Being Used for Temperature Monitoring



Source: a2b Communications

Smart metering

This system is being applied in the utility industry. Most applications are built on the data collected by the meter, be it value or status, and as a result it is not surprising to find a common solution. For example, a2b Communication Intelligent Metering Solution (IMS) combines wireless and internet technology for gas, water, electricity, heat, liquid, oil, steam and effluent meter reading, without physical access or visual inspection of meters. Meters are read automatically without human intervention, monitored 24 hours a day, seven days a week and 365 days a year. Data is processed in real-time and a report (daily or weekly) is sent to the customer automatically. In the event a meter stops operating or leakage has occurred, a2B Communication's system will automatically notify the customer for immediate actions to be taken.

In filling in a typical meter reading form there is a significant amount of information that comes in a number of ways. The key to a solution is in tying this data together with appropriate unique identifications. For example, when installing a meter a unique ID is associated with the meter and then other information can be stored against it, such as:

- Serial number
- Make
- Model
- Location

A simple process of scanning the ID and associating this with a keyed input will give the meter reading.

Figure 10: RFID Being Used for Smart Metering

Source: Key2Id

A rich variety of information including the time that the tag was read is collected each time the meter is scanned. It is not always necessary to have the details of the physical meter pre-entered into the system; meter readings can be taken and the missing information can be brought up to date when appropriately qualified personnel are available.

It is with the freedom of this approach that information systems can adapt and absorb information to provide complete pictures of what is known and more importantly identify what is missing, with the liberty to add on future relevant information at a whim.

As every scan and note is time-stamped, limitless opportunities exist to use this information. Compared to traditional methods, data input takes a fraction of a second and inevitably it is significantly more reliable.

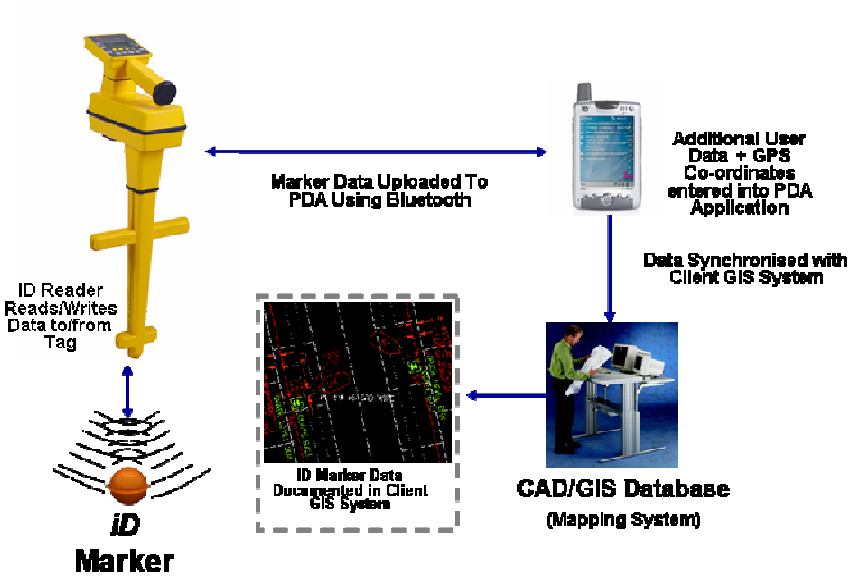
Utility Pipe Work Tracking

Buried pipes and cables can be located using attached RFID tags, as long as the read range is not exceeded. For plastic pipes, a more suitable technology uses magnetic nanoparticles during production of the pipe. It is possible to introduce conductivity into plastics by simply mixing in conductive nanoparticles in the production process. Thus, magnetic nanoparticles can be used to introduce a unique magnetic 'signature' to plastic items, which can then be scanned like bar codes. In the construction field, this would allow simple and accurate location and identification of underground services such as gas and water pipes, communications cables, etc. If the magnetic signatures are repeated at regular intervals along the entire length of the pipes and cables, they could be tracked throughout the site.

A small UK company, Key2ID, has teamed up with 3M to provide a GPS utility marking system. The system can be used for both new and existing pipes. With the latter a robot with a camera is used to pinpoint the fault in the pipe. This robot is fitted with a RFID tag that is located through the special focusing reader. The marker data is then uploaded to a PDA wirelessly over Bluetooth. Additional information can then be added (e.g. GPS coordinates) by the PDA application. With new pipe work, RFID tags are fitted at junction points and thus the location of the pipes can be found accurately.

This system provides location accuracy and leads to reductions in congestion and costs for utilities and local authorities.

Figure 10: GPS Utility Marking System



Source: Key2Id

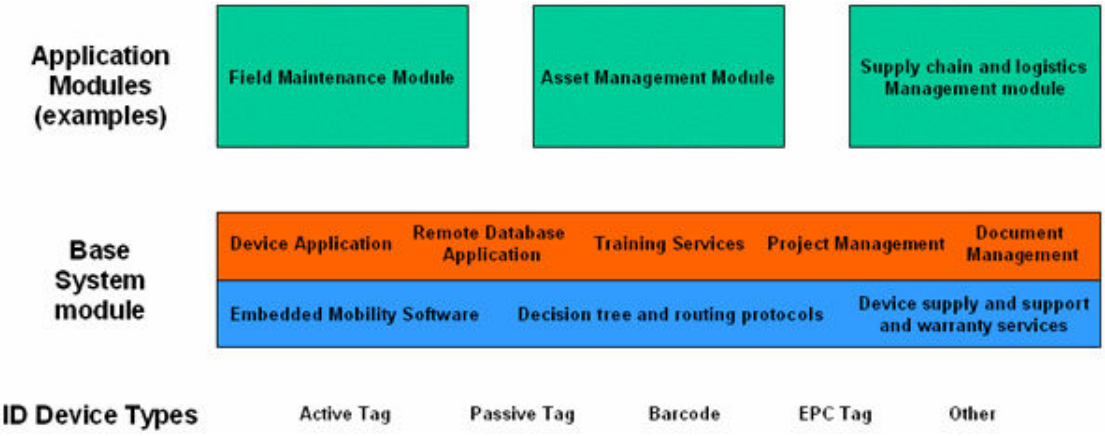
The Key2ID product consists of three parts:

Key2ware: a scalable middleware engine built specifically for real-time data collection, filtration and business rules driven event management. It is device agnostic and runs in a heterogeneous environment of RFID technologies, smart bar codes and other tagging methods.

Key2ware applications: include custom designed business applications spanning the lifecycle of a product. Examples include: asset tracking and verification; asset depreciation; snagging and handover; planned and preventive maintenance; field maintenance; energy saving; valve identification; shipping / receiving reconciliation; returns / recall management, and many others.

Key2ware device management: This provides integrated management for RFID readers, bar code scanners and major printers, coders and markers. It enables the configuration, installation, fault detection and operation of devices both within and across locations.

Figure 11: Key2ID RFID Product Features



Source: Key2Id

Service Maintenance

As the construction industry sees the potential of after service, so RFID can be seen to provide added-value in terms of ease of use and security.

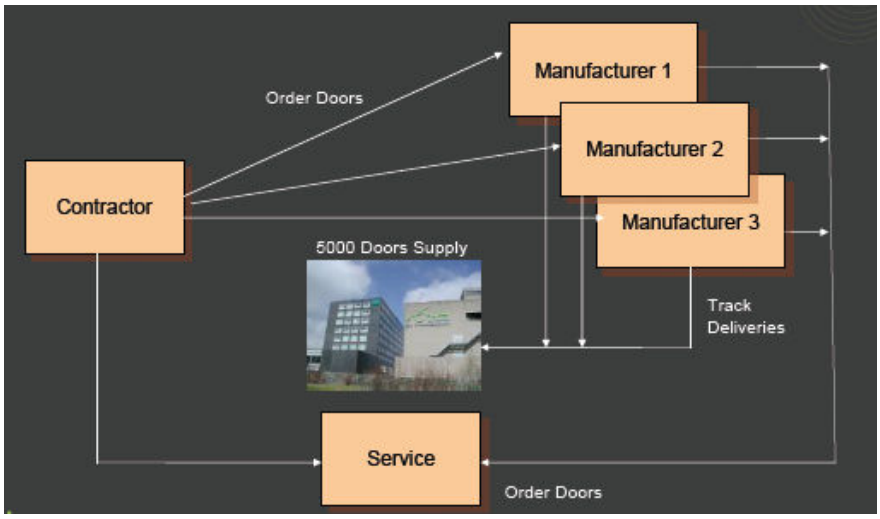
RFID technology can be a helpful record-keeping tool for high-value assets and equipment service logs. Applications would allow mechanics in the service bay to read and write to the tags, reducing the amount of paperwork related to warranties and time consuming maintenance logs. It will also encourage operators and managers to keep better track of their assets because there are not hundreds of different pages mixed around for a variety of tools and equipment. The equipment would display its records upon request via an in-cab smart tag display powered by the equipment. The tag would store information regarding maintenance and moderations, tire pressure and dimensions for rubber-tired tools and equipment, service history, inspections, and operating or erection information and checklists.

An example of how RFID has been used for after service is a trial done by BRE for Hazlin in the UK. Hazlin was established in 1974. In 1992 the company embarked on a growth plan to make it a foremost player in the bespoke architectural veneering market. Since this time the company has become a source for high quality architectural veneered doors, panels and door sets for use in quality domestic residences, schools, hospitals, financial institutions and large construction projects throughout the UK. Hazlin was selected to carry out research into product e-tagging with BRE in 2005.

Embedded in a product, the small electronic RFID tag stores much more information than a bar code. With a read-and-write capability and using the low-level radio frequency generated by a hand held reader, information is transmitted to and from the tag's memory. Combined with an accompanying hand held scanner and software, the trial tags installed in their doors contain a wealth of information. Amongst many other uses their contact details and door product code simplify the reordering process where damaged doors need replacing, as well as providing a hi-tic solution for security inspection in large buildings.

The outcome of the trial was a fully automated system delivered using Web based front end that allowed the customer to audit an order in the supply chain through to delivery, as shown in Figure 11.

Figure 12: Hazlin Supply Chain

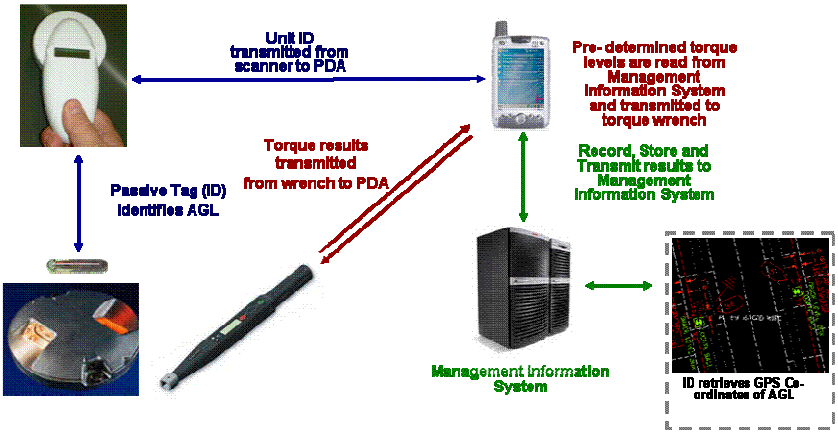


Source: BRE Projects with RFID in Construction, Karim Esmail, 2006

KRD Corporation in the city of Zama (Kanagawa Prefecture) developed RFID bolts. Using special digital torque wrenches, a user can maintain records about each bolt: when it was fastened and how much force was applied while fastening, etc. Potential application areas include airplane assembling factories where lots of parts and bolts are used, since RFID bolts may be used to make sure that all bolts are fastened.

Key2ID have developed an Aeronautical Ground Lighting (AGL) solution that provides real time maintenance information. This solution improves safety, increases efficiency and cuts costs. In addition, it enables proof of conformance / compliance to regulator. A similar system has been installed at Frankfurt Airport by SAP.

Figure 13: Key2ID Aeronautical Ground Lighting (AGL) solution



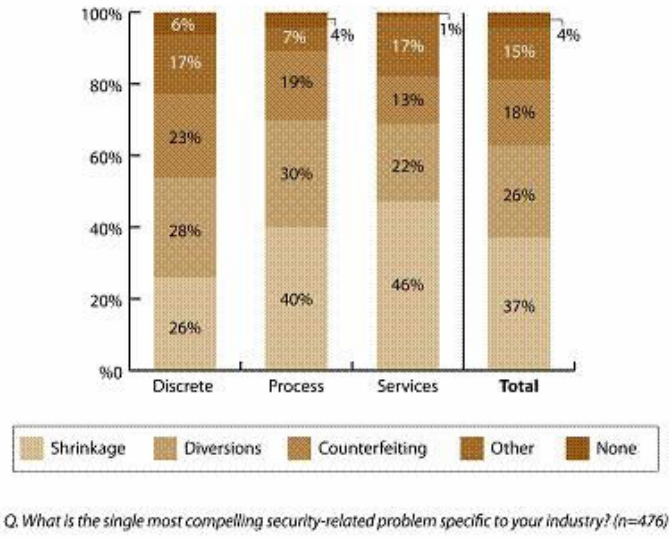
Source: Key2ID

Shrinkage is prevalent as in all industries. RFID can provide a mechanism to aid in reducing this cost.

Shrinkage

Shrinkage is a problem for many industries. In a recent AMR Research survey, over 40% of companies in process and services industries claimed that shrinkage was their greatest supply chain security challenge.

Figure 14: Security Challenges by Industry Segment



Source: AMR Research, 2005

RFID is not just for large companies, nor does it need to be applied across extensive areas. Klumpp, a SME automotive supplier manufactures turned parts that on leaving the lathe are cleansed by the basket in hydrocarbon solvent to remove oil and dirt residues. Up to 10% of parts are lost during this phase, but conventional bar coding is not sufficient as the label would disintegrate in the solvent, plus it requires manual intervention which greatly slows the process. A heat and solvent-proof RFID transponder fitted to every basket now stores the basket's tare weight. After treatment this weight is subtracted from the basket's total weight, including turned parts, and the result is divided by the weight of the part as stored in the ERP system to reveal the exact number of parts in the basket after treatment. As the tag is on the basket and not the items, it can be used time and time again. Return on Investment is fast because all losses are recorded at source and rectified.

Electronic Proof of Delivery

With the need to know what has been delivered to a given site, RFID has started to be seen as a cost effective technology to provide the necessary tracking and tracing mechanism.

Electronic proof of delivery is a step in the overall process of fulfilling an order and invoicing the customer. A solution confirms the goods have been delivered, the address they were delivered to, the time they were delivered and electronically records the signature of the person receiving the goods.

"(RFID) is appropriate for several construction applications, providing cost savings through increased speed and accuracy of data entry."

Yu-Cheng Lin, Assistant Professor, Institute of Civil Engineering and Disaster Reduction Technology, Ching Yun University, Taiwan

Delivery / collection instructions: the driver's delivery / collection manifest, stop sequence, delivery and complete load sheet are all stored on the handheld device.

Amend delivery items: the driver can amend the delivery details for over / under delivery quantities, enter actual delivered quantities for bulk tanker deliveries, and enter collection / uplift details – including details of unexpected returns / collections.

Item tracking: every delivery and collection confirmed updates the item tracking on the handheld device, which maintains a vehicle item manifest. On completion of the route the system will provide an unload schedule for failed delivery items and returned / collected or uplifted items.

Electronic signature capture: once the delivery details are confirmed the receiver signs for the items on the handheld device and an accurate delivery note, complete with the signatures, is printed at the point of delivery. This information (including signatures) is stored on the handheld and passed to the office database.

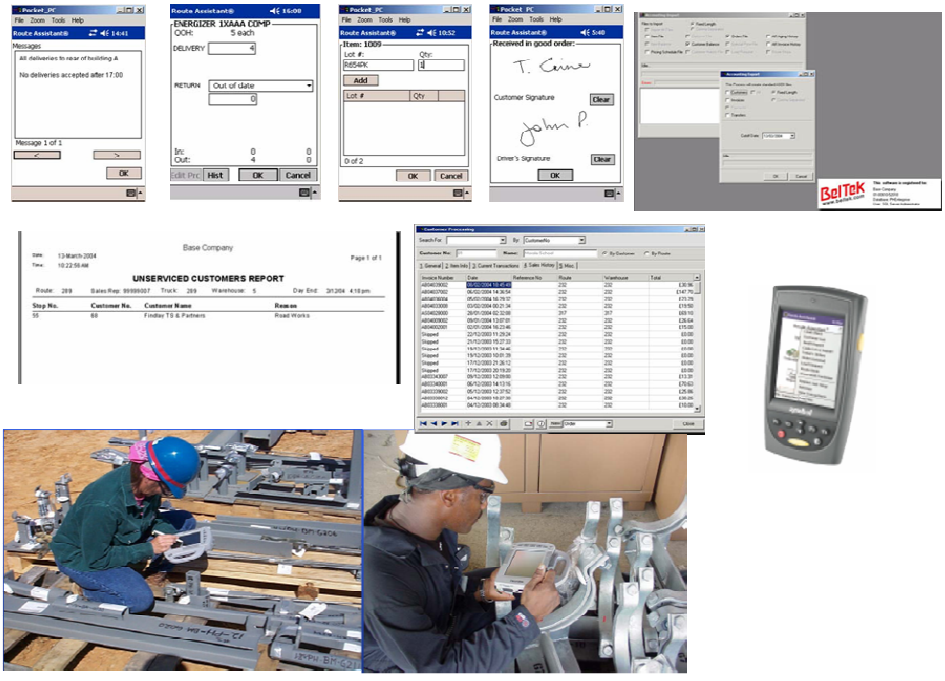
Data transfer to office system: all the delivery information is passed as electronic data from the handheld device to the office system. No office copy paper delivery notes are necessary and there is no need to collate and file office copy delivery notes for possible retrieval at a later date. These are all stored electronically and can be recalled at any time, complete with the recipient's signature.

Exception reports: where an adjustment has been made to a delivery this will be highlighted on exception reports as will other discrepancies such as unload quantities incorrect, failed deliveries, etc.

POD recall instantly: the proof of delivery has been captured on the handheld device and passed to the office system as electronic data. The proof of delivery can be recalled at any time, instantly, from the office system and emailed, faxed or printed and posted to the enquirer, complete with the electronic signatures captured at the point of delivery.

Integration to other systems: proof of delivery solution has been designed to integrate with other applications – allowing the delivery data to pass to our system to generate load schedules, delivery manifests, routes, stop sequence and so on. On delivery confirmation, the delivery data is passed back via the integration module to the other systems that may be used for delivery confirmation and customer invoicing.

Figure 15: Example of Electronic Proof of Delivery



Construction companies are continually challenged with ensuring that expensive assets are secure and have maximum utilisation. Construction sites, with their multiple contractors and ever-changing environments, pose multiple risks including theft, misplacement and unauthorised use of equipment. BT Auto-ID[5] has recently concluded a RFID asset-tracking trial with the potential to transform the construction industry. The results of the project, which took place on a major London construction site over a period of two months, could radically improve cost-efficiencies and the management of vehicles, tools and equipment on large sites nationwide. The trial was the first of its type in the sector and was prompted by the increasingly urgent need for monitoring the location and condition of construction assets in transit around sites. The project was undertaken with one of the UK's largest international construction companies. The ever changing environment is hindered further by limited or no access to power or wired communications. By combining advanced wireless technologies with long battery life, BT was able to increase asset visibility and reduce installation, integration and reconfiguration times.

BT was supported by asset-tracking specialist OxLoc in the project. Based on global positioning system (GPS) technology for location, global system for mobile communication (GSM) for data communication and ultra long-range active RFID for asset identification and monitoring, the resulting system had a self-contained battery source, which could be installed within 15 minutes and was capable of supporting a range of sensors to control and monitor asset condition.

The result of the project was that it has successfully proven the benefits of an entirely wireless asset tracking system where expensive assets such as plant are constantly mobile and exposed to intense conditions.

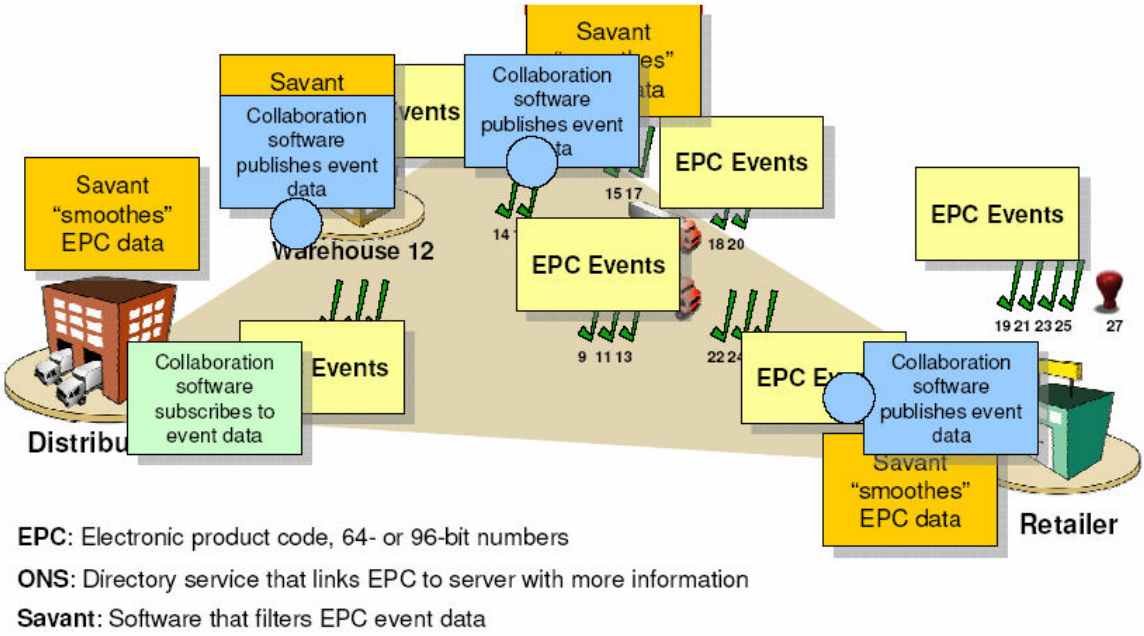
Product Authentication (e-Pedigree)

The authentication of products is a vital component in today's world. RFID has proved an effective mechanism to provide the e-Pedigree.

A number of industries are concerned about the authenticity of their products. These include pharmaceuticals, aerospace, automotive and high fashion. This is also true in the construction industry in terms of key products used. Most of the examples of e-Pedigree systems have been developed for the pharmaceutical industry, so I will use these to illustrate the concepts of the solution.

Raining Data's ePharma solution tracks the individual pedigree of drugs throughout the pharmaceutical supply chain and allows the major trading partners, pharmaceutical manufacturers, wholesale distributors, pharmacies and pharmacy benefit managers, to act on this information. The system tracks the location of pills from RFID tags or bar codes and the change of custody at all change of ownership points. Specifically, the system supports serialised and non-serialised pedigrees, as well as item level and / or case level serialisation.

Figure 16: e-Pedigree in Practice



Source: Cyclone Commerce, e-Pedigree and RFID/EPC, February 2005

The electronic pedigree is an ever-growing chain of custody detailing the path of the drug through the supply chain. Each company adds to the pedigree. The seller identifies the drugs and the full chain of custody, then certifies the pedigrees and transmits them in advance. The trading partner receiving the drugs authenticates the pedigrees. When the shipment

[5] BT Auto-Id web site, http://www.auto-id.bt.com/subsection/mediacentre/press_releases.htm#0

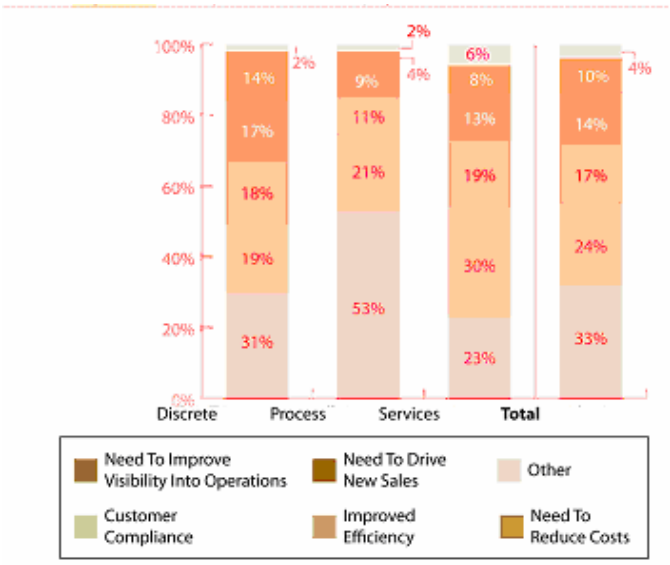
arrives, the pedigrees are matched to the products and signed verifying their accuracy. The pedigree software maintains the product-to-pedigree match while the products are in inventory. If an inspector visits and selects a product, the company must be able to produce the pedigree for that product. Software application e-Pedigree solutions manage the pedigree documents of record in a compliant repository and enable rapid retrieval of the corresponding pedigree.

In the construction industry, e-Pedigree solutions could be used in conjunction with electronic proof of delivery to provide verification of the delivery of the right material.

Enabling Compliance and Quality

Among companies in a recent AMR Research survey[6], customer compliance was very important in process industries, primary consumer goods and pharmaceuticals.

Figure 16: e-Pedigree in Practice



Source: AMR Research 2005

Responding effectively to customer orders is a fundamental requirement for any business, but when your order turnaround times take several hours and your processes are manual, it can seem a major challenge. This was the situation facing third part logistics provider Can U.S. The company maintains 60 trucks and handles products ranging from CDs to stainless steel sheets, and even fur coats for a wide range of customers across the US and Canada. Some of these products are also prone to loss at points through the supply chain, further reducing customer satisfaction with the company's response to orders. After working with a leading provider of RFID services in Canada, Ship2Save, the company implemented an $80,000 RFID-based solution (based on a Microsoft platform) in the warehouse dock and distribution centre, plus in-transit monitoring of trucks and contents. The results were not only surprising but also provided spin-off benefits which were not immediately apparent:

- Theft reduced by 95%, plus loss of perishables was nearly eradicated.
- Order turnaround times reduced from several hours to just ten minutes, enabling redeployment of two operatives from the warehouse.
- Reduced insurance premium by 15%. (A spin-off often ignored by companies.)
- Time spent on the phone with customers regarding shipment status was reduced by 75%.
- Projection to increase revenue by 3% in 2006.
- Manual inventory count reduced to one hour / month avg. (another welcome benefit).

Another use of RFID for compliance would be to provide visibility to your customer of the exact status of an order; especially in situations where shipment details may alter with minimum notice, such as in medical supplies or consumer

[6] AMR Research, 2005

goods. One such example is hospital logistics (however the same principle could be applied to many manufacturing supply scenarios). The goal of the project was to associate RFID tags with orders and ensure that orders were being fulfilled by positively reading the tags that were associated to orders. The customer wanted to ensure that before medical supplies left their distribution centre they stopped any errant containers from reaching a wrong hospital. The customer currently has a good bar code system in place but wanted to reduce the amount of labour required and the number of manual errors that occurred.

A usability trial is now underway with Microsoft partner Cactus Commerce but it is expected that the project will go live and reduce errors close to zero. Cactus Commerce is also involved in another solution, this time concerning document storage, again utilising Microsoft's technology. Secure document management company, Securit handles document storage for its customers and needs to be able to identify exactly what part of the process a customer's assets are at, with the objective of providing a guarantee that at all times its clients can have knowledge of where their documents are located, for fast retrieval, to reduce waiting times and ensure security. The value of this RFID solution to manufacturing is that the same method could be used to track documentation such as design, recipe, formulation or costing information which might be at risk.

Hong Kong's mass transit railway operator, MTR Corporation Ltd (MTRC) has innovatively used RFID technology in its construction process to ensure quality control of the concrete[7] used. Depending on the construction process, MTRC has developed three separate applications to ensure quality control:

- The LYNX system is used to test each batch of concrete mixed on site. For onsite mixes using LYNX, a sample cube from each truck is tagged with a RFID chip and sent to a test lab to ensure its quality. The results are uploaded to a central server, which allows authorities, contractors, architects and concrete suppliers access to the results.
- The QTRAC system ensures that pre-cast concrete components are up to mark. For pre-cast concrete, a RFID tag containing all the necessary quality inspection data is embedded into the pre-cast component. This ensures that when it is delivered, onsite personnel can check the quality of each component as well as obtain the unique identification information to help them co-ordinate all the components and speed up the construction process. The same RFID tag has enough memory so that information on the unit can be updated during scheduled checks.
- MTRAC is the third system, an online application to help regulatory authorities to certify the quality of their components. After onsite checks, the authority then issues a certificate allowing factories that pass the inspection to use RFID tags (which includes product details as well as the identity of the manufacturer and certifying authority) in their construction of pre-cast components. This accreditation scheme can be used to ensure that manufacturers are recognised for meeting certain standards.

To use RFID in construction, MTRC has had to put in tremendous innovation into "ruggedising" its application as the environment is not known to be gentle on technology. The RFID tags for concrete cube testing for example, is being patented, and is rugged enough to withstand the elements like water and dust, as well as being tamper proof to prevent fraud. For the QTRAC application, the RFID chip also has to be well protected to last for years on end.

The benefits MTRC has gleaned from RFID are tremendous. With the LYNX system itself, MTRC has reduced manpower costs by 20% and paper usage by 80%. Also, because the concrete cube testing process is fully automated, laborious work is reduced by half. The RFID applications are also being marketed to multiple parties and MTRC expects to reap significant revenue in the future.

Health and Safety – Hazardous Conditions

All major organisations have a key corporate responsibility for the safety and health of their employees.

Balfour Beatty made the following statement on their web site[8]:

"Preventing injury and ill-health, and maintaining a first class safety and health culture are key objectives of our business. Caring for the safety, health and well-being of our employees and everyone affected by our activities is of critical importance to us.

We take a structured, risk-based approach to managing health and safety across the Group. In 2005 we strengthened further our company-wide requirements "Balfour Beatty Expectations for Managing Health and Safety" by setting long term objectives for our operating companies, and requiring them to develop and implement strategies to achieve these by

[7] Radio For Help, Gerald Wee, CIO Asia, March 2005

[8] Balfour Beatty Safety web page, http://www.balfourbeatty.com/bbeatty/cr05/safety/

All construction companies have a remit to provide a safe environment for their employees. Safety is linked to environment issues as well. HSE provides another area where RFID can provide visibility.

2010. Our safety performance and safety management processes are continually improving."

Laing O'Rourke holds health and safety as a core business value and is committed to creating a future free of incidents and injuries.

This is not just a focus for the large enterprise organisation, but also for the small and medium size enterprise, for example, Wellington Construction whose main focus of work lies in building for the private, social and commercial sectors, states[9]:

"Wellington Construction shall ensure as far as reasonably practicable the health, safety and welfare of all its employees as required by current regulations. Wellington Construction commit themselves to core Health and Safety objectives which are regularly reviewed and improved upon:

- Promoting the concept that all accidents can be avoided
- Ensuring a safe and healthy workplace for all employees, including their surrounding neighbours and sub-contractors".

In the construction industry, it is important to know:

- Safety information relevant to equipment, tools, machines and materials.
- Violation notification.
- Condition monitoring.
- Inspection history.
- Fail safe automation.
- Work authorisation.

Let us look at how one organisation in oil and gas (another industry with heavy health and safety regulations), has tackled this problem. In 2005 at a BP refinery in Texas, there was a major incident in which a number of people were killed or seriously injured. BP set out to see how RFID could be used to improve safety and operations efficiency at chemical plants, refineries and E&P facilities by locating workers[10]. They wanted to be able to:

- Track workers that perform tasks in large, remote or dangerous environments and quickly locate workers in an emergency.
- Provide warnings to workers in hazardous environments.

BP set up some trials to prove the concept, with the aim of refining it further to prove operational feasibility by addressing intrinsically safe, form factor, size and cost issues.

One of these trials involved the use of RFID tags to check protective clothing and equipment was correctly being used. The check occurred as the employee was about to move from the control (safe) environment to the hazardous zone. The RFID reader in the confined entry point checked for the following:

- Is correct clothing being worn?
  - Safety equipment – hard hat, goggles, gloves, etc.
- Is breathing apparatus detected?
- Is there a "permit to work"?
- Is there more than one person present and who are they?
- Do those present have valid training certificates?

The trials also involved integration with local handhelds or back-end systems.

This use of RFID in the construction industry is one which would provide immediate returns on the side of employee corporate social responsibility for little cost.

[9] Wellington Construction safety web page, www.wellingtonconstruction.co.uk/ health&safety.htm

[10] Sensory Networks in BP, Mike Haley, BP, Chief Technology Office, RFID Networking Forum, May 2005

Figure 17: Safety Equipment Check

Source: Sensory Networks in BP, Mike Haley, BP, Chief Technology Office, RFID Networking Forum, May 2005

Plant Maintenance

Asset maintenance is one function in particular that can benefit from using RFID to access and update important information.

Every manufacturing organisation has to plan the maintenance of its plant resources. The maintenance of plant is a cost in terms of lost production time. The biggest issue is the amount of unplanned maintenance that can occur and its serious impact on tight production schedules. So how can RFID be used to help control and manage plant maintenance?

I will use as an example of the possible, some work done in BP[11]. BP tackled the plant maintenance issue at two levels. Firstly they digitised operator rounds to improve efficiency and avoid unplanned maintenance. This supported the refining business's drive for a "highly reliable organisation" by capturing the complex work rules into mobile applications. The processes followed are the same each time and are based on best practice. RFID is used to give a unique identification of the assets. As the operator checks the asset so an audit trail is automatically produced. The mobile applications are used to automatically generate work orders. The result is that instead of the work being to respond to breakdowns, it has been transformed to preventing them.

The cost of maintaining a machine is a direct function of the maintenance frequency and failure interval for the machine and major components, the time and labor required to complete unscheduled maintenance actions, and the time and labor required to complete routine maintenance tasks.

National Institute of Occupational Safety and Health

Secondly BP has used RFID and wireless technology to reduce unplanned maintenance and gather information in a trial of mote technology in a refinery to capture "secondary readings" and environmental data. Mote / sensors cost a fraction of the cost of wired sensors. Drawing upon BP's experience in using this technology in one of their ships, Loch Rannoch, it worked out how to bring motes / sensors together into a fully packaged solution with intrinsically safe requirements.

These solutions plus some for Shell have been delivered by an Aberdeen-based consultancy, Arnlea. The Arnlea's SmartFieldOps™ system helps customers replace inefficient and error prone paper-based processes with an electronic solution that is simple to use, flexible and efficient. Information is automatically downloaded from the office-bound systems to rugged, waterproof, intrinsically safe handheld WindowsCE computers, ensuring that authorised field personnel have the very latest information at their fingertips to guide and assist them whilst performing their tasks. Field data is entered directly into these handheld computers where it is validated (eliminating human error) and time-stamped. When the task is complete, this information is automatically transferred back to the office-bound systems.

[11] Sensory Networks in BP, Mike Haley, BP, Chief Technology Office, RFID Networking Forum, May 2005

Figure 18: The Arnlea SmartFieldOps™ solutions

Source: Arnlea

Both these solutions could be applied to the provision of services for plant, and supplied by construction companies as part of their after market services.

Hazardous Waste Disposal (RoHS and WEEE)

The European Commission worked for a number of years to understand the environmental impact of electrical and electronic waste, and concluded that the volume, the toxic content and the relative ease of recovering and recycling important materials justified EU wide action. The environment is defined as the 'surrounding in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation.'[12]. Under the WEEE Directive, EU member states have to ensure that systems are set up by producers to provide for recovery and re-use of separately collected waste electrical and electronic equipment, according to set recovery, re-use and recycling targets. Central to the effective functioning of these systems is the handling of large amounts of data; this is recognised in the directive by the significant data reporting obligations placed on producers.

The new EU directives around waste management provide an opportunity to use RFID for tracking and tracing visibility in a compliance arena.

In order to identify the producer, the equipment must be marked with the producer's name and the date of introduction to the market. Moreover, information must be provided to enable treatment facilities to identify components and the type and location of substances – including hazardous ones. In addition, WEEE specifies requirements for appliance specific reuse and recycling percentages, calculated from the material content of the product.

The breadth of data required by the new directive has led many companies to consider RFID tagging as the best means of documenting the entire lifecycle of products. However, for this to be successful, waste treatment facilities must also "buy into" the technology and standardise on a particular tag type and tag frequency. The standardisation issue apart is that the process of recycling of electrical and electronic waste is a challenging one for the application of RFID technology. The major reason for this is the metal contained in the products and the containers in which they are collected.

In addition to actual operation of the tags, two other major issues are what size of tag to use and what to do with the tag itself when the equipment reaches the recycler? Ideally, for producers to benefit from economies of scale, standardisation of the size of tag used on all of their equipment is essential. As regards the tag itself, when it has provided all the data required by the waste treatment facility it is then redundant, so part of the information it must provide concerns its own material of construction, and how it should be recycled. These key issues are addressed by IDC in conjunction with its smart media partner, a collaboration that provides complete turnkey solutions to RFID projects. The partnership is able to convert raw RFID tag inlays into smart media, such as self-adhesive labels. These offer read and write capability and can also incorporate bar codes where necessary, with company specific encryption if required; and they can easily be integrated into all types of merchandise.

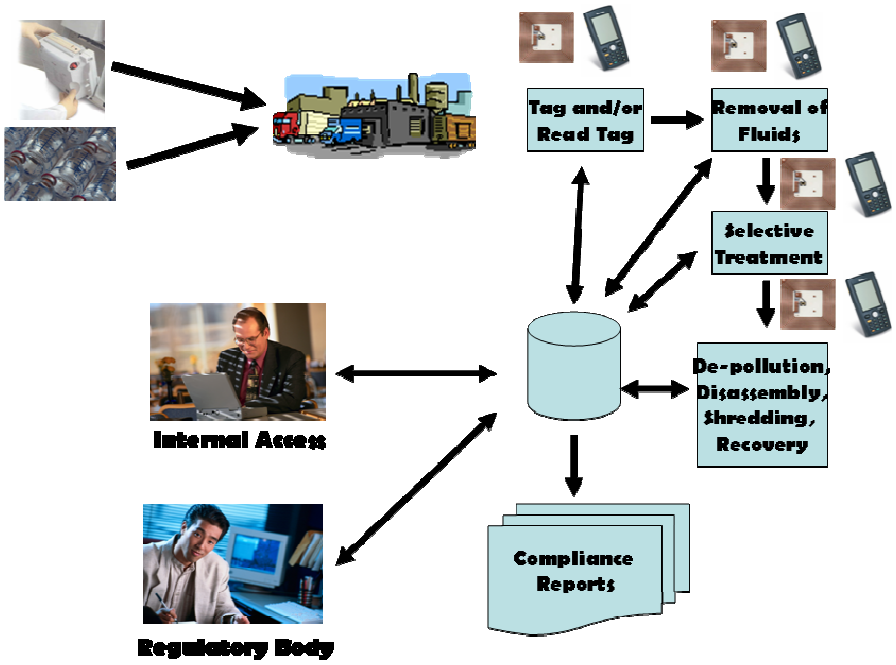
One successful project already completed by IDC as part of the WEEE Directive concerns fridge recycling. With nearly 2.4 million domestic fridges and freezers entering the waste stream per year this is a critical activity. IDC's involvement in the recycling process was the result of a contract requirement for 58 Irish local authorities to track obsolete domestic and commercial refrigerated equipment from collection to disposal. This was necessary to verify the number of units processed to determine payment to the recycler. The process of tracking begins when the fridges are collected from the various civic amenity sites throughout Ireland. All the fridges are equipped with Smart Tags™, applied at the collection

[12] ISO

sites, which are then scanned by the collection team using Symbol pocket PCs with a built in bar code scanner and wireless WAN/LAN connection, as they are loaded onto the van or truck. The pocket pc also has an infrared link, which enables the collection data to be printed onto a portable printer to enable the civic amenity manager to retain a hard copy of the data. All the collection teams are provided with security codes for operating the handheld units. The loaded fridges are then transported to collection depots situated in Northern Ireland and the Republic of Ireland. On arrival at each of these regional depots the Smart Tags™ data is automatically downloaded over a wireless connection to a PC, which automatically logs and records the collection data before the fridges are shipped to the recycling facility.

Collection details are archived and sent via dial up networks on a regular basis to the server based at the recycling centre in St Helens. This is responsible for holding and processing all fridge records from the point of collection to final disposal. Upon arrival at the recycling centre, the fridges are scanned again, at which point the manufacturer is also recorded and the units are then processed or put into storage waiting processing. The server runs the "Recycling Manager" software that provides a history of all shipping and processing with reports, some of which are automatically generated, and others that are generated on a calendar basis.

Figure 19: RFID with Document Management and Workflow Management Solution to WEEE and RoHS Compliance



Source: Microsoft Corp

Creating automatic systems that provide the user organisations with the process of disposal and also the ability to prove compliance is what is required. Using RFID either when the goods are produced to show when end-of-life occurs or when goods are returned to the original supplier, can help with the tracking and tracing of the goods through this special version of reverse logistics. There is a major requirement to prove that a company has complied with procedures for the safe disposal of material. Therefore RFID in conjunction with workflow management and document management provides a solution to this problem.

Implementation Challenges of RFID

Implementing RFID is a business decision, not a technology question. Implementing RFID involves a multitude of challenges. Multiple goals of an RFID deployment can lead to a complex project. It's better to focus on a few clear objectives. "The fragmentation of the business case is forcing people to be more cautious and more analytical in how they approach the technology," Overby of Forrester Research said in an interview.

"In the final analysis, it's not about the cost of the tags. It's about staying in - and ahead of - the game."

Association of Automatic Identification and Mobility

The other big challenge, she says, "continues to be cost," although Overby predicted that the adoption of the EPC Class 1, Gen 2 standards will put downward pressure on pricing. The Gen 2 standard makes the use of one, secure tag possible worldwide and it is expected to aid adoption of RFID across all industries. Other challenges include:

Besides the technology, RFID projects because of their close relationship to business process improvement and effectiveness require a high degree of change management skills to achieve successful implementation.

- **Resistance to change.** Many organisations today rely heavily on manual processes or bar code scanning to track goods. In any organisation, moving from the familiar to new technology poses a challenge especially when it requires process change.
- **Established bar coding infrastructure.** In many manufacturing facilities and distribution centres, bar code systems have been used for many years. Since bar code systems are efficient and represent a substantial investment, it can be difficult to justify a change to RFID.
- **No one size fits all.** Today's RFID systems are customised for each deployment. "In fact, a successful implementation typically requires considerable experimentation to achieve adequate read rates and the delivery of actionable information to appropriate recipients," says Alok Ahuja, Microsoft's Senior Product Manager, RFID.

"RFID represents both a major IT modernization and a major investment for organizations. While the initial costs of implementation are substantial, companies should leverage the opportunity for cost-saving process improvements by embracing the technology's ability to give near real-time visibility into inventory, asset locations, and operations."

Cougaar Software

- **Environment.** The physical properties of the products to be tagged, the antenna design and other environmental factors can make it difficult for readers to work reliably. Liquids absorb radio frequency signals, metal reflects them. As a result, performance can be affected by the item on which the tag is attached. External factors like RF noise from nearby electric motors can also impact performance. However, as RFID technology matures and experience increases, tag and reader placement will become less an art and more of a science.
- **Lack of integration.** Lack of integration and isolated islands of automation can pose other problems for those considering RFID. Manufacturers' enterprise resource planning systems may not be linked in real time to shop floor systems. Currently, integration with back-end systems generally requires creation of custom interfaces, an often time-consuming and expensive undertaking.
- **Lack of skilled personnel.** RFID-knowledgeable IT personnel are hard to find. Many organisations, regardless of size, will discover they have no qualified IT personnel in certain locations.
- **Evolving standards.** Managing multiple readers and related hardware can be a challenge, especially across multiple facilities. That's because global standards governing how RFID devices communicate with higher level systems are evolving. At present, communication between hardware and software requires custom configuration. The situation is similar to that found in the early days of personal computing when a specific vendor driver was required to link a printer to a PC and print documents. For those moving forward with RFID deployments, the fluid standards situation makes it imperative that system components provide an easy, inexpensive upgrade path.
- **Data overload.** A RFID reader will continuously scan each tag several times per second as long as it remains in its read range, so the potential for data overload must also be considered. Some readers can be programmed to eliminate duplicate information, but data volume still can be overwhelming to the network. The reason: RFID systems can capture information at more points than was practical with manual or bar code systems. Because few ERP systems were originally built to accept a high volume of low level data, RFID system designers typically include some data filtering at the edge (device level).
- **Data noise.** The torrent of RFID data (called "noise") can overwhelm readers or cause ambiguity, especially in dense reader environments where scanning areas may overlap. Read rates are improving but often not anywhere near 100% due to unreadable, damaged or missing tags. In addition, because reading is based on proximity, mistakes can happen. A reader, for example, may read the tag on an item passing by on a forklift rather than on a stationary target. To prevent inaccurate data from being transmitted to enterprise applications, a successful RFID solution must be able to deal with erroneous or missing information.
- **Multiplicity of vendors.** No single vendor does it all, so most RFID systems must be assembled from multiple sources. This can create integration obstacles if hardware and software don't work together.
- **Resistance to information sharing.** In systems that depend on information from various trading partners, information sharing issues must be resolved to achieve maximum benefit.
- **Privacy issues.** Finally, some privacy advocates claim RFID will violate consumer privacy and have become vocal opponents of the technology. Although much of what they fear isn't currently practical (or in some cases, technically feasible) these critics are being heard. Of particular concern is the use of RFID technology without advising the consumer of its presence and how it is being used. Vendors and users of RFID should be committed to using the technology responsibly and they should be vigilant about any perceived or actual misuse of personal data.

While companies have to justify an acceptable ROI for the costs associated with implementing RFID, they often overlook

the price of not implementing it. Some considerations are:

- Will profitability eventually decrease if the status quo is maintained?
- Will the company lose a potential competitive advantage?
- Will the company eventually lack sufficient accurate information about its processes or inventory to effectively manage its business?
- Will customers' perception of the company suffer?
- Will the company be able to catch up once competitors implement RFID?
- Will existing inefficiencies become unmanageable as the pace of business continues to increase?

Not to be entirely negative, you also want to ask this question:

- Will RFID enhance your company's ability to serve its customers? Improved customer service and customer loyalty are sometimes difficult to quantify. Sometimes it is easier to look at the negative side to understand the value of customer service. In other words:
  - What is the cost of losing a customer to a competitor who offers better service?

When you look through all the scenarios described in "Using RFID to Solve Current Business Issues" section of this paper, it becomes very apparent that the solutions involve more than just the use of tags and readers. They also provide support for integration with ERP solutions that run company's businesses, collaboration with supply chain partners both up and down the chain, and security / privacy. This requirement plus all the issues discussed above, mean that the architecture in question must be both agile as well as heterogeneous in nature.

How does Microsoft BizTalk RFID Address the Business Needs?

Microsoft has entered the RFID market with a view to reduce the costs and provide an environment that allows ease of operation and use.

To encourage widespread adoption of RFID technology and address the customer pains of managing multiple devices, smoothing the data, translating data into meaningful events and combating costly integrations, Microsoft is developing a layered RFID infrastructure, named BizTalk RFID, using an open building block approach. It relies on related Microsoft applications platform products and a growing number of integrated partner solutions. This approach provides a wealth of solutions for any size organisation or industry vertical, including manufacturing, pharmaceutical or aerospace. Also, the combination of Microsoft's technology platform plus partner solutions offers a multiplicity of applications reflecting the broad potential of RFID.

> "The idea is for Microsoft, together with its partners, to provide one-stop shopping for a RFID solution."
>
> Anush Kumar, Program Manager, BizTalk RFID, Microsoft

BizTalk RFID enables compliance, automation and business process transformation while shielding users from changing standards / regulations. Toward this end the company is developing core infrastructure components to support RFID applications and solutions. It is also RFID-enabling select systems within its family of Microsoft Dynamics enterprise applications products. The infrastructure provides a base set of tools for device abstraction and management, event processing and applications integration.

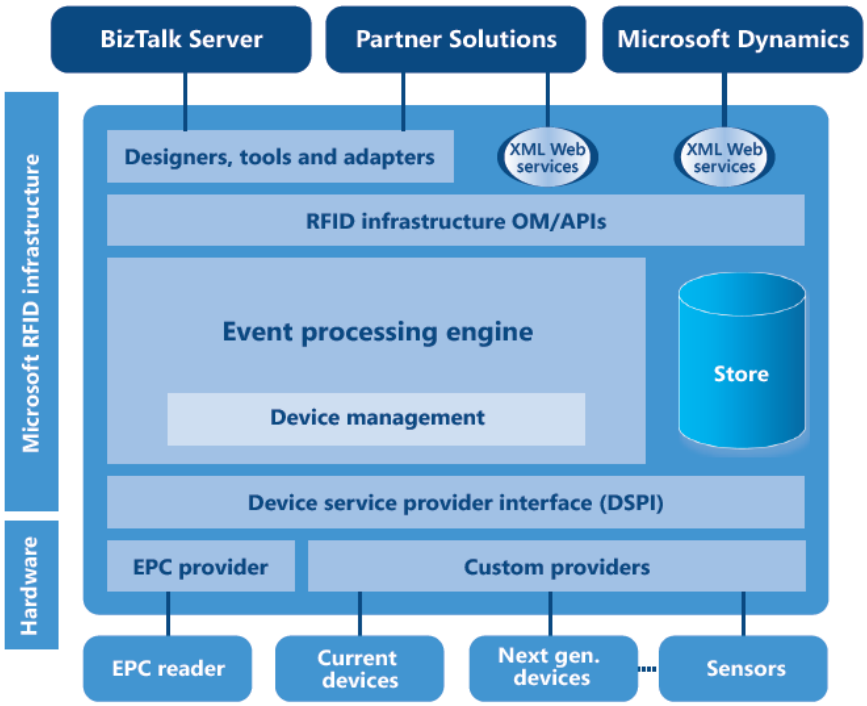
Independent hardware, software and systems integration partners play a key role in developing RFID applications based on the Microsoft .NET® foundation technologies and Microsoft's applications platform products such as BizTalk Server, which provides data integration services for supply chain operations. BizTalk RFID can be embedded within third-party applications or used on its own to capture and interpret data from sensors and manage business events in an easy-to-deploy, user-friendly environment.

Microsoft's Layered Approach

BizTalk RFID platform consists of layers (see Figure 20):

1. Devices, such as readers and sensors
2. The Device Service Provider Interface
3. Event processing engine
4. RFID APIs
5. Tools and adapters

Figure 20: Microsoft's BizTalk RFID Architecture



Source: Microsoft Corp., 2006

Data transmissions from EPC readers and other devices from multiple vendors are processed via a Device Service Provider Interface included in BizTalk RFID. It provides a platform for independent software vendors and system integrators to install hardware in a plug-and-play fashion, resulting in a complete and seamless RFID solution.

Because the layers are tightly integrated, applications and devices can seamlessly interconnect. Here's how the layers work together:

Devices layer

The bottom devices layer consists of hardware such as RFID readers, printers, sensors, bar code scanners, 802.1X access points for wireless local area networks, handheld terminals and pocket PCs, which are provided by partners.

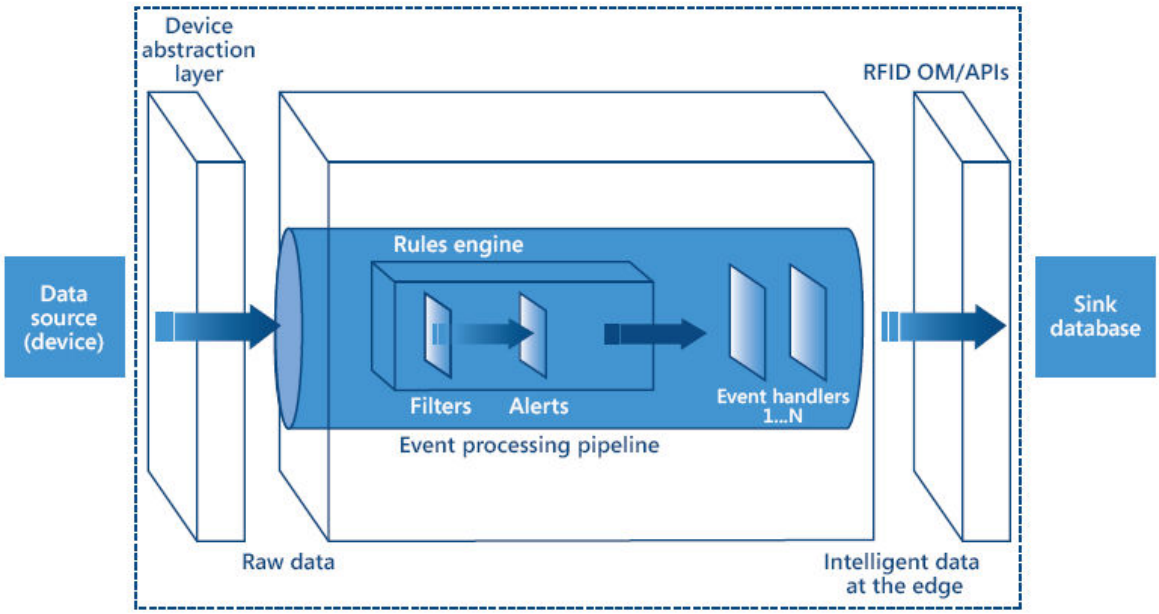
Data collection and management layer

To accommodate the potentially large variety and number of devices that could be resident in an RFID implementation, a Device Service Provider Interface (DSPI) provides a consistent way for devices from multiple hardware vendors to expose their device services to the Microsoft platform. DSPI provides a scalable, extensible infrastructure that allows customers to read data through any standards-based or non-standards-based sensor regardless of format, thereby reducing dependency on a specific technology and protecting RFID investments long term.

Event processing engine

This layer includes event and workflow management, messaging and a business rules engine. The event engine enables context-based or rules-based processing of RFID data to provide information directly to line-of-business applications. Information also can be delivered to business processes that span applications via Web services integration and orchestration products such as BizTalk Server. This layer provides the structure for integration across multiple facilities and partners. It also includes device management, to convert data into business process relevant information (see Figure 21).

Figure 21: The Event Processing Layer



Source: Microsoft Corp., 2006

An event, such as the movement of a box with a RFID tag from a conveyor belt to a pallet, triggers a data transmission that is processed by the rules engine. The rules engine determines which enterprise application is updated about the box movement and also automatically triggers any alerts that were incorporated into the business rules.

"This enhances flexibility, reduces the expenses related to building applications and simplifies integration, particularly when legacy systems are involved." Alok Ahuja, Programme Manager, BizTalk RFID, Microsoft

Services layer

The services layer includes product information resolution lookup, business process management, analytics / reports / notifications and enterprise content solutions.

BizTalk RFID makes it easy for partners to embed functionality directly into their application or build applications on the infrastructure. Open application programming interfaces (APIs) and .NET-centric tools allow partners to quickly create specialised vertical solutions across a wide range of applications.

The services layer also provides lookups to EPCIS servers where data about a tagged object resides.

Application solutions layer

This uppermost layer relies on services, data and tools from the lower layers to implement application solutions that drive business processes for the end user. Microsoft relies on its partners to build out many of the solutions, which are divided between two classes of applications: real-time enterprise / point applications and batch-oriented enterprise applications. In addition, BizTalk RFID also supports the Microsoft Dynamics family of enterprise applications.

Business Benefits

BizTalk RFID offers many potential business and technology benefits to those considering RFID systems today. In all cases, careful attention has been placed on open standards and overcoming the shortcomings of today's custom systems. Thus, BizTalk RFID is designed to lower total cost of ownership, simplify integration end-to-end from the device level to back-end applications, convert data into actionable information and provide a platform where Microsoft and its partners can build applications that take advantage of the volume and real-time nature of RFID data.

Lower total cost of ownership. One of the most significant potential benefits is helping clients leverage existing investments in Microsoft Windows Server 2003, SQL Server and BizTalk Server as well as popular ERP and CRM systems, including Microsoft's own integrated ERP system: Microsoft Dynamics. "The idea is for Microsoft, together with its partners, to provide one-stop shopping for an RFID solution," says Anush Kumar, Program Manager, BizTalk RFID.

These familiar tools also shorten the learning curve and make the applications easier to use.

Simplified integration. BizTalk RFID allows for seamless integration of devices with provisions for discovery, configuration, communication and management. Essentially, it provides ways "to integrate data from disparate sources from the physical layer such as shop floor, warehouse floor and trading partners and governs how information flows through the stack and ends up in business solutions that partners or Microsoft Dynamics provide," says Alex Renz, RFID Program Manager, Microsoft Dynamics.

Because DSPI basically makes hardware such as readers and printers plug and play, it helps system builders assemble the optimum solution and focus on larger project issues without worrying whether a driver exists. Meanwhile, organisations deploying RFID are better positioned to take advantage of the hardware innovation and falling prices that DSPI promotes.

Firmware updates can be performed remotely across an enterprise to eliminate the need for physical intervention. "With potentially hundreds of readers on a network, you want to be able to update firmware remotely," says Overby of Forrester Research. "You don't necessarily have IT staff at the distribution centre to configure hardware so the network recognises it."

Hardware health can also be monitored remotely. "The platform sends readers health monitoring events to confirm they are working," explains Microsoft's Renz. If a reader doesn't respond as expected, an administrator receives an alert so corrective action can be taken.

Converting data to actionable information. Above Microsoft's devices layer, an event processing engine filters incoming noise while providing alerts and transformations. It reduces the data "noise" created by the volumes of redundant data it receives and converts it into actionable information. This functionality is enhanced by the use of English-like vocabularies for rule creation and a high degree of built-in configurability, making it easy for users to modify. Similarly, performance and scalability are built in so large volumes of irregular event streams can be handled and deployment can be distributed.

Built-in edge processing includes a highly flexible and configurable rules engine that addresses potential business problems. For example, if a shipment of 24 cases is expected but only 20 tags are read when it arrives, the system can send an alert so the operator can check the pallet. The operator can then confirm the presence or absence of the four unread cases and transmit accurate receiving information to the enterprise application. Whether done at the edge or centrally, processing of data is transparent to the user.

Data management also requires context. Is the object arriving? Departing? This information can be provided by sensors on the device layer that show the direction of movement. Or it can be done by a combination of history and rules. For example, if the system has seen an object before, it would suggest it is departing rather than arriving. Adding the context of pending orders provides further confirmation of status.

Application platform. Open APIs and a rich object model make it easier for partners or users to build new RFID-enabled applications or integrate RFID data with back-end applications. "This enhances flexibility, reduces the expenses related to building applications and simplifies integration, particularly when legacy systems are involved," explains Microsoft's Ahuja. Tools include a centralised dashboard for device monitoring and configuration and a tag data simulator which permits RFID events to be simulated without input from actual devices. Tight integration with BizTalk Server and existing enterprise software make it possible for partners and clients to convert RFID events to BizTalk Server messages and build closed loop "RFID aware"' business processes..

Building RFID Applications with GlobeRanger iMotion

Solidsoft has recognised the need to provide support for RFID applications to exploit the RFID data. Solidsoft has teamed up with GlobeRanger to offer the iMotion suite.

Widespread RFID deployments, increasing numbers of other edge devices and high transaction volumes are exposing the limitations of existing infrastructure and applications. Compliance with customer mandates drove many initial RFID deployments; however, today's deployments are moving beyond mere compliance to involve more processes, applications, readers and higher transaction volumes. Users who met compliance mandates with minimal investment are now encountering problematic system limitations:

- Insufficient system scalability.
- Performance bottlenecks.
- Inadequate support for management of tens, hundreds or thousands of discreet edge devices.
- Inflexible edge architectures and edge platforms.

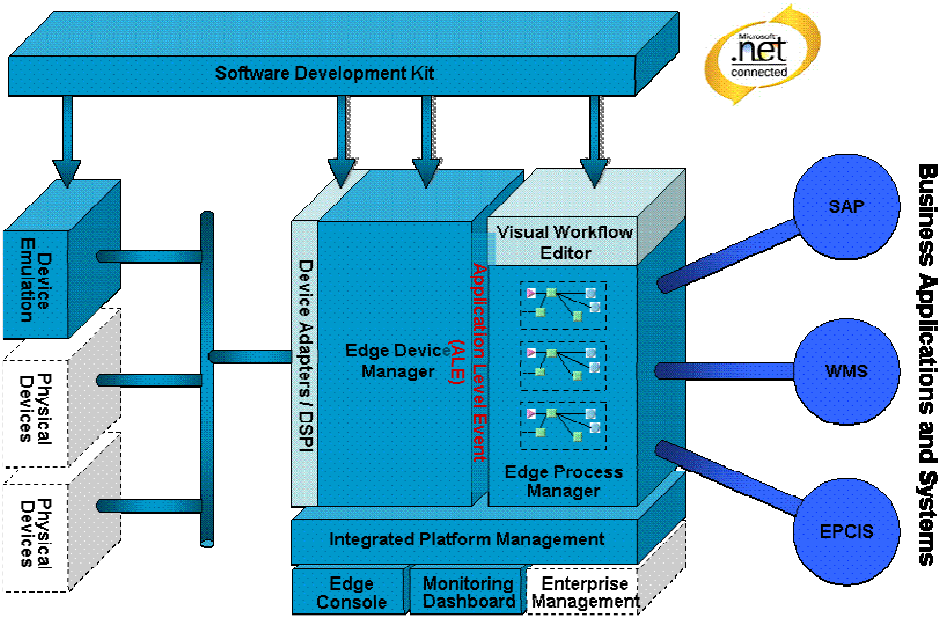
Companies must acquire the ability to effectively extract meaningful and actionable information from this growing sea of data generated by a collection of edge devices in order to put the information in a business context and then access other integrated existing systems to take appropriate action.

"The market increasingly demands ready access to shipment information at the item level. GlobeRanger provides us with the ability to meet our customer requirements while addressing our need to capture transaction information for real-time decision making."

Kai Timmermann, VP, GilbertUSA

To this end Solidsoft has partnered with GlobeRanger to offer the iMotion® Edgeware™ platform. This platform is built specifically for these production-scale implementations of RFID and sensor technologies. iMotion system management and device monitoring enables operation staff to instantly monitor and manage equipment locally or centrally throughout the network of facilities from a single location.. iMotion maintains optimum functionality across the entire network of devices, including passive RFID readers, motion sensors, light stacks, printers and handhelds, and the flexibility to quickly adapt and integrate new technology as it become available. iMotion serves as the foundation for edge solutions, providing a platform runtime for managing devices and edge processes, a software development kit (SDK) for easy extensibility, pre-build process components for rapid implementation, and comprehensive tools for rapid solution development, production deployment and on-going operation. Based on Microsoft's .NET Framework, iMotion enables business consultants, application developers, and systems engineers to easily create, configure and manage RFID solutions.

Figure 22: GlobeRanger iMotion Component Architecture



Source: GlobeRanger Inc

Figure 22 shows the different components of the GlobeRanger iMotion platform.

"We've taken the first steps to providing our customers with the most secure and protected pharmaceutical supply chain."

Robert Kashmer, VP of Information Technology, H.D. Smith

The iMotion Edge Management Console (EMC) provides graphical real-time monitoring and control of device networks and allows edge processes to be executed, both locally and on a global basis, from a single management console. iMotion abstracts the physical device layer, isolating applications from device configuration details. This capability enables the sharing of RFID and sensor infrastructure across multiple applications, maximising ROI. Operation and performance information for devices is available through industry-standard SNMP and WMI interfaces, allowing for integrated monitoring of RFID solutions through standard network-management and system-management systems.

Data is delivered through the EPCglobal standard Application Level Events (ALE) interface, providing immediate interoperability with any ALE-conforming application. iMotion is EPCglobal ALE 1.0 certified. The iMotion platform includes components that enable connection to RFID and sensor data streams through the industry-standard ALE 1.0 interface. Configuration capabilities give solution developers the ability to easily select and utilise the desired data.

iMotion enables the rapid evolution of software systems by leveraging modern, agile software frameworks and technology. iMotion extends the state-of-the-art rich, rapid application development (RAD) environments provided by Microsoft with equally flexible technologies specific to sensor-based environments.

Standard support is available for major HF and UHF RFID readers: Class 0, 0+, 1 and Gen 2. New readers are easily supported by downloading new reader adapters.

RFID data must be combined with business context to create actionable events for consumption by upstream systems. iMotion's functions enable rapid development and deployment of edge process workflows. Business logic flows are constructed by drag-n-drop of process components, minimising the cost and time required for updates and business rule changes. The Event Workflow Editor provides the benefits of customised solutions without the expense of custom development.

Bundled, pre-built workflow components enable rapid solution development. Components for standard notification methods such as email, file and database logging, HTTP POST, audio alerts and visual displays are provided. Adapters to other data sources and upstream systems can easily be developed using iMotion's software development kit.

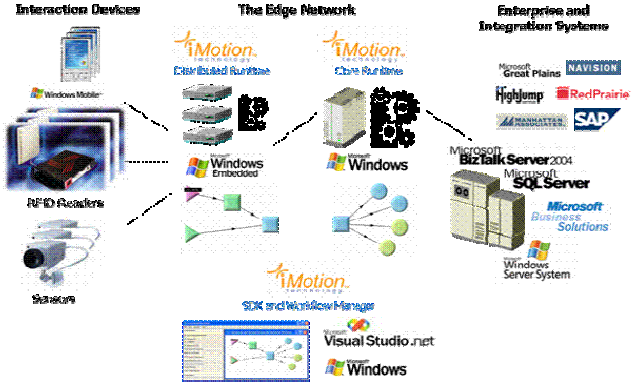
Edge Process Runtime and Management provides reliable and controllable execution of edge processes, fully distributable to enable scaling across a site or an entire enterprise.

iMotion visual tools address all stages of solution development and delivery, maximising productivity and ROI. The Visual Device Emulator simulates real-world behaviour of RFID readers, printers, tags and other sensor devices, providing solution developers with the ability to model physical deployment scenarios prior to actual equipment purchase. In addition, iMotion's Visual Device Emulator eliminates the dependence on physical hardware for development, testing and integration of RFID systems. The event monitor displays an accurate, real-time view of RFID tags being read. It captures history and analysis of tag-read events for application tuning and optimisation.

Software Development Kit (SDK) provides a comprehensive set of .NET classes and APIs that enables rapid development of custom workflow components. These components drop into the Event Workflow Editor (EWE), providing the same drag, drop and connect configuration as built-in components. The SDK is fully integrated with Visual Studio .NET, providing templates for rapid ramp-up with minimal training. Sample components and applications are included to jumpstart development efforts.

When looking at edge to centre processing requirements then Solidsoft exploits the capabilities of Microsoft BizTalk Server to provide the necessary links to ERP and other central applications being updated with edge application data.

Figure 23: GlobeRanger iMotion Scalable Solution



Source: GlobeRanger Inc

Conclusions

The construction industry is made up of many mini-industries with differing objectives and demands, which need to be respected in any RFID solution. Flexibility is key. Solutions need to cope with bar codes, active and passive tags, as well as read and write technologies. Since changes in working practices and technologies are inevitable, any solution must be able to cope with as many future developments as possible without the need for programmers. RFID can enable better performance in a number of key processes and functions in construction.

Figure 24: RFID in Construction

Process/Function	Workforce Management	Asset Management	Facility Management	Operations Management
Access Control	☑		☑	☑
Productivity/Budget Management	☑			☑
Asset/Person Location	☑	☑	☑	☑
Evacuation Management	☑		☑	☑
Time and Attendance	☑		☑	☑
Asset Security		☑		☑
Asset Usage Compliance		☑		☑
Asset/Real Estate Utilisation		☑	☑	☑
HSE Compliance	☑	☑	☑	☑
Inventory Management (high value)		☑		☑
Site Logistics		☑		☑
Plant/Process Scheduling	☑	☑		☑

Source: Use of Practical RFID Applications in Construction, Alan Evans and Callum Moy, Transforming Construction Performance, May 2006

RFID offers new levels of visibility for companies that want to track physical items between locations. In the supply chain, goods tagged at the point of manufacture can now be traced from the factory to the retail shop floor, providing a real time view of inventory for all supply chain partners.

"Even low-value items such as household bricks could be fitted with individual electronic identifiers, allowing an architect or surveyor to walk round a half-finished school or hospital and see an image of the building skeleton pop up instantly on their ultra-thin laptop."

The Guardian

The potential of RFID technology is enormous. Realising the value however, requires a business-wide approach:

- Maximise the value through understanding the full breadth of the implications and opportunities presented by the technology.
- Minimise the risk of failure through appreciation of the pitfalls involved in RFID technology selection, integration and implementation in the end-to-end supply chain.
- Bring the right skills to bear, including:
  - Supply chain process reengineering
  - RFID physical layer implementation
  - Technology integration Enterprise systems
  - Finance and tax planning
  - Regulatory implications
  - Program management
  - Change management
  - Corporate and social responsibility

Solidsoft's experience of designing, developing, testing and successfully implementing Business Process Management and Integrations solutions using Microsoft Technologies provides Solidsoft with the ideal credentials to assist organisations in getting the best ROI from RFID. Solidsoft utilises a framework approach to the delivery of solutions in one or more of the following:

- Product information management
- Track and trace, especially for reverse logistics
- Agile delivery
- Maintenance, repair and overhaul
- Authentication
- After service
- Health and safety

Through a network of world-class partners, including ISVs, hardware vendors and specialist business consultancies, Solidsoft delivers RFID solutions on a Microsoft platform that add value to businesses and enable fast returns on technology investments.

Solidsoft is playing a leadership role in RFID through participation in a number of industry initiatives. Solidsoft is a leading member of the Microsoft Partner Advisory Council for RFID which includes future releases of Microsoft BizTalk Server, including the future RFID platform.

Microsoft recognises Solidsoft's ability and agility to deliver innovative business solutions based on Microsoft technologies. This culminated in Solidsoft being chosen as Microsoft's Global Technology Innovation Partner of the Year 2006 in the Business Process & Integration Solutions category.

Today the construction industry as a whole must determine where RFID is applicable so that united it can overcome current limitations and provide improved RFID systems in the field of construction. Through further development and research, the testing of RFID in construction will make contractors and owners more familiar with their applications, opening the window of opportunity to a limitless potential of RFID applications in the construction field. The key to realising the benefits of RFID technology is treating it as true enabler of business re-engineering: a step change in improving a step change in improving both integrity and efficiency both integrity and efficiency.

Author

Simon Holloway, Solidsoft's Principal Industry and RFID Consultant is responsible for the development of all RFID-based solutions within Solidsoft. He is a valued member of Microsoft's Partner Advisory Council for RFID and has written numerous white papers on RFID in a Microsoft environment, from general to industry specific perspectives (aerospace and defence, pharmaceuticals, supply chain and construction).

Before joining Solidsoft, Simon spent three years in the role of Manufacturing Industry Architect and RFID Lead at Microsoft EMEA. Prior to that he worked for five years as the iPlanet Product Marketing Manager for Northern Europe at Sun Microsystems, and additionally spent over 15 years working as a principal consultant for a number of IT strategy houses.

Simon has written a number of books on data management, methodologies and CASE (Computer Aided Software Engineering) tools. He is also a regular speaker at events and a contributor to articles.