White Paper

RFID: Deployment

Deploying RFID – The Bigger Picture

This white paper describes for C-level executives and line-of-business managers the processes involved in the deployment of RFID by taking the "Bigger Picture" route. It identifies the challenges that have to be solved from a business and technical standpoint in terms of:

- The complete process from pilot to roll-out.
- The selection of tags, readers and printers (the hardware).
- The site survey (the environment).
- The selection of RFID software (the middleware).
- The need for integration.
- Security and privacy.

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.

For manufacturers and retailers, the business benefits of RFID are compelling. Not only does adding RFID technology to many environments increase operational efficiency, but it provides total supply chain visibility, offers better asset tracking to help reduce internal theft, flags errors and container tampering issues, and enables better processes for product status verification.

As convincing as the benefits of a fully realised RFID solution are, end-users, application developers, systems integrators and device manufacturers continue to experience many obstacles to development and adoption. The obstacles include difficulty in configuring and managing devices, making sense of raw RFID data, a lack of standards, a confusing variety of access protocols, and limited integration with an organisation's existing systems such as ERP systems, WMS systems and so on. Complexity of translating data into meaningful business events and difficulty in ensuring scalable solutions are also common roadblocks.

> "Only end users with first-hand knowledge of this powerful wireless technology (RFID) will be able to maximize its impact on their supply chains".
>
> Tom Coyle, Vice President, Supply Chain Solutions, Matrics.

Challenges to Adopting RFID

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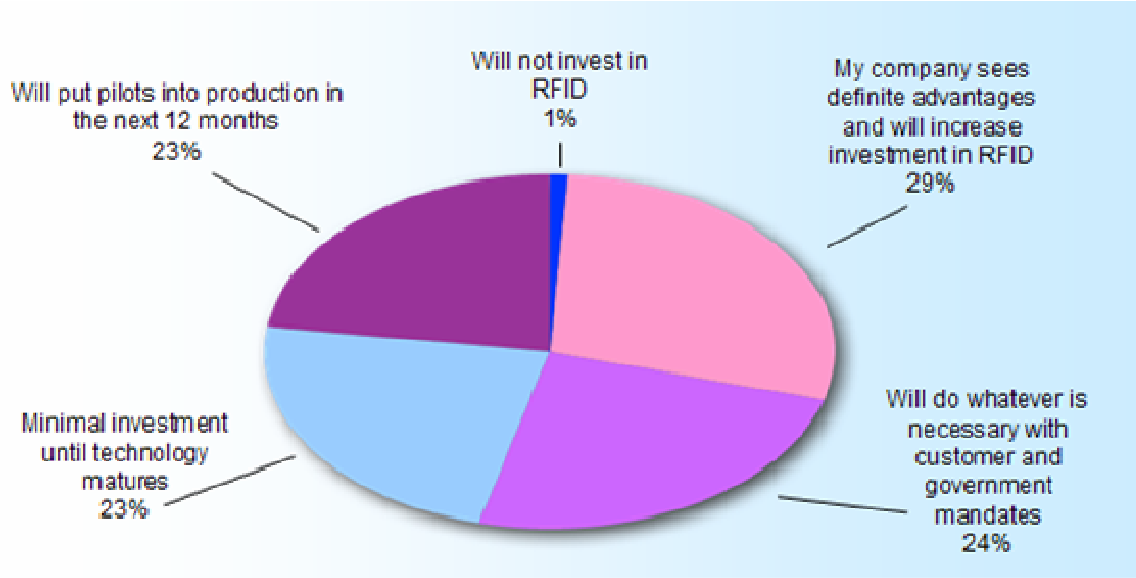
"If a company is interested in adopting RFID technology, it must think beyond technological challenges, such as Information Technology. It must be able to see that RFID adoption is more about selling experiences than selling products or services."

Adi Tedjasaputra, RFIDAsia Founder, June 2005

Uncertainty over these technical issues is almost certainly constraining near-term market growth. According to a late 2005 study of 250 industry executives conducted by Aberdeen Group, Boston, Mass., nearly 50% of respondents were either unwilling to invest in RFID until the technology matures, or were reluctant to do anything more than a pilot test for the next year.

Figure 1: RFID Investment Plans for the Next Three Years



Source: Aberdeen Group, December 2005

RFID Deployment Challenges

Solidsoft uses a five step process to ensure the RFID deployment roadmap is flexible and agile.

The most important issue to understand is that everything associated with RFID deployment is changing rapidly. Software, tag and reader designs, standards and vendors are all in a state of flux, with many vendors and standards groups vying for dominance.

What does this mean for deployment? Your RFID deployment roadmap must be flexible enough to adapt to the changing vendor and equipment landscape. That is not an easy task with so much in flux. The five step process below takes these challenges into consideration to minimize the impact of variability on the success of your deployment.

"It takes more than technical knowledge to ensure a successful RFID project. Superior integration and effective deployment is a key factor"

Indigo

Establish the Business Case

Building a business case involves researching RFID and the issues in your organisation. You must think outside the box to be effective.

It is important to develop a strong understanding of the technology's challenges and opportunities right from the start. Do your research – learn from companies that have conducted pilot programs, attend objective industry seminars and workshops, engage respected consultants, consider joining EPCglobal, and read as much as possible.

> "The business case needs to be closely linked to one company, its purpose, values and culture. What does it stand for? What are leaders in the company trying to do and change? "
>
> Mark Goyder, Director, Tomorrow's Company

Use innovative thinking to discern potential applications for RFID in your operations.

Although an EPC compliance mandate might be your pressing priority, consider the technology's potential applications within your entire supply chain. Research where our company can derive the most value. EPC compliance by itself is cost additive, but there are many areas where the application of RFID technology can result in considerable reductions in cost, increases in throughput, and enhancement of revenue.

Make sure you interview all areas of the organisation to solicit potential opportunities and get estimates of payback. Think outside the box when evaluating options. Your greatest returns will usually not come from simply automating current processes. General areas to consider include improvements in visibility, reductions in labour theft and counterfeiting.

Based on a thorough review of the potential areas within your company where RFID technology may have positive impact, select one to three targeted applications for detailed case analysis. This selection should be based on which opportunities appear to provide the best potential return on your investment. Of course, if supplying a customer who requires compliance, is a major part of your business, this must be one of your selected opportunities, but look beyond compliance to how the technology can add value to your operations.

To develop a business case for your selected opportunities, you will need a well-defined plan that is clearly tied to your business objectives. Defining the system requirements, how long will it take, etc.) will help you accomplish this step.

If preliminary research indicates RFID could be a valuable solution for your company, continue to the next phase, planning a realistic RFID roadmap. If the results are questionable, you may need to re-evaluate your company's situation and weigh technology alternatives. Or revisit your original list of potential opportunities based on what you have learned to determine if other applications may be more appropriate. Similarly, be cautious if the results appear unrealistically high. Your assumptions about costs or returns may be too optimistic. For example, if you based your business case on the assumption of the "5 cent tag," you will find your predictions will not hold up to reality.

The project cost will need to include the following:

- RFID readers.
- RDBMS and Business Intelligence Tool.
- Integration.
- RFID tags.
- Network infrastructure.
- Human resources.
- Technology partner.

A key part of this step is to understand the business drivers for RFID in the organisation. The most likely ones that you will come across include:

- Regulatory / compliance to a mandate.
- Security.
- Brand protection.
- Identity.
- People's health and safety.
- Track and trace.
- Cost.
- Process improvement.

Shown below is an example of a business case framework carried out at Goodrich Aviation Technical Services in 2005[1]:

Workshop: assemble a cross-functional team of executives who are then educated on RFID concepts. Define the scope and develop the hypothesis for the macro-level issue to be solved for the agreed-upon area of focus.

RFID knowledge repository: set up a secure, web-based knowledge portal to serve as a communication vehicle for sharing RFID related information, project schedules, team member information, work products, important links, idea sharing and deliverables.

"As-is" process flow: develop a high-level process flow of the functional areas and inventory locations within the operation through several facility walkthroughs and interviews. This process flow is transferred to a wall-sized brown paper and provides a practical context for developing focus interview questions.

Analyse operations and processes: conduct twenty cross-functional focus interviews using the brown paper as a reference during the interviews. The interviews identify micro-level connections across functional areas. The business processes associated with the macro-level issue are itemised to reveal both quantitative and qualitative ROI.

External interviews: conduct interviews with RFID technology suppliers to determine potential, high-level solutions and costs. Conduct interviews with largest supplier / customer to understand the implications and timing of RFID within the complete supply chain network and the business value chain. Interview any major industry body to help identify current and future industry standards, and the feasibility and applicability of the identified solutions.

Building the benefits stack: compile a benefits stack listing the factors within the company's' control that contributed to the macro-level problem. In addition, list all benefits identified.

Approach agreement: use different models of transformation depending on complexity of design, risk, availability of resources, and current business needs. These models include: proof of concept, iterative releases, and full scale.

Prioritise projects: after breaking down all the processes, develop a list of projects where RFID could solve some of micro-level issues that contribute to a macro-level challenge. In addition, identify several other (non-RFID) projects that could cut costs or boost efficiencies associated with the same macro-level challenge. Prioritise the projects based on complexity, required investment, industry trends and ROI.

Develop scope of project: for each project, develop a scope based on a proof of concept approach and the operations environment. Review the scope of each project in terms of the required level of tagging (pallet, case or item). Projects that are easiest to achieve and did the most to advance the macro-level goal receive the highest priority.

Financial assessment: compile the cost of a proof of concept for RFID deployment from three vendors.

Sensitivity analysis: analyse assumptions with regards to the potential variances that could alter the business case benefits and costs for the project.

High level roadmap and plan: develop a practical, high-level roadmap based on project priority and milestones. Create a step by step path forward plan.

Build a Practical Roadmap

The roadmap should cover not just the first project but all the other projects identified in the initial phase.

Several factors should be carefully considered as you develop your roadmap. How will your company absorb and deploy the technology, and will the market be able to support these activities? Is the project based on customer-driven demand (i.e. compliance to a retailer or a defence ministry)?

Consider your supply network – how do you bring products to the marketplace and how would you deploy the technology based on your topology? What about transaction volumes and infrastructure? If your company only ships small quantities and limited SKUs to customers who demand compliance to a RFID policy, your strategy will be different than if you ship to multiple mass merchandisers on a global scale. Honest and realistic answers to these questions will reveal if your company should continue to explore and invest in RFID.

"……we conducted a business case analysis, finalized in December of 2005. Out of that, we've revamped our RFID roadmap. It showed there are areas where we are - and are not - going to get value from RFID."

Darrell Biggs, Mallinckrodt Pharmaceuticals, May 2006

[1], Case Study: RFID at Goodrich Aviation Technical Services, Doug Hoselton, UsingRFID.com in August 2005

Projects start with the executives' vision of what RFID technology can do for their company, such as:

- Reducing tack times and work-in-progress.
- Maintaining continuous inventory visibility for leaner supply chain.
- Reducing time spent on non-value-added activities (e.g. locating).
- Building flexibility into assembly lines to respond to market trends.
- Error proofing for increased quality control.

The benefits of applying RFID technology include lower operating costs and improved efficiencies, providing competitive advantages for customers. This also translates into more powerful positive vendor and customer experiences. Cost savings and process improvements are mainstream RFID advantages; however, meeting expectations is crucial to the success of the project.

A key part of this step is to develop the key performance indicators (KPIs) that will serve as the yardstick by which you will measure the success of the subsequent steps and deployment. Without meaningful, relevant KPIs as evaluation criteria, subsequent steps will yield uncertain results.

The roadmap you build for RFID deployment will be very similar to those for other technology deployments. However, make sure you include time and any necessary support for unique RFID issues such as tag placement, reader / antennae placement, orientation and attenuation, and environmental testing. In most cases, expertise in these disciplines will not reside within your company.

The vision needs further refinement with site surveys and the establishment of goals and objectives, all of which need to be documented and then approved. The process of vision building also needs to include educating project managers and executive sponsors to ensure the expectations were aligned with those of the project.

Conduct Rigorous Environmental Proof of Concept Testing

RFID hardware must undergo vigorous environmental POC testing. There is no substitute for this testing in situ.

Before mounting a full-scale RFID implementation, it is critically important to conduct meticulous product tests in a real-world environment. Companies must define optimal technology combinations during product testing (i.e. various types of tags, readers and business software). A complicating factor is the changing vendor and technology landscape. Make sure your technology selections will still be appropriate at the time of deployment. Design contingency plans to deal with potential changes.

"RFID testing provides necessary data on both component quality and expected performance in real-world conditions."

Avery Dennison

You must also understand how the environmental attributes of your products will affect RFID readability. For example, what is the optimal read distance and tag size, and how many antennae are required for a consistent read? The presence of RF technology using the UHF band can cause prohibitive interference; how will you get around this issue?

Product makeup will also affect readability (liquids absorb radio signals, metals scatter them), as will mixed pallet scenarios and tag placement. Make sure your testing takes all of these factors into account or it will come back to bite you later.

Finally, understand the product certification requirements demanded by your clients; for example, a mass merchandiser may require certain performance standards (i.e. 100% tag readability on a conveyer at 150 feet per minute). The results from environmental proof of concept tests will yield key information for a successful pilot. It may also whittle down your list of opportunities for further consideration.

Carefully Pilot the Proposed Solution(s)

During the pilot phase it is important to get the integration to the back office systems that run the business working.

To begin the pilot phase, closely integrate your RFID software to your logistics applications in order to approximate truly a real-world environment. Then connect to host systems for actual data transfer. Because you cannot shut down actual operations to conduct the pilot, be sure the two can run in parallel. This may require modifications to existing systems.

To the extent possible, design your pilot tests to reflect the business case scenarios defined during requirements definition. For example, if your pressing need is to ship to a customer needing compliance, your pilot should test the product types and quantities, material handling equipment and shipping methods that will be used for that purpose.

Besides testing equipment, software and processes, be sure to test your business case assumptions. Use the results of pilot testing to rework your ROI analysis and your deployment roadmap. Do not be afraid to rule out applications or deployment plans that no longer meet expected ROI or other corporate objectives.

Zebra Technologies[2] compiled a response to the question, "How should you plan to pilot the production environment?" In part of their response they list the below steps during the pilot:

"We cannot stress enough, though, that each pilot will end up being a highly individualized experience based on your products, environment, systems capabilities, etc. Of key importance is to use RFID suppliers with solid RFID track records whose products and services have been successfully used in real-world implementations. The experience of these "trusted advisors" can make or break the success of your pilot.

Zebra

- Define the use of RFID data, and how you will use "new RFID data" in a familiar manner
- Define the pilot test, including site, product, methodology, and criteria for judging success
- Commence the pilot
- Monitor the progress. Be prepared to modify the pilot implementation in order to achieve optimised results—and be prepared to deal with the unexpected
- Watch for ways to change current processes during the course of the pilot
- Review results, share lessons learned
- Define improvements for next phase/pilot

Rollout Solutions Based on ROI Considerations

Rollout is not just about taking the pilot project across the business, but also implementing the roadmap derived in the second step.

In order to obtain executive buy-in and approval for RFID implementations, use pilot test results to demonstrate the technology's value to your organisation. Be prepared to specify where RFID will add value, how it will benefit your operations and exactly how much savings your company can achieve from each application. Be prepared to discuss how this value compares to associated costs and risks, and demonstrate in detail how RFID supports corporate objectives.

Your rollout plan should implement the highest value RFID applications first, based on your business case analysis. Use the KPIs to gauge success and measure performance against actual results at each stage. Analyse results from each implementation and adjust rollout plans for future implementations accordingly.

Even with the best business case analysis and thorough roadmaps, there is one item often overlooked that can determine success or failure of deployment – change management.

People are naturally reluctant to change. This is usually caused by fear of the unknown that change represents. Resistance can usually be overcome with proper training. Since much of projected ROI may be based on streamlined processes, employees must be trained in how to perform the new processes and operate new equipment. Training should explain why the new technology is beneficial and address any fears.

"New developer toolkit technology and intelligent edge devices, growing adoption of standards across industries, and the falling cost of tags and sensor hardware, are shortening the expected time to positive ROI. In particular, the once hidden costs associated with sometimes dramatic organisational changes brought about by (or necessary to) a successful RFID implementation can now be anticipated and managed. As a result, enterprises are enjoying shorter design and pilot phases, scalable solutions, smoother rollout, and less challenging integration tasks."

Russ Klein, Aberdeen Group

[2] Zebra Technologies FQA webpage (http://www.zebra.com/id/zebra/na/en/index/rfid/faqs/pilots.html)

Environment Issues

Site surveys

A site survey is a critical component of business case evaluation; the results will help to determine the infrastructure requirements, hardware needs, installation methods and the associated cost of each element.

Successful RFID solutions begin with a comprehensive assessment of the physical environment, the RF characteristics, and the products' materials at the deployment location. RFID site surveys are an essential step at the start of any RFID design or feasibility project to ensure that the correct equipment is chosen. If this is not done, read rate performance may be compromised, rendering the solution ineffective and therefore resulting in poor return on investment. A well-executed site survey provides insight into potential pitfalls, appropriate scope, deployment requirements and the most effective deployment topology. Whether in a manufacturing facility, warehouse or distribution centre, this work helps to identify and account for the many variables that exist and affect system design and performance.

"A site survey is an essential part of the process of implementing and deploying RFID. It must be remembered that each installation in a company must be surveyed, as no two sites are exactly identical."

Simon Holloway, Solidsoft

Consideration of the practical issues concerning the installation of a RFID solution in terms of the electrical, data cabling and hardware installation requirements should not be overlooked. Timescales and the practical impact on the organisation need to be assessed. Health and safety are paramount and as such a comprehensive review of health and safety procedures relating to the implementation of RFID should be carried out. The costs of deploying the solution need to be estimated and should form part of the business case, which is crucial before committing to a large scale investment in hardware and software.

The first step is studying the facility layout and its RF environment. This information enables us to learn both physical requirements for deployment and where RF interference must be managed. With this knowledge, you can estimate the number and position of RFID readers and antennae required; and you can develop a sense of project scope and cost.

The next step is to study process workflow and the RF characteristics of the specific products included in the RFID project. Workflow tells us the optimal points at which to apply RFID tags, read data and record results. Product RFID characteristics are also important and can affect both number and placement of readers and antennas. You then define the scope of the RFID requirements to this level. You are then able to predict system performance given the physical and RF variables identified, and recommend the exact equipment needed.

In a half-day on-site visit, data is gathered on the physical layout and features of the facility, including power sources and existing network wiring. The facility's workflow is noted to learn where RFID readers and antennas might be best placed. The various sources of RF in the production environment are identified and recorded. Lastly, the types of goods and packaging that will be part of the RFID program are noted and categorised as "RFID friendly" or not. This site survey results in a comprehensive written report.

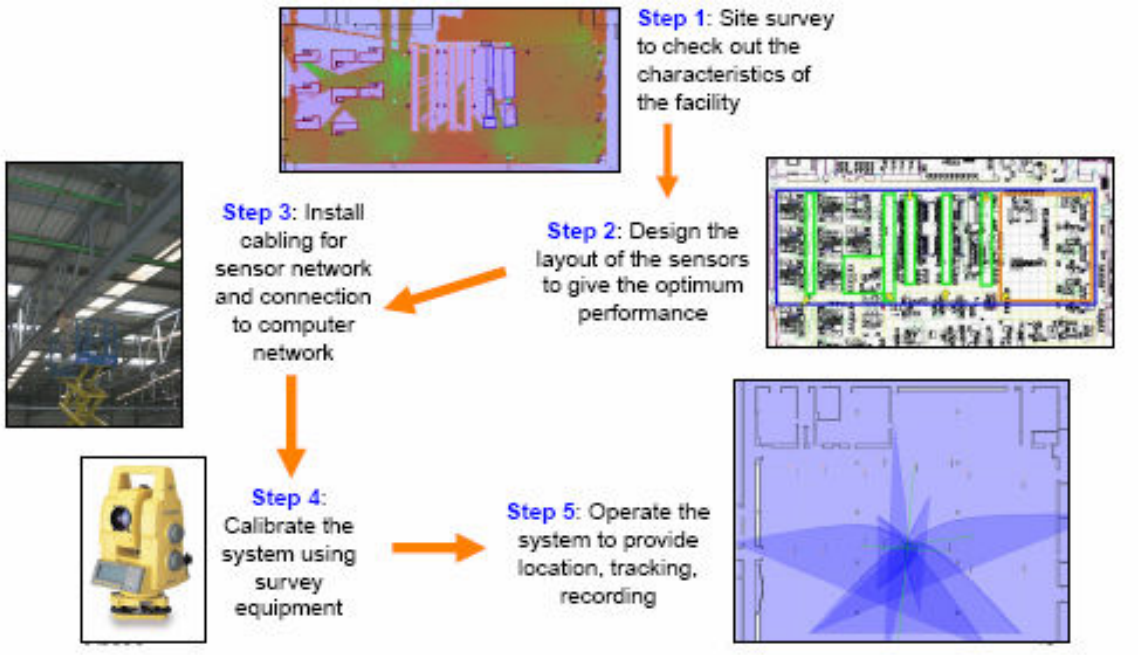
The benefits of a RFID site survey are straight-forward:

- They save customers time and money.
- They eliminate the need to re-design elements of the deployment.
- They speed the customer towards realising the benefits of their RFID system investment.

Providing a clear, unobstructed view of operations up and down a supply chain is critical for success. Without visibility, an organisation has limited ability to plan and react to changes in its supply chain. Whether in a single-enterprise or a multi-enterprise supply chain, increased visibility results in greater access to information about inventory, orders, shipments and invoices. These improvements enhance internal communication, as well as communication with customers and suppliers. Globalisation, outsourcing and compressed product life cycles, as well as the shifting competitive dynamic from enterprise to supply chain, has created a need for increased accountability. Companies need a view into fragmented business processes, and a way to manage numerous disparate sources of information.

In today's world, supply chain information is typically communicated without context through fax, e-mail and telephone conversations. In addition to affecting the productivity of business managers, traditional client-server based enterprise systems are essentially blind to these interactions and cannot respond fast enough to supply bottlenecks or shifts in demand. In a recent AMR Research study, lack of goods visibility was cited as the single most compelling supply chain / operational issue by both process and discrete manufacturers.

Figure 2: The Site Survey Process



Source: David Theriault, Real-Time Location with Active RFID: Success and ROI in Logistics, IDTechEx Actibe RFID Europe 2006, September

Choosing the right sort of tag in terms of: active or passive; frequency (LF, HF or UHF); tag design; required time and expertise to get right.

Hardware Issues

One of the key factors to successfully implementing RFID technology in your operation depends on your selection of RFID tag. RFID tags come in many different shapes and sizes, allowing them to track effectively various packaged goods and material types. In addition, the diverse set of tag formats and protocols that are geared towards specific use cases, ranging from animal tracking to supply chain management, make tag selection a challenge for many organisations. The ideal RFID system spans a range of hundreds of feet, works in moist environments and on metals, has a read rate of hundreds of tags per second, costs little, and uses low power. All of those properties are available from RFID, but alas, not from the same RFID system. This section serves as a way to quickly learn about tags, navigate through the different tag options and help you select the tag that is right for your application.

Tag Checklist

A checklist for tags supplied by Intermec.

Use the following checklist to determine which types of RFID tags are most compatible with your unique business environment:

Range performance

The read range performance of a tag is usually considered the primary gauge of its suitability for a particular application. However, not all applications require maximum range. Many tag and insert designs, though optimised for maximum performance on specific materials, are often used with other materials for applications requiring less than optimal read range, or where greater range may actually be detrimental. For example, write range for Intermec's tags is approximately 70% of the read range.

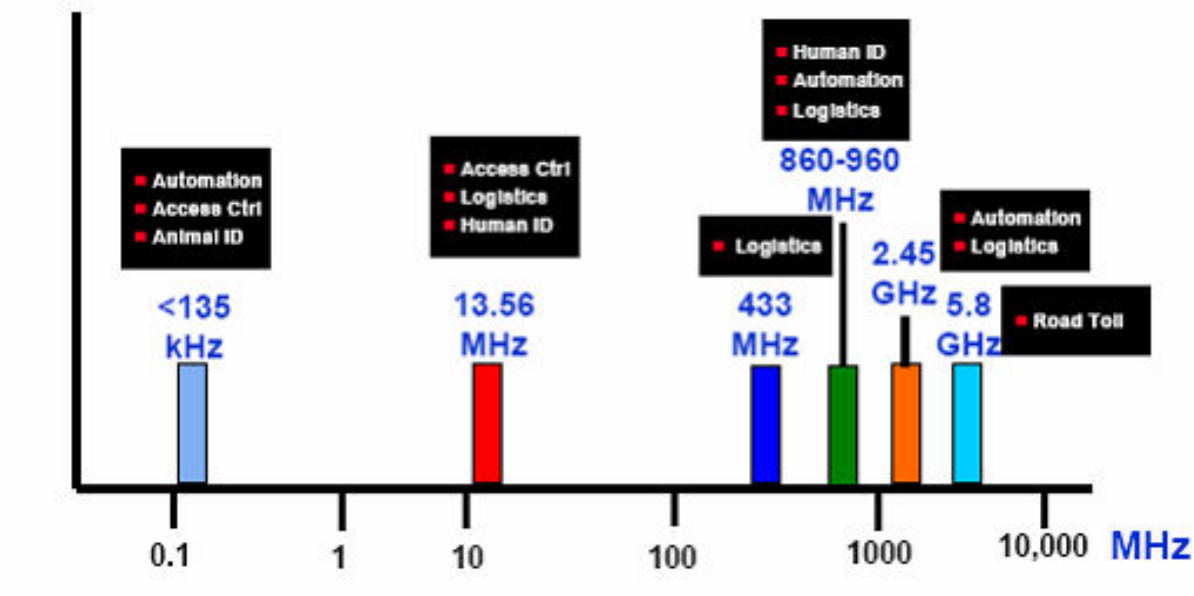
Read-write vs. read-only technology

With the ability to write comes the ability to dynamically change data stored on the tag. Flexibility is key, especially as business operations, information needs, industry standards, customer requirements and other variables change over time. Once a read-only RFID tag is programmed, the data cannot be altered for the life of the tag. Therefore, I would recommend the use of read-write technology. This allows you to alter the data content of the tag according to your specific needs. Moreover, if desired, you can permanently lock the data on a byte-by-byte basis at the time and place of your choosing.

Frequency range

RFID products currently on the market operate at a variety of frequencies, with each frequency targeted for specific geographical regions, applications and performance requirements. When selecting a tag or insert, you must first consider the general performance characteristics and the regulatory requirements associated with the permitted frequencies for your region of operation. For instance, Intermec's Intellitag® integrated circuit (IC) possesses frequency agility, allowing for operation at 2450 MHz, 869 MHz and 915 MHz with a single design. The actual frequency of operation for a particular tag or insert is determined by the tag's antenna design, but the same IC can be used regardless of which frequency is desired. Each frequency range has its strengths and weaknesses.

Figure 3: Choosing the Tag Frequency



Source: TAG! You're It… or Not? RFID Technology in the Airport, Yemmi Agbebi, IDTechEx Smart Labels Europe Conference, September 20th 2006.

Form factor

While range performance is often viewed as the best gauge for a tag design, the tag form factor cannot be overlooked. The general rule of thumb suggests that larger tags provide better range performance. Yet large tags are not always suitable for every application and it often becomes necessary to balance your choice between the tag size and its range performance. Intermec has developed a portfolio of tag and insert designs that utilise state of the art materials to provide a wide range of options for combining size and performance.

Environmental conditions

How and where the tag or insert will be used plays a significant role in determining the right tag for your application. Performance will differ depending on what materials (wood, liquid, plastic, metal) are adjacent to the tag. Generally, the lower the frequency, the better it penetrates through obscuring liquids, paint and grease, etc. but the more it is absorbed by metal, the higher the frequency, the less penetration and the more reflectivity there is. Water friendliness is why LF devices are used for injectable tags in animal tracking. Other environmental conditions such as temperature and humidity may also affect performance. Many vendor tags and inserts are available in a variety of designs and use materials capable of surviving even the harshest environments.

Standards compliance

As with bar code technology, standards play an important role in the selection of RFID technology. The RFID tag vendors maintain an active presence within the worldwide RFID standards community and will continue to develop products that meet existing and emerging standards, including the EPCglobal Class 1/Generation 2 (C1/G2) and Class 2 requirements. This ensures compatibility and interoperability with other products meeting these standards and protects your investment against premature obsolescence.

Do remember that EPCglobal is not the only standard around at the time of writing this paper, there is also an ISO standard.

Active or passive

Passive RFID tags can be as small as 0.3mm and do not require batteries. Rather, they are powered by the radio signal of a RFID reader, which "wakes them up" to request a reply. Passive RFID tags can be read from a distance of about 20 feet. Semi-passive RFID tags contain a small battery that boosts the range. Passive tags are generally read-only, meaning the data they contain cannot be altered or written over. Active RFID tags, also called transponders because they contain a transmitter that is always "on", are powered by a battery about the size of a coin, and are designed for communications up to 100 feet from the RFID reader. They are larger and more expensive than passive RFID tags, but can hold more data about the product and are commonly used for high-value asset tracking. Active RFID tags may be read-write, meaning data they contain can be written over.

Other issues

There are an additional number of other issues that have to be taken into account. These include:

- Determining a price that you can afford and that will still yield ROI
- Orientation of building layout
- Security issues (tamper proof)

RFID Readers

The right RFID readers also need selecting to meet the environment of the customer and items that are being tagged.

RFID readers, also called interrogators, firstly are used to query RFID tags in order to obtain identification, location and other information about the device or product the tag is embedded in. The RF energy from the reader antenna is collected by the RFID tag antenna and used to power up the microchip. There are two types of RFID readers:

RFID read-only readers: as the name suggests, these devices can only query or read information from a nearby RFID tag. These readers are found in fixed, stationery applications as well as portable, handheld varieties.

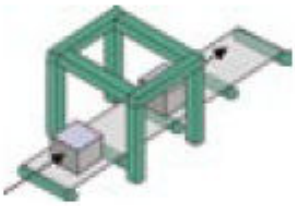
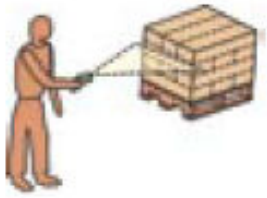
RFID read-write readers: also known as encoders, these devices read and write (change) information in a RFID tag. Such RFID encoders can be used to programme information into a "blank" RFID tag. A common application is to combine such a RFID reader with a bar code printer to print "smart labels". Smart labels contain a UPC bar code on the front with a RFID tag embedded on the back.

"With the variety of form factors and functionality of RFID readers available today, the application should be the determining factor in reader selection. For example, some items, due to their bulk, will always need to be transported via forklift truck, which would necessitate overhead scanning for volume processing, and handheld mobile scanning when reacting to an exception."

Intermec

With the variety of form factors and functionality of RFID readers available today, the application should be the determining factor in reader selection. For example, some items, due to their bulk, will always need to be transported via forklift truck, which would necessitate overhead scanning for volume processing, and handheld mobile scanning when reacting to an exception. Figure 4 outlines best-fit reader options for some of the most common RFID reading applications.

Figure 4: Best-Fit Reader Options for Some of the Most Common RFID Reading Applications

Application	Description
Conveyor Reading 	Recommended for case-level and each-level tracking, conveyor reading is best achieved with multiple antennas. Recyclable plastic containers (RPCs) with embedded RFID tags have also proven effective in conveyed reading applications.
Dock Door or Portal Reading 	Ideal for pallet-level reading, portal readers work in conjunction with presence detectors and an RF-reflective surface, such as metal mesh. The metal mesh, which surrounds the doorway, prevents transmissions from adjoining doors being read in error.
Stretch Wrap Station Reading 	The stretch wrap station provides a fixed reader ample time to identify and categorize items on pallets and to associate them with RFID-enabled pallets.
Overhead Reading 	Using a fixed reader and a single set of antennas that radiate downward to an RF-reflective surface, bulky single items and pallets, with RFID tags oriented skyward, can easily be read while traveling on a forklift truck.
Handheld Mobile Reading 	There is always a need for exception-based scanning. Applications requiring a search for specific item are made easier by the mobility of a handheld mobile RFID reader because the user can bring them to a specific location to execute a search.
Forklift Reading 	The mobility and flexibility offered by an RFID-enabled forklift mounted computer can be a good alternative to portal reading applications. It is especially well-suited for reading pallet-mounted or pallet racking tags.
RFID Printer Reading	While often overlooked as a reader, RFID printers do contain a reader module that allows the printer to verify the data commissioned to the smart label insert at the time of printing.

Source: The Intermec® Guide to RFID Reader Selection

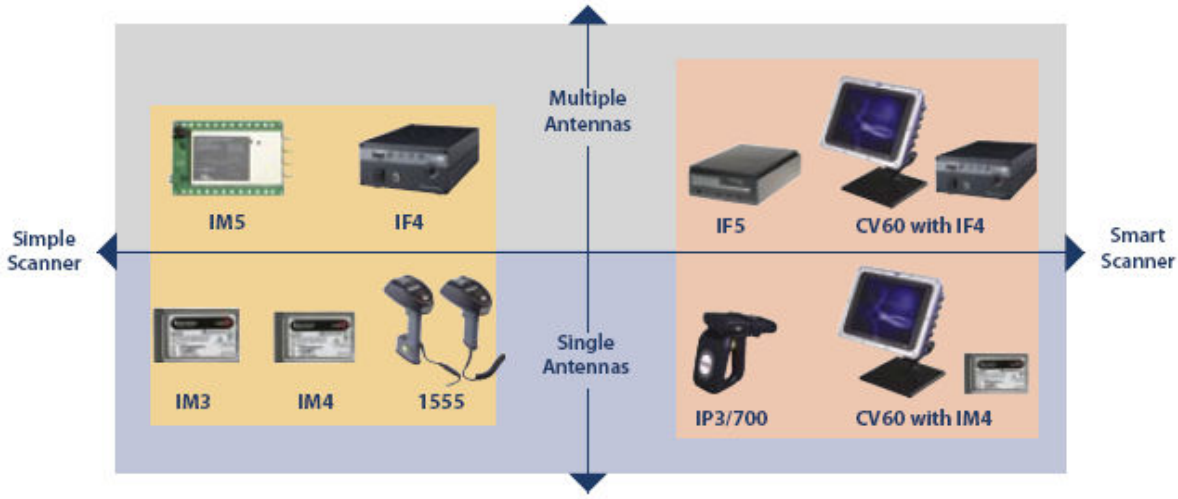
Not all readers are created equal, and for good reason. They can be grouped into four simple categories based upon the maximum number of antennas they support and local intelligence they provide. The characteristics and behaviour of the tagged items play a large role in determining the number of antennas your reader needs to support.

Your application may dictate the use of a sophisticated RFID reader capable of controlling peripheral devices based on data read from the tag, or you may need to attach your RFID reader to a separate local server or a programmable logic controller for local decision making.

The questions below have “either / or” options that are colour coded to aid you in determining your reader choices in the quadrant below.

- Are the tags you are trying to read always oriented the same way or are they unpredictable in their placement?
- Will you be reading a small number or large number of tags at the same time?
- Will the tagged items be moving slowly or fast at the time they are read?
- Will filtering of redundant tag data need to be performed at the reader level or by a server or host?
- Are PLCs currently used or will local decision making need to be handled by the reader?

Figure 5: Intermec Reader Selection Quadrants



Source: The Intermec® Guide to RFID Reader Selection

With a primary function of collecting and passing on tag data, simple scanners rely on a host system “up stream” for decision making. The host system can either be a tethered handheld or vehicle-mounted computer, or a cabled connection to a programmable logic controller, server or PC. This is an adequate solution in environments where PLCs and edge servers are already relied upon to drive application-based decisions. A simple scanner, combined with a single antenna, will usually provide a cost effective solution when:

- There is already a local controller.
- Tags are consistently oriented the same way and always located in the same place.
- Only a few tags travel through the RF field at a time, relatively slowly.

Simple scanner readers with multiple antennas can alleviate issues with tag orientation, quantity and speed by increasing the “read field”. Additionally, simple scanners offer a more economical option for enterprises that want to leverage their investment in existing handheld and vehicle-mounted computers to achieve RFID capability.

When the application requires real-time decision making based on the data read from the tag, smart readers are the clear choice. Local intelligence within the smart reader allows it to not only evaluate the data on the tag, but also respond to it, such as triggering a red signal light to indicate that manual intervention is required. Because decisions are made by the reader, they occur without communications or server-induced delay. Smart readers combined with multiple antennas are better equipped to cope with the unpredictable tag placement, tag volume and speed, while also providing local filtering. Smart readers with a single antenna are often mobile and therefore offer best solution for exception reading and subsequent re-writing because local decision making can be taken directly to the item to be read.

RFID Label Printers

Particularly for pallet and case tagging, RFID printers will need selecting.

RFID label printers, also called printer-encoders, combine a traditional bar code printer with a RFID encoder to print "smart labels". Smart labels contain UPC bar code information on the front with a programmed RFID tag sandwiched in between the paper layers. RFID label printers are used for both product shipping labels as well as "smart" wristbands, and can encode (write) information to RFID chips at the same time they print UPC bar code information.

RFID printers encode data in the high-frequency (13.56 MHz RFID) and ultra-high frequency (900 MHz RFID) ranges. RFID printers connect to a PC with a serial, parallel, USB or Ethernet connection.

RFID labels used in a RFID printer are a critical element of the RFID printer system. Label design, specifications and selection are of the utmost importance. In a RFID implementation, the tag can be encoded, verified, printed and even applied to the box by one machine.

The RF inlay adds a level of complexity to an otherwise straightforward process. Both the microchip itself and the edges of the inlay cause “bumps” in the otherwise flat label surface. This can cause print distortion. Perhaps even more problematic, the RF environment inside each RFID printer is different. Printer and inlay manufacturers are hard at work within EPCglobal to develop standards to address this. However, for now, the differences between the inner cavity of the printer and the reader antenna location often require unique inlay orientation and placement for labels used on different printers. Also, spacing between smaller labels often needs to be increased to prevent more than one tag from being programmed at the same time. Stand-alone printers can try more than once to programme a tag. However, a printer / applicator must keep up with cartons moving along the conveyor and therefore must discard tags it cannot programme the first time.

There are a number of options available for automatically dispensing and applying the tag. Factors that affect the selection of an applicator include label size, carton speed, carton placement, and height variation and placement accuracy requirements. The preferred methods are semi-automated or automated "print-and-apply" processes. In these systems, the cartons are fed to the label applicator by hand or preferably by conveyor. Another label printer at the end of the process prints a pallet level label that is applied before the palletised load moves through the RFID portal.

RFID Software Issues

Middleware

RFID middleware, also referred to as Edgeware, provides the means to interpret, analyse and store RFID data close to where the action is.

Middleware for RFID applications sits between the RFID reader and conventional middleware, facilitating communication between enterprise systems and automatic identification devices. Some RFID middleware includes full track-and-trace reporting, device and network diagnostics utilities, and an open development platform, while other solutions focus solely on data consolidation and translation. Middleware is playing two critical roles in RFID deployment and use. First, it is used to efficiently connect readers to enterprise systems and data repositories. This feature provides benefits in deployment - as well as benefits after implementation when other new systems are introduced. Second, most RFID middleware vendors are developing tools to help you filter data more effectively, and to remotely monitor, control and maintain readers. These tools can make RFID more valuable to business users and reduce the challenges involved in the deployment and long-term management of the hardware. Any project beyond a very limited pilot should include RFID middleware as a core component.

How do you choose the RFID middleware that is right for you? Damon Bramble, General Manager of the RFID Solutions Center, a division of Alien Technology Corporation in a web article in inboundlogistics.com gave these 10 tips[3]. For more detailed information on the processes involved in the selection of software, the reader is referred to Sharland [4]

> “Reading the mainstream RFID news, you may think only two things matter: tags and standards. But that's only the start. Middleware is playing two critical roles in RFID deployment and use. First, it is used to efficiently connect readers to enterprise systems and data repositories. Second, most RFID middleware vendors are developing tools to help you filter data more effectively, and to remotely monitor, control, and maintain readers.”
>
> Bret Kinsella, Supply Chain Director, Sapient, March 2004.

Know what you are buying, and carefully examine what you need

A managed supply chain information system captures, filters, analyses and acts upon data. You need to understand all the components of the system, and how middleware fits. Buying a complete RFID system may allow you to incorporate

[3] Deborah Catalano Ruriani, Selecting RFID Middleware, inboundlogistics.com, June, 2006
[4] Richard Sharland, Package Evaluation: A practical guide to selecting applications and system software, Avebury Technical, 1991

the technology into your operations without integrating deeply into your ERP system. But purchasing a minimal RFID system may provide easier integration into back-end systems, low total cost of ownership, and enhanced scalability and fault tolerance.

Do your homework

Before purchasing middleware, investigate available vendors - determine which ones are pursuing specific vertical industries and what solutions they support. Check out trade journals, RFID solutions centres, industry events and trade shows, and RFID education programs. Talk to peers who have successfully implemented RFID middleware.

Put together an internal team

Your RFID implementation team should consist of representatives from the technology, operations, customer service and finance / business process departments. An optimal selection team consists of: a buyer; a specialist in integrating RFID with back-end systems; an IT network administrator; a specialist in integrating automatic identification devices on the plant floor; a business analyst; a program manager for middleware implementation; and your RFID program's technology leader.

Build a plan

Start with a vision of where you want RFID to take you, and a decision tree that leads you there. This high-level plan needs to present an integrated and balanced view of risks, costs, benefits, staffing and any other factors that affect your business, so you can objectively make decisions. An IT plan can aid your decision process by spotting potential problems before they occur and planning investments wisely. Follow up with a short-term plan defining exactly what you want to accomplish; include milestones, metrics and success criteria.

Meet the vendor's whole team

Just because a middleware vendor tells you that a differentiator is important, or professes incredible competence does not mean you have found your provider. Meeting the team who will provide business / relationship management, technical strategy, implementation and support is key to installing a successful system.

Send out requests for proposals (RFPs)

RFPs are efficient tools for capturing the current and future capabilities of RFID middleware vendors. Do not rely solely on what someone else tells you about a vendor's capabilities; get it from the vendors themselves.

Make sure the middleware provider offers excellent service

RFID is still in the early phases of adoption, so do not expect to buy off-the-shelf products that need little support. When a problem occurs, you need to know who will own it - the systems integrator, device manufacturer, middleware provider, or someone else. Does your prospective middleware provider have the expertise to help you align your business processes with RFID data? Ideally, you want to select a vendor that is committed to implementing a middleware solution that meets your budget and schedule requirements.

Dig deep to find out what features are available

Aside from price and other common questions, ask your potential RFID middleware provider how easy it will be to integrate with your back-end systems. Also, ask if its pre-built business processes align with yours, or if you will need custom development. What is the provider's short-term and long-term vision? How much time will your IT staff need to implement and maintain this system? What fault tolerance steps has the vendor taken, and how will they ensure uptime for both your software systems and RFID devices? Does the middleware provider take advantage of "smart" devices - such as lightstacks and presence detectors - that can reduce infrastructure costs and network traffic? Alternatively, does the vendor implement with additional control systems?

Get references

Working with a middleware provider that has a good track record allows you to overcome hurdles that can be costly to your business. Among other features, experienced middleware companies have quality processes for managing device driver release schedules, and the capability to automatically alert system administrators to potential problems. They also may have integrated devices with the flexibility to allow for configuration, which optimises performance.

Make the right decision for you

Once you have gathered enough information to begin the middleware selection and purchase process, it is important to define and prioritise metrics that affect your business. Do not simply use a similar company's scorecard. Doing the latter will deliver a pilot, doing the former will deliver value.

Data Management

Data management is an important aspect of deploying RFID, but one that is often forgotten. However, it can make or break the solution being developed.

While the business benefit of RFID holds tremendous promise, one of the biggest hills to climb is dealing with the flood of data that RFID generates. Managing the data associated with RFID is the much more complex process and one that is given too little upfront consideration. An in-store RFID implementation at Wal-Mart will generate as much data in three days as is contained in the entire U.S. Library of Congress (based on estimates from analyst Jim Crawford from Retail Forward). It is not just a problem for companies the size of Wal-Mart because even modest RFID deployments will generate gigabytes of data a day. To make matters worse, the data changes quickly, so approaching RFID by trying to handle the data volumes in large batches just will not work. The volume and velocity of RFID data places too heavy a burden on existing technology infrastructure. RFID applications are able to capture vast amounts of event data that has not been available to the business previously, and so the business will now need to determine what information it needs, to what detail and when they will need it.

> "Recent advances in RFID technology are causing excitement throughout the retail supply chain. Not a day goes by without an announcement of increasing reader distances or decreasing tag sizes, all of which give the impression that implementing a successful RFID infrastructure is simply a hardware decision. However, organisations that believe this are set for failure because RFID is much more than that. In fact, the hardware choice is the easy part, managing the data associated with RFID is the much more complex process and one which is given too little upfront consideration."
>
> Reqio.

Capturing large volumes of data at high velocity is just the first step. Woody Allen once said, "I took a course in speed reading and was able to read War and Peace in 20 minutes. It's about Russia." If all you learn from massive volumes of RFID data is the most general conclusions, then the value of that data is lost. It is as if one looked at a 250 gigabyte disk drive filled with useful information and concluded that it simply contained 10,424 files. Therefore, if all you do is capture RFID events, most of the value is lost because the advantage of RFID is real time knowledge, not data collection.

Stephen Keith of Sun Microsystems stated that the data management concerns could be split in two:

- Technical:
  - Raw RFID data volumes generated by readers (100's of reads per second per reader)
  - Need to convert RFID events into meaningful business events
- Process:
  - Increase in process node / control-points
  - Quantity of data per business event

Data management for RFID can be broken into three broad categories:

- Data integration, including enterprise applications integration (EAI).
- Product data management and data synchronisation (Global Data Synchronization – GDS – and Product Information Management – PIM).
- Analytics and business intelligence, including data warehousing.

Without some combination of these three elements in place, an enterprise architecture for RFID falls short.

There is a need to be able to answer the following questions about the data being collected:

- Is all of this data reliable and accurate?
- Where should this data be stored?
- What business processes can be applied to this data?
- What applications can use this data?
- How can this data be leveraged across the enterprise?

Instant decision-making on high-volume, high-velocity data streams is not a new challenge. It is the same problem found in the program trading systems of large investment banks, the command and control applications used by the military, and the network management applications in telecommunications. Based on experience in those industries, as well as RFID system development, Mark Palmer of Objectstore posed seven principles to help you effectively manage your RFID data.

Principle No 1: Digest the data close to the source

Try to deploy a RFID system by directly connecting RFID readers to your central IT systems and the results will be disastrous. A better approach is to digest your RFID event traffic close to the source – at the "edge" of the enterprise – and forward only the meaningful events to central IT systems. This digestion process is more than basic filtering – it's data cleansing, consolidation and summarisation; it's exception handling of many types – automated and human-made; it's compensation for unreliable technical infrastructure – application, hardware, network failure; it's adjustment for unreliable RFID tag reader environments. Digestion of data close to the source allows this complex processing to occur and exceptions to be handled locally thus protecting central IT systems from the flood of data.

Principle No 2: Turns simple events into meaningful events

Complex Event Processing (CEP) is a new field that deals with the task of processing multiple streams of simple events with the goal of identifying the meaningful events within those streams. CEP helps discover complex, inferred events by analysing other events. According to Gartner, CEP will become a common computing model within five to ten years.

Principle No 3: Buffer event streams

One way to deal with the gush of RFID data is to develop RFID data "concentrators" that help buffer the flow of RFID event streams. A RFID data concentrator is software that collects and processes raw RFID event flows close to the source of the data (Principle 1). There are three primary elements:

- RFID middleware provides the interface for applications to receive events from RFID readers. There are many commercial implementations of RFID middleware available today. Additionally, the EPCglobal standards organisation is in the process of defining a standard for RFID middleware, the ALE (Application Level Event) standard, which defines a reader-neutral interface for receiving events from RFID readers.
- Event processing handles high-volume, high-performance flows of events by organising raw events into pipelines. Pipelining is a concept found in hardware and software systems of many types, including the central processing units (CPUs) in your computer, in software designed for handling stock market feeds in real time, and transaction processing systems that your credit card company uses. Pipelines allow the events to be categorised, it then processes those categories with a set of simple tasks as each thread gets a slice of processing time from the CPU. By performing a large number of operations on data in small "bursts", overall throughput is increased, and the average speed that any individual event can be processed at is increased as well.
- An in-memory database or data cache makes the concentrator work in real time. In-memory data management techniques are crucial to accommodate the real-time nature of RFID. It's a basic law of physics: memory is 1,000 times faster than disk.

Principle No 4: Cache context

Most RFID data is simple. Unless you are using sophisticated, expensive tags all you get is an identification number for the item, a time, and a location. Determining complex events from simple RFID event data requires context. Moreover, context typically comes from reference data, in a variety of forms.

For example, context can come from information in an advanced shipping notice (ASN). As provided by a manufacturing plant, the ASN can be used to confirm that tagged items sent by the manufacturer were actually received. Context may also come from an EPC information services directory (EPC IS). EPCglobal is defining standards to allow the EPC IS to serve as the framework for trading partners to exchange detailed product information. The EPC IS allows anyone with proper authorisation in Kellogg's supply chain to learn whether the EPC tag 01.0000A89.00016F.000169DC0 is a 24-ounce box of Kellogg's Corn Flakes or a Gillette Mach3 Turbo razor. In addition the EPC IS will allow you to determine where it came from, where it's going, when it was produced, and so on. Reference data may also come from internal enterprise systems. For example, RFID-enabled baggage handling systems use data from passenger information systems to ensure that RFID-tagged bags get on the same plane you do.

Just as Principle 3 leverages in-memory data caching for event data, context data needs the same approach. EPCglobal's Gen2 standard of RFID readers specifies read rates of 1,800 RFID tags a second, which means a distribution centre with 20 readers could generate 36,000 events a second at peak rates. Adding 36,000 SQL requests to your existing warehouse database probably isn't feasible, so it's best to replicate and cache this data in your data concentrator such that is available in real-time.

Principle No 5: Federate data distribution in near real time

Principle 1 advocates processing data close to the source to manage complexity and protect central IT systems. However, the items you are tracking will not stay put for long. For example, a RFID baggage tracking system must distribute data about your bags to your destination airport far in advance of your arrival. Moreover, since most operations

are distributed, you must plan to distribute RFID data in near real time.

Federating data is hardly new – trading systems federate data daily among different financial centres and do it in near real-time. For RFID, federated data distribution unites the RFID data concentrators in an alliance – whereby meaningful RFID events and context data is shared among members. A reliable, distributed middleware fabric facilitates data federation, integrated with the data caches at each concentrator, thus enabling meaningful events to be distributed among concentrators.

The implementation details of this near real time distribution fabric is beyond the scope of this paper, but the principles are the same as we've described: process data close to the source, utilise data concentrators, cache data in concentrators, filter and handle exceptions. Ultimately, one must forward meaningful events to members of a distributed "alliance" to enable as close to a real-time view of the system as possible.

Principle No 6: Age RFID data gracefully

Even if you're Wal-Mart, you probably will not be adding seven terabytes of disk capacity daily to accommodate your RFID data. By continuously aging RFID event data, you can reduce your working set, augment event data appropriately and reduce load on down-stream systems, all at the same time.

An airline baggage handling system must track events from the gate to the plane, but the events don't all have to be stored forever. Yet RFID-enabled systems must permit operators to see the end-to-end baggage flow. The value is in understanding the baggage origin, how long it was on the conveyor belt, where it was handled, and how long it was handled for. Furthermore, the basic flow of information will need augmentation – for example, at what time was the bag loaded into the aircraft and which cargo bay was it placed in? Finally, performance and scalability typically requires that the storage of these events be optimised as the system runs. The RFID concentrator can delete events that are superfluous, supplement events that require context, siphon data off to other systems and prepare event data to be distributed to other airports. At every step of the aging process, the data concentrator's cache (Principle 3) is kept transactionally consistent to provide system recoverability.

Principle No 7: Automate exception handling

Exception handling is the primary job of any RFID system. In the world of today, people handle these exceptions. In RFID-enabled systems of the future, your software must both detect exceptions and then automate the handling of those exceptions. Though detection of events is done by complex event processing, exception handling requires knowledge of what happened leading up to this event. That operation requires an algorithmic approach to corrective action. The combination of CEP and event replay is what makes exception handling possible.

Without event replay the RFID system has no ability to go back in time to discover when a bag was loaded, which section of the plane it was loaded into, and what to do to correct the exception.

Integration Issues

A key part of any RFID project is what you are going to do with data you have collected. One aspect of RFID data is to update your back office systems that run your organisation. This means integration.

The early acceptance of RFID realises the need for a good "integration fabric'" that can seamlessly allow data to flow from the devices (tags) through the readers to the RFID middleware systems, and be utilised by the existing or new applications to trigger meaningful transactions. The vision is to combine the best of each into a smooth, tightly knit system, offering the end-user more information in less time.

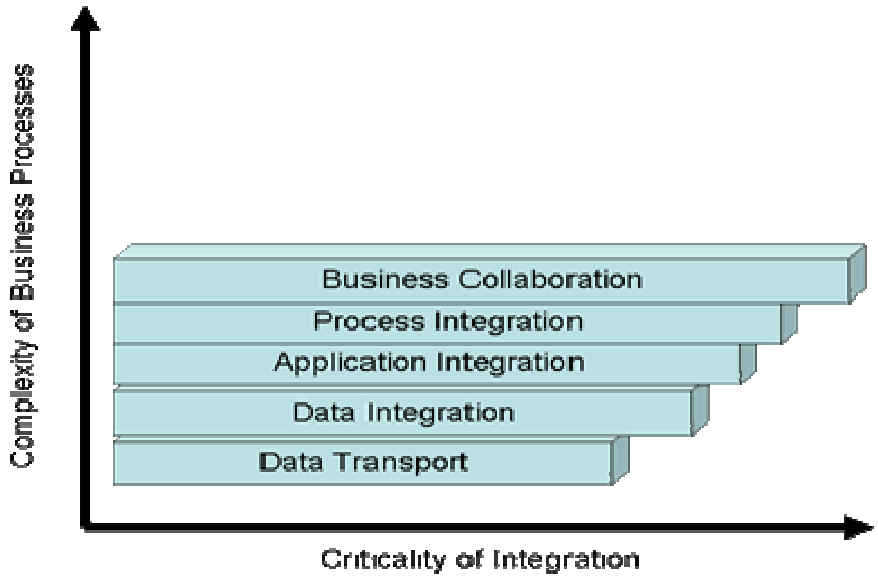
The integration landscape that will evolve needs to address issues such as device integration, data integration, presentation and management, ERP, warehouse management systems integration, work flow integration (with partner systems) and concerns for security and privacy. The IT industry comes into the picture while making data available through the artefacts on integration – in turn providing data for better decisions and driving towards quantifiable benefits of the investments.

To realise the dream of having every item identified on the lines of an "Internet id", it would mean having similar infrastructure in place as in the case of the Internet and Web. This brings in the need to have mechanisms that can seamlessly integrate the data captured at various levels in the chain, with the back-end applications, decision support systems and management dashboards. As the EPC/RFID technology becomes ubiquitous and the implementations mature, more and more demands will be made on the integration landscape leading to an increased complexity of business processes. Figure 6 depicts the importance of integration in an organisation against the complexity of the business.

"Integration will be a major risk area - the metadata and semantics of the RFID data must be consistent with existing operational data, or you will store up future maintenance problems even if the initial RFID project "works" in the short term. Once you collect data for inventory, management will come up with business intelligence applications for it and this can be another source of confusion."

David Norfolk, March 2006

Figure 6 : The Importance of Integration



Source: Integration in RFID, Sandhya Sule and Sapan Shah, Patni Computer Systems Ltd., July 2004.

Integration Options

Companies have many different options for the integration of RFID and sensor data with existing IT systems. The main options are:

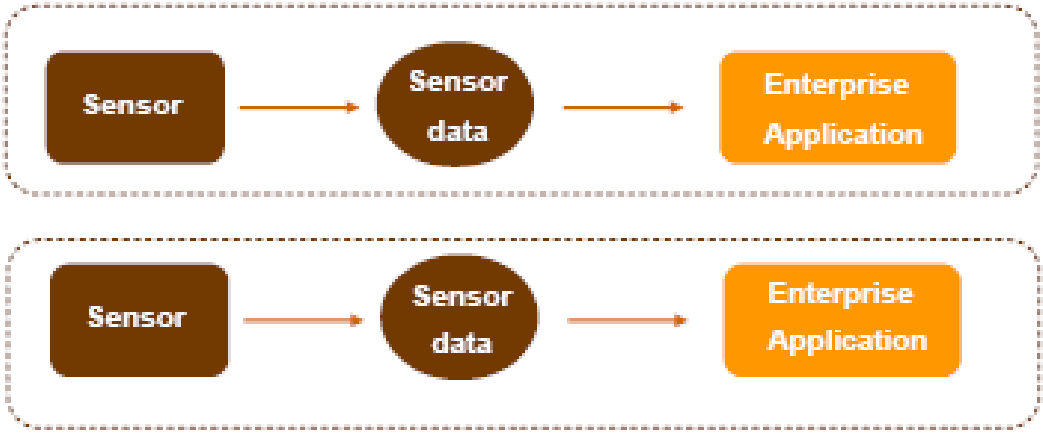
- Full abstraction.
- RFID middleware.
- Edge processing.

Full abstraction

For many years, software products such as warehouse management systems (WMS) and manufacturing execution systems (MES) have integrated with RFID and bar code systems. The key features of this are:

- The software applications need to interpret and filter all sensor data.
- Each application is a silo.

Figure 7: Full Abstraction Option



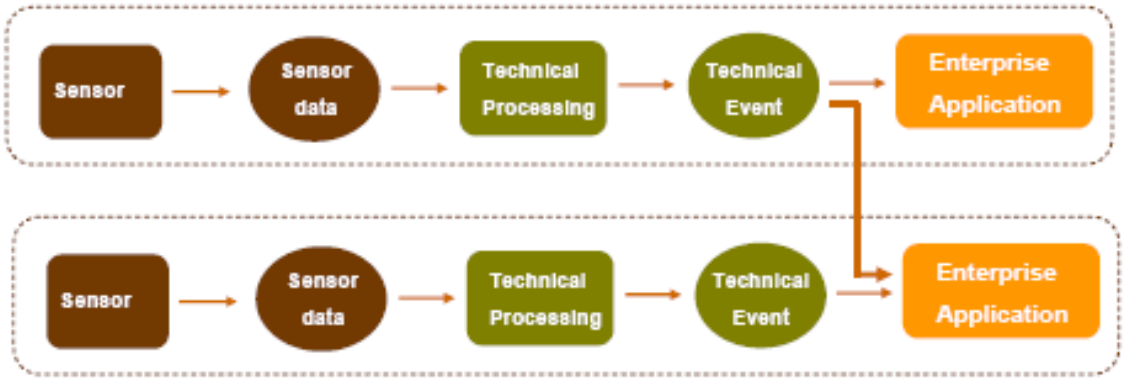
Source: How RFID and Sensors will Change Corporate IT Architectures, Eelco de Jong, LogicaCMG, IDTechEx Smart Labels Europe Conference, 19 September 2006

RFID middleware

The focus for integration today is on RFID middleware, based on the EPCglobal standard and vision. The key features of this integration option are:

- Separation between sensor layer and application layer
- Technical processing of sensor data, to create technical event
- High volume of sensor data

Figure 8: RFID Middleware Integration Option



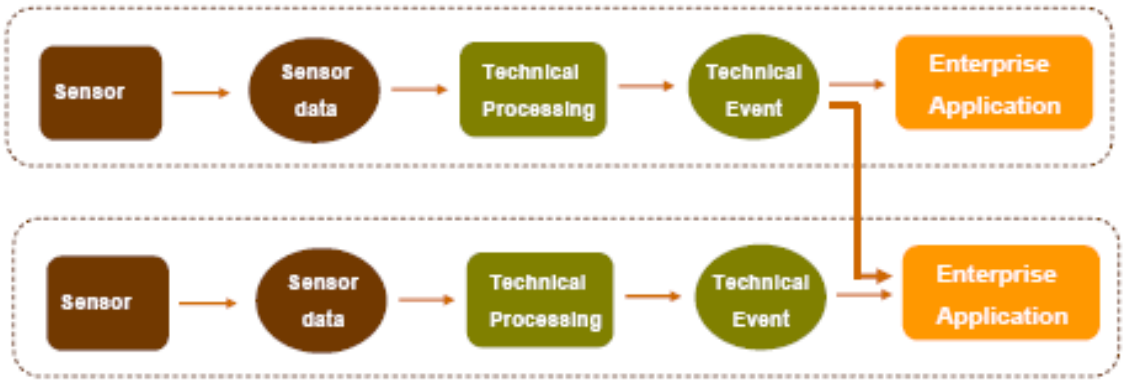
Source: How RFID and Sensors will Change Corporate IT Architectures, Eelco de Jong, LogicaCMG, IDTechEx Smart Labels Europe Conference, 19 September 2006

Edge processing

To create flexibility and efficiency with high volumes of sensor data, business logic will move to the edge of the network. This will lead to an event-driven architecture. The key features of this integration option are:

- Business logic becomes distributed, at the edge of the network.
- Processing of sensor data based on context information, to create business events.

Figure 9: Edge Processing Integration Option



Source: How RFID and Sensors will Change Corporate IT Architectures, Eelco de Jong, LogicaCMG, IDTechEx Smart Labels Europe Conference, 19 September 2006

Layers of Integration

The success of RFID will depend a lot on the rollout plan of the organisation. The ideal way to do the same would be to divide the processes and technologies into various layers to make the impact of adoption minimal.

Device integration

As organisations proceed to adapt themselves to the RFID technology, the RF-enabled readers have to integrate with the existing auto-id technologies for capturing the data. This drives the need for integration at the device level that comprises

device-device integration, device computer integration and data capturing technologies.

Application integration

Application integration is a part of the evolution of application delivery that includes improved software componentisation and the increasing acquisitions of packaged software. In its simplest form, application integration is the encapsulation of an existing application by a software component that acts as a functional interface to that application. The creation of an interface allows the other applications in the portfolio to interoperate with the wrapped application, increasing its value and long-term usability.

The existing applications, now, in RF-enabled environment need to communicate in the EPC compatible language. The data that is gathered at the middleware is converted to the application compatible format and sent across to the legacy / enterprise applications for further processing.

Process integration

Process integration tools provide a level of abstraction by letting users define integration requirements through workflow and business process models. This capability shields business analysts from the complexity of underlying middleware. Using process modelling, business analysts focus on optimising processes and easily change or implement new processes with minimal amount of coding. The models map the flow of business processes and business rules across applications and people. When business processes change, the changes are made at the model level and even the on-going processes are updated.

After the application level integration, the organisations move onto process integration to combine and automate the processes, thus optimising the data flow. The drivers for process integration in RF-enabled systems are:

- Existence of third-party process modelling tools.
- Workflow modelling.
- Process simulation.
- Process-based task monitoring and management.
- The need for runtime changes in processes.

Business integration

The completely automated systems fall in place when the organisations inter-operate on business transactions. This is possible by reducing the cost of data ownership and reusing the information between vendors. Physical Mark up Language (PML) plays a key role by enabling the business partners to access the information about the object that is being read in RFID.

Business integration depicts end-to-end business process flow across business units. It ensures the management and reliability of processes on the path. Organisations, with the help of business integration, are able to bridge the application environments across composite applications creating a networked world.

Integration Challenges

The adoption of RFID, along with an ease of management invites a series of challenges for early adopters. The challenges start right from integrating the readers for identifying the data, to monitoring the data in the ERP and SCM systems, to later manage this data. The most likely areas where challenges can be foreseen are:

- Incomplete packages and inflexible solutions: organisations having partial packages - supporting functionality in chunks are likely to face a challenging stint with RFID. This is because of the fact that lot of amendments may be required in order to leverage the provisioning of RFID to the utmost.
- Need to integrate legacy: while RFID is being integrated, organisations would want to re-use their existing systems. This will not only save cost and time, but also require less amount of familiarisation time for in-house users.
- Need to incorporate new functions: even while organisations are looking only at the identification aspect of RFID, there are many areas where new functionalities would be required to automate the existing systems. Vendors providing integration packages would be expected to develop their products / solutions in a way that integration in such scenarios can be achieved with minimal customisation.
- Diversity in technological standards: the ERPs and SCMs within organisations can be proprietary as well as vendor provided. However, in any case, with each ERP having different standards in the technology aspects, integration challenges are likely to soar up in this arena.

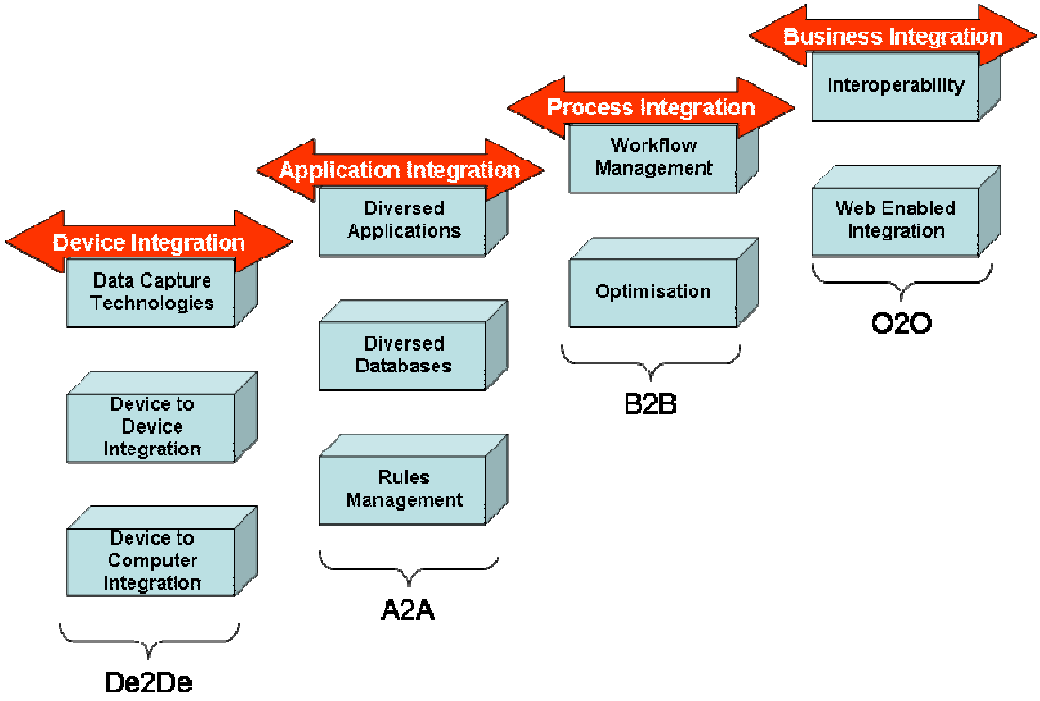
- Incompatibility in business processes: the better you want, the tougher it is. Automation is to bring in a series of changes in the existing processes that may or may not be compatible with each other. This puts up a challenge at the process integration level to provide an oblivious means for optimised automation.
- Complex technology with heterogeneous platforms, N-Tier Distributed Computing and the Web: Distributed computing environments and the advent of the Internet brought in a concept of inter-organisation business communication through loosely coupled systems. eXtensible Markup language (XML) is accepted as a standard for such communications. The combination of Internet and XML gave birth to Web Services, which support multi-language and multi-platform systems. Integration aspects of RFID will cover a lot in this area with processes being automated and organisations reducing their cost of ownerships.

Roadmap to Integration

While RFID is being promoted as an applied science to provide real-time visibility of data pertaining to items, cases and pallets at all stages of the automatic identification, organisations are researching continuously to improvise their strategies for optimising their efficiencies in terms of costs, timely deliveries, consumer satisfactions and above all managing the complicated business rules using this tool.

Figure 10 illustrates the roadmap for integrating RFID with existing processes. The permeation through these stages can give: integrity, accuracy, unified view of business information, infrastructure optimisation, technological flexibility, and above all, integrated real time data visibility.

Figure 10: Integration Roadmap



Source: Integration in RFID, Sandhya Sule and Sapan Shah, Patni Computer Systems Ltd., July 2004.

With individual technologies rapidly becoming generic or obsolete, integration plays a vital role for a smooth running system. The requisite of an integrated platform envisages an approach to product development and opens the door to intelligent systems.

RFID promises an era of ubiquitous computing. The “Internet of Things” is being realised as the means of low cost of ownership and a substance for real time monitoring. RFID is moving forward with a thrust and the need for integration at various stages with RFID becomes a crucial aspect for a smooth operation of the system. What makes the integration aspect vital is the existence of diverse applications in functional and technical aspects. Vendors across the information technology spectrum are taking the plunge for providing solutions that are extensible and robust to meet the challenging demands of every vertical concentrating on RFID. And what is promised is a better management of data and information for organisations, in turn, boosting efficiency and optimisation of the resources.

Security and Trust

In the rush to RFID, security and privacy issues got little attention, but recently there has been much more focus as implementations drive real world issues. At its most basic, early RFID technologies had no mechanisms to prevent unwanted scanning and tracking of people and goods. End users of RFID technology are getting mixed messages regarding data security. RFID vendors claim their products are secure, while media reports and researchers sing a different tune: that currently deployed passive RFID systems are prone to eavesdropping and other attacks, and that vendors have to do some important work to bolster data security. In a newly published report by market-research firm Forrester, lead author and senior analyst Paul Stamp concluded that with respect to data security, passive RFID tags and readers as they are currently designed are only appropriate for a limited number of scenarios.

According to the CBDiForum, the immature status of RFID security is obvious and there is much work to be done. For example enterprises will need to establish privacy policies that protect their consumers, such as:

- Inform consumers about products containing RFID chips by clearly labelling them,
- Provide consumers or purchasers with rights and mechanisms to permanently disable tags upon purchase.
- Provide consumers and or purchasers with information collected about them via RFID tracking systems

Key Developments in RFID impinging on Privacy

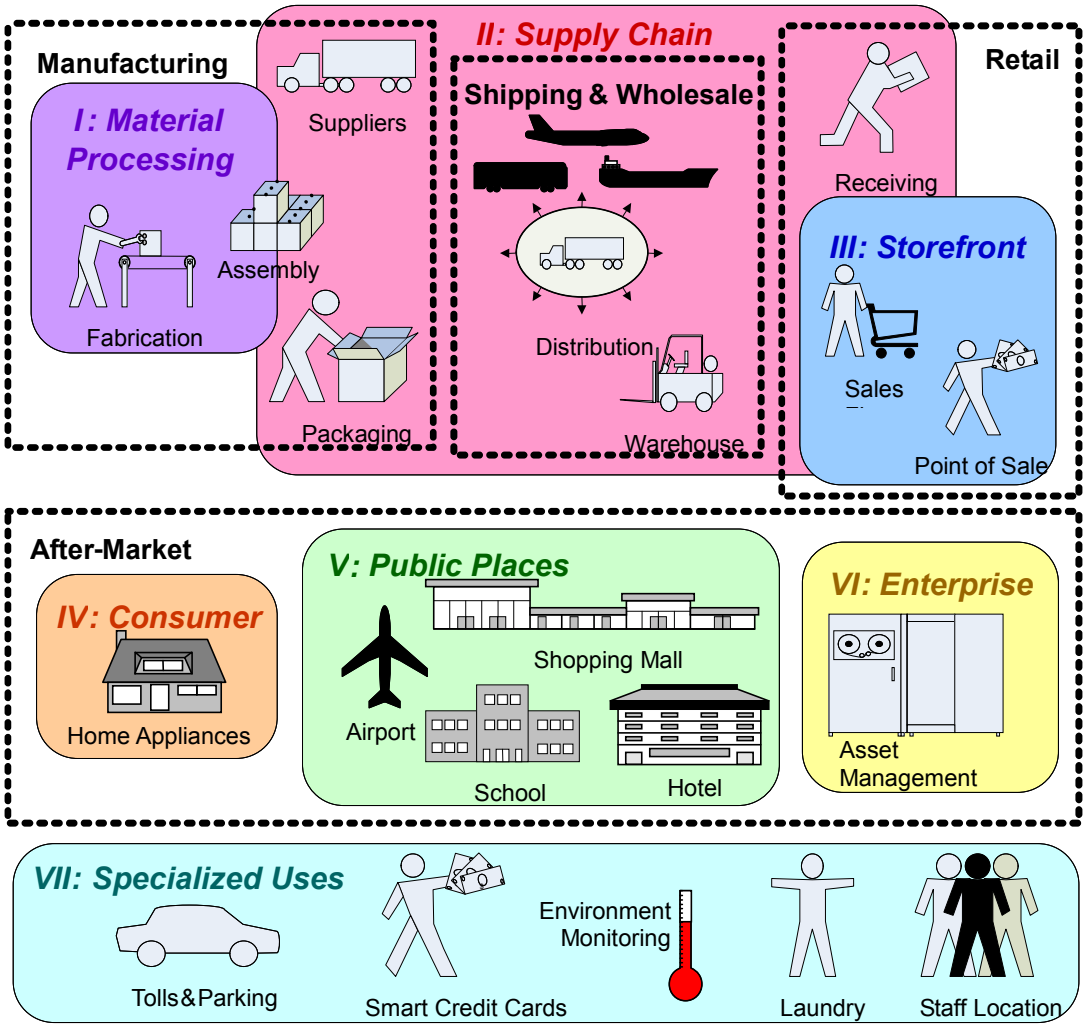
The key developments in RFID that are raising the risk to privacy protection, according to Microsoft, are:

- **Unobtrusiveness:** RFID is being developed to replace or augment bar codes in many scenarios. It offers the advantages of being able to operate without clear line of sight, and without the need to isolate each individual label and scan it physically by nearly touching it. These conveniences also mean that neither tags nor readers need to be visible to an observer; tags may be scanned without the need to physically present them to a scanning device one at a time; and there may be no human operator of the scanner to signal its presence. Thus, RFID tags and readers, and their operation, may not have any visible indications to an observer.
- **Uniqueness of ID:** there are many private series of bar codes, but the one system in most common use across enterprises is the UPC (Universal Product Code) and its counterparts across the world. UPC codes designate the manufacturer or source of a labelled object as well as the type of object to which it is attached. The counterpart for RFID, now under development under the name EPC (Electronic Product Code), includes the same information and includes a unique serial number for each tag. Thus, while a UPC bar code designates a type or model of object, an EPC RFID tag designates a specific object. This raises the possibility that individual objects might be tracked over time through the accumulated record of their sightings by RFID readers.
- **Proliferation:** the above developments, combined with cost-reducing technologies, are fuelling a massive movement around the world to improve the efficiency of goods distribution (the supply chain) through the application of RFID. This is a very commendable goal, whose success is a goal of Microsoft as well as many other industries and agencies. However, the proliferation of RFID tags will also mean that the risks associated with the developments outlined above will increase. Where risks exist, vigorous attention to their mitigation is necessary.

A detailed analysis of the scenarios of RFID use shows that these developments are not likely to result in privacy breaches in the mainstream use of RFID currently under development, i.e. in the supply chain. The scenarios that would result in the leakage of individual private information are still hypothetical and require numerous developments in the marketplace and in consumer lifestyle. The potential is there, but society-wide privacy breaches through RFID are not imminent at this time.

Some technological considerations also limit any current risk to privacy. One factor is that the passive tags slated for widespread adoption have a broadcast range limited by unlicensed radio power regulations and by physics to roughly 10 feet in practice (the reader signal may be received from farther away, perhaps 90 feet, but the tag response is a fraction of that power). Active tags used in transportation and manufacturing may have a broadcast range of 300 feet, but these are much more expensive and are not slated for labelling individual consumer items. At the other extreme, contactless smart cards and related RFID tags may become common for consumers, but they have a communication range around eight inches. Another mitigating factor is that while security measures on RFID tags are rare today, they are becoming much more common. The new generation of passive tags being developed for mass deployment will have a number of password protections built into the hardware, making it difficult for a snooper to get access to private information from the tag, including the ID number itself.

Figure 11: The Many Settings for RFID Use



Source: Kim Hargraves and Steven Shafer, RFID Privacy: The Microsoft Perspective, (Submitted to the Federal Trade Commission), June 21, 2004

Microsoft has identified that the key privacy-related issues which can be noted through Figure 11 are:

- Privacy threats are primarily embodied by tags that are interoperable across enterprises, meaning that many different enterprises may be able to access data about the same tags, and the data may be held by many operators. This arises in settings II, III, IV, V, and possibly VI. According to Forrester, the current levels of data protection for RFID tags are sufficient with regard to basic slap-and-ship applications of RFID for improved supply chain visibility. However, users who want to encode sensitive data to tags, or to store that data in RFID middleware integrated into a company's back-end IT systems or shared with trading partners, could be taking serious risks.
- Privacy threats in RFID generally concern its association with information about individuals, which can only occur with item-level tagging. This will arise only to the extent that setting III becomes viable, or for high-value or large goods that are also shipping units.
- Information about purchases that is contained within the retail establishment is generally considered a legitimate record; the privacy concerns thus arise when tagged goods are carried by individuals from the storefront into settings IV and V.
- If tags are deactivated at the point of sale, then private RFID information is not carried from the storefront to the after-market settings. Thus, the privacy threat is substantially limited to the case that tags are not deactivated at the point of sale. Assuming deactivation is available, the motivation for not choosing it might be from the consumer's desire to use tags in settings IV and V, however, such scenarios appear to be distant. Another motivation might be compliance with requirements such as return or warranty policies, item function or recycling regulations. There are no such compliance requirements at this time.

- Even if all the above conditions were met – interoperable tags, applied at item level, carried out of the storefront, for use in after-market settings – the privacy threat is minimal inside of one's home (setting IV). It arises only if there are involuntary leaks of data by appliances, or snooping by guests in the home (invited or uninvited); we do not expect these to be common scenarios. (Scares about snooping from outside the home are not supported by the technological realities.) Thus, it is the carrying of tags into public places that gives rise to the key privacy concerns (setting V).

The Primary Scenario

The primary scenario in which RFID poses risks for consumer privacy will arise when a person has an item that has been acquired, with an RFID tag that remains active for after-market scenarios, especially when this item is carried into a public venue. The clear privacy threats emerge under these conditions:

- The tag must be on an item that a consumer would acquire, rather than on a shipping unit.
- At the point of acquisition the RFID tag ID can be associated with other personal information.
- If a tag is deactivated at the point of acquisition, it no longer exposes personal information. But if there are after-market scenarios for RFID use, a customer might be motivated not to deactivate the tag at the point of acquisition.
- The threats are greatest when the item is carried into a public venue in which its tag may be exposed to RFID readers operated by other parties.

The exposure of private information can be due to snooping (unauthorised) or legitimate use (authorised).

Unauthorised access to RFID and associated information

Unauthorised access to information in computers is generally prevented by security measures built into those systems. The new threats from RFID arise from the proliferation of such data, and from the possibility of snooping via radio.

- The security issues arising from the proliferation of data can best be addressed by continuation of current efforts to develop stronger protection technologies, to educate system operators, and to provide them with new tools that are easier to use and more effective.
- Radio snooping must be prevented by a combination of three features:
    - Authorisation of readers to tags, for example requiring a password from the reader before a tag will communicate with it.
    - Authentication of tags to readers for anti-counterfeiting, for example using an algorithm or unique "signature" feature of a tag.
    - Encryption of data transmitted between a tag and a reader.

Authorisation, authentication and encryption for RFID should all be developed and applied on a routine basis to ensure trustworthiness of RFID radio communications.

One source of concern to privacy advocates and to the general public has been the absence of these features from the current proposals for interoperable RFID tags. However, it appears that the technology currently under development will include some or all of these features. This does not eliminate the exposure to snooping completely, but it does help provide limits. There will remain a need for development of a password management paradigm to utilise these new RFID tag features effectively.

Authorised use of Personally Identifiable Information (PII)

The below points were made by Microsoft in its submission to the Federal Trade Commission around the policies needed. I would recommend it as a good checklist to be used to ensure you have this issue covered.

- Conspicuous notification must be posted and the governing privacy statement must be available near the readers and tags when RFID tags are in use. Items or packaging tagged using RFID tags must be so labelled. The privacy statement must include information on the purposes for which tags and readers are being used.
- Consumers must be provided with the choice to remove or deactivate tags on purchased items without impairing the primary use of the item or impacting the conditions of purchase, e.g. warranty and returns.
- Consumers must be notified if personal data associated with RFID tags is being transferred to third parties and the consumers must be given the opportunity to consent to any secondary use. Data transfers of personal data must include appropriate security measures.

- Reasonable access must be provided for customers to their personal data associated with RFID tags to correct or amend such data.
- Appropriate security measures must be in place to help protect personal information from unauthorised access, use or disclosure.
- Reasonable steps must be taken to ensure personal data associated with RFID tags is relevant and reliable for its intended use.
- Consumers must have a mechanism for dispute resolution with the RFID data collector.

Conclusions

Implementation Challenges of RFID

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.

Implementing RFID involves a multitude of challenges. Multiple goals of a RFID deployment can lead to a complex project. It is 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.

The other big challenge she says, "continues to be cost," although Overby predicted that the adoption of the EPC Class 1, Gen 2 standard 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:

"RFID represents both a major IT modernization and a major investment for organisations. 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

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.

"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

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 on 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 were 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 are 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 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 that offers better service?

Being Prepared

Although the use of RFID in a variety of industries has grown tremendously in recent years, its potential has not been fully realised due, in a large part, to the challenge of configuring and managing a multitude of incompatible devices and difficulty in building meaningful applications and integrating them with back-end systems. "Until RFID can be fully exploited through the use of technology-based applications, analytical tools, and hardened enterprise-scale technical infrastructure, adoption rates won't meet the expectations most market-watchers set," notes John Fontanella, author of "The RFID Benchmark Report" from Aberdeen Group.

Experience shows the most successful companies at deploying new technologies are those who have a clear business case, a well-defined roadmap and who continually measure against their original objectives and make adjustments accordingly. RFID deployments are no different; they just have a few extra technology considerations to address.

Rigorous application of this five step deployment methodology will minimise internal risk and put your company on the right track for RFID compliance and competitive advantage. Although your immediate motivation may be meeting compliance mandates, the real value of RFID deployment will come from improving your company's operations.

You need to define a dominant architecture style. This will depend on the type of organisation and market, and maturity of current IT architecture. It is vital to define corporate RFID standards and a migration path. You must know whether you are starting in a green field or not so analyse current and planned RFID pilots in the organisation. RFID requires you to create a desired governance structure. RFID requires investment funds not just in terms of money to buy hardware, middleware and software but in terms of people; it will involve process change if you really want to get benefits.

I came across an article that summed up the whole issue discussed in this paper; it was entitled "The Magnificent 7 Real Life Challenges of Implementing RFID":

- Capacity: Will I obtain 100% read rates? Will it scale?
- Distance: Will I achieve my desired read distance?
- RF Issues: Which tag? Which reader? Security? Environment?
- Integration: Will everything talk to everything?
- Success: Who should I partner with? Will RFID work?!
- Cost / ROI: Is it affordable? Will it pay its way?
- Privacy: Will consumers respond or resist?

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.

The key to realising the benefits of RFID technology is treating it as true enabler of business re-engineering – a step change in improving both integrity and efficiency.

Author

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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.