Communications of the Association for Information Systems

Volume 12 Article 19

8-21-2003

Developments in Practice X: Radio Frequency Identification (RFID) - An Internet for Physical Objects

Benn Konsynski
Emory University, benn_konsynski@bus.emory.ed

Heather A. Smith
Queen's School of Business, Queen's University, hsmith@business.queensu.ca

Communications of the Association for Information Systems

DEVELOPMENTS IN PRACTICE X: RADIO FREQUENCY IDENTIFICATION (RFID) - AN INTERNET FOR PHYSICAL OBJECTS

HEATHER SMITH
School of Business
Queens University
Hsmith@business.queensu.ca

BENN KONSYNSKI
Goisueta School of Business
Emory University

ABSTRACT

This paper explores the applications and future commercial impacts of radio frequency identification (RFID) technology. Its objective is to summarize the ways in which organizations and academics are thinking about these technologies and to stimulate strategic thinking about their possible uses and implications. It first provides an overview of this technology and how it works. Then it explores the surprisingly wide variety of current applications of RFID. Next it looks at several classes of potential RFID applications and how these might affect how organizations work. Finally, it examines the cost and implementation considerations of this technology. The paper concludes that RFID is a viable technology with many possible applications. However, only some of the impacts on organizations and society can be anticipated at present.

Keywords: radio frequency identification, RFID, RFID applications, new technology, technology strategy

I. INTRODUCTION

New technologies offer companies the opportunity to rethink how they do business. As a society, we typically overestimate the short-term impact of new technologies and underestimate their

KEY SPONSORS OF RFID INITIATIVES

- ***The U.S. Government*** invested $9.3 million towards funding proof-of- concept projects related to homeland security [Werb and Sereiko, 2002].
- ***The U.K. Home Office*** established a Chipping Goods initiative and is spending €8.5 million on eight RFID projects in a variety of retail applications [Tierney, 2002).
- **The MIT Auto-ID Center** is coordinating an international RFID standards initiative. With its many corporate sponsors (e.g., Wal-Mart, Proctor and Gamble, Philip Morris, Johnson and Johnson, Pfizer, Westvaco, Kimberly-Clark, Coca-Cola, Pepsi, Home Depot, UPS and the US Postal Service) it is conducting a three-phase project to track products through a supply chain. Phase 1 is already successfully completed [Hodges et al, 2002].

long-term impacts. This paper explores the applications and future commercial impacts of radio frequency identification (RFID). Its objective is to summarize the ways in which organizations and academics are thinking about this technology in order to stimulate strategic thinking (and possibly strategic experiments) about their possible uses in a wide variety of industries. Today, companies have the luxury of time to consider their options with this technology. This will not always be the case. Pressures to adopt RFID will mount, now that large firms are adopting it and if governments decide to mandate it.

II. RFID TECHNOLOGY OVERVIEW

RFID uses radio frequency chips to track pallets, cartons and individual items in warehouses, stores, and other locations. In the near future, companies will be able to create a network of physical objects much as they now create networks of people and information. This network would mesh completely with other networks and open up new opportunities for product and supply chain management.

Figure 1 shows an example of how RFID products can be imbedded in a product.

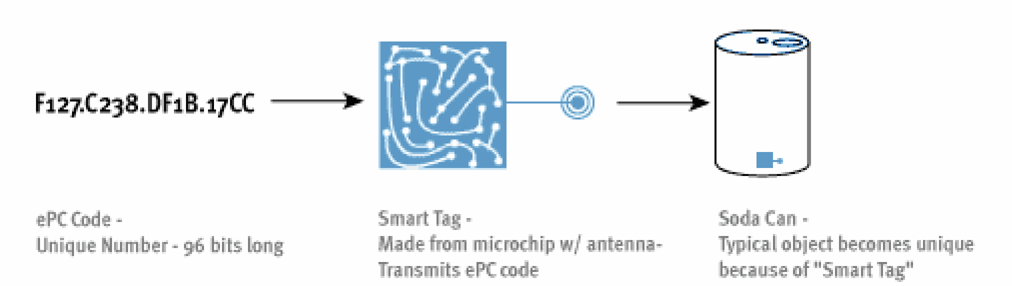

Figure 1. Example of how RFID Tags can be Invisibly Embedded in Many Different Products [Mayfield, 2002]

RFID technology is composed of four major components [Agarwal, 2001]:

1. **E-Tags.** These electronic radio frequency tags are essentially tiny computers (smaller than a “D” on a penny). They are tiny, lightweight, cheap (predicted to eventually be less than five cents for a basic tag) and versatile, enabling them to be easily and invisibly embedded in most product packaging, clothing or parts. Different classes of tags will be available. The most basic will simply contain product identification information. Other classes will include monitors that can be updated with information such as weight, temperature, and pressure. Tag readers, based on cellular technology, can scan products as needed so that a system can identify what products are located in a particular physical space. Unlike barcode

scanning, line of sight is not required and readers can deal with hundreds of tags at the same time. It is estimated that 100 billion e-tags will be needed to identify the global supply chain [SIM Advanced Practices Council, 2002]. An E-tag is shown in the photo above.

2. **Electronic product code (EPC).** New universal standards are being developed to identify individual product items (e.g., cans of Coca Cola) through an EPC. These standards will create a unique identifier for an individual item. This new naming scheme is based on a 96-bit code. It will enable the identification of 1.5 quintillion objects. The EPC will be the minimal information carried on an e-tag. Most other data will reside on a server accessed via the EPC.
3. **Object name service (ONS).** Based on its EPC, an item can be associated with one or more networks either on the Internet or a virtual private network where information about it resides. The ONS sits on a local server and matches e-tag EPC information with other information about the item, including location.
4. **Physical markup language (PML).** This standard is used to describe product items. It is being developed by the MIT AutoID Center.

RFID technology is superior to barcode technology because its user does not need to know where an object is and does not need to get close to scan it. Since tags can be read at a distance and do not require line-of-sight, they lend themselves to many more applications across a supply chain.

> ***Strategic Implication.*** RFID technologies represent a common standard for data storage and retrieval that could improve collaboration and data sharing between non-competing organizations.

III. APPLICATIONS OF RFID

Although RFID technology is still emerging, governments and companies are already exploring a number of proof-of-concept applications. A survey of the business press over the last two years, shows a surprisingly wide variety of organizations are already implementing RFID applications. While most applications are still in the pilot stage, some are now actually operational. Some of the types of applications that are currently running include:

- **Airport Baggage Handling.** Prototype demonstrations of e-tagged baggage handling are underway in airports in San Francisco, Seattle, Houston, Singapore and London Heathrow with a number of airlines [Brakeman, 2001; Wilson, 2001]. Bags are tagged with an RFID tag rather than a bar-coded tag so that they can be tracked by readers throughout their journey. Initial results are very promising (see sidebar). Safety is improved because security information can be associated with particular tags enabling them to be routed automatically through an explosive detection machine. Jacksonville Airport was given approval in 2002 for a full-scale RFID baggage tagging system, the first of its kind in the world. It will use secure data encryption and tags with read/write capabilities [Anon., 2002c]. E-tags will be applied at curbside check-ins and allow information to be added during a bag's journey, giving security personnel a snapshot of the route each bag traveled. Tagging will also eliminate the need for manual sorting and lifting through the use of conveyor belts equipped with tag readers.

> **INITIAL RESULTS OF RFID BAGGAGE TAGGING**
>
> - 25% greater throughput
> - improved reading accuracy
> - faster airplane loading
> - reduced compensation claims
> - reduced turnaround penalties
> - improved security
> - reduced handling costs.

- **Electronic Payment.** Both Exxon and Phillips 66 have implemented RFID systems that enable customers to instantly charge their fuel and convenience store purchases without using cash or a credit card [Anon., 2001b]. Customers enrolled in these programs wave a miniature transponder attached to their key chain in front of an electronic reader at the pump or checkout counter.

- **Retail Theft Prevention.** E-tags are still too expensive to use on all items, but several retail stores have started to use them on their high value items to eliminate theft. Wal-Mart in the U.K. is using RFID to track CDs [Tierney, 2002]. Woolworth's in the U.K. is using it for "high-risk" items, such as mobile phones, children's clothing, CDs, and computer accessories [Anon., 2002g]. Marks and Spencer in the U.K. has ordered 3.5 million tags, which it plans to embed in its reusable plastic trays, dollies and cages used to transport refrigerated fresh foods [Anon., 2001a].

  Prada's flagship store in New York puts e-tags on all its garments. As a customer heads to the fitting room, clerks can monitor their route and provide an image of the garment and details about its cut, fabric, and color. Prada is also using its system to collect market research information [Bednarz, 2002].

  Strategic Implication. As customer demand becomes more visible and accurate RFID will help companies become more responsive to changing customer wants and needs.

- **Library systems.** VTLS, a firm located in Blacksburg, VA, developed an RFID system for libraries. New Hanover County Public Library in North Carolina installed the first system (see sidebar) and three more libraries are committed to adopting it. The system employs RFID tags in books with a self-checkout workstation and a self-return book drop [Anon, 2002a].

> *"The immense potential savings in staff time clearly justifies the costs. This technology eases the workflow and provides a single solution for all material management functions",* New Hanover County Public Library Director [Anon., 2002a].

- **Automotive manufacturing.** Toyota-South Africa installed an automatic tracking system in its auto plant using read/write e-tags [Anon., 2002b]. The tags are mounted on auto paint shop dollies and hangers to allow Toyota to track vehicles at any point during the painting process, and to track the maintenance records of each dolly and hanger. A second phase will implement a similar system in the plant's Body and Assembly departments and through Toyota-South Africa's distribution channels.

  BMW-South Africa is using RFID technology to streamline its automotive spare parts warehousing and distribution operations [Anon., 2001d]. Its system handles spare parts receiving, parts storage, and distribution of parts to its 60 dealers throughout Southern Africa. Ford uses an RFID system in its automobile assembly plants in the U.S. to request parts replenishment to the line [Anon, 2001c].

- **Parking.** Organizations in more than 16 countries use RFID technology to provide everything from automated controlled access to parking lots to the accurate collection of parking fees [Anon., 2002e].

- **Postal services.** The Italian postal service now uses e-tags to ensure mail is moved to the correct destination and to monitor delivery times [Langnau, 2001]. Mail bags are tagged with read/write tags as they arrive at Italy's airports. As the bags are loaded on conveyor belts, readers can verify each bag's destination automatically and route it appropriately. The service also puts e-tags in envelopes and mail throughout the country. As these letters arrive at a routing area, their travel time data are recorded. The tags help identify delivery problems.

- **Homeland Security.** To facilitating the efficient movement of commercial assets into and throughout the United States, automated vehicle identification is proposed to positively identify and monitor containers, cargo, trucks, trailers, drivers, and crew [Anon., 2002d, Werb and Sereiko, 2002]. The Departments of Transportation and Defense are integrating two existing RFID programs to prevent terrorists from hiding weapons or explosive material in a container. CargoMate has implemented an operational pilot in New York and New Jersey

SETTING STANDARDS FOR RFID USE

MIT's Auto-ID Center is working with a number of industry groups to set international open standards for RFID use. The Center is holding adoption forums to introduce the standards. And technology the created. The forums focus on different industries.

Strategic Implication. In spite of many potential benefits in an individual company, the full potential of RFID systems will only become apparent when EPCs are adopted widely and open standards are used throughout a value chain or other type of system.

The Automotive Industry Action Group has developed a standard for labeling tires and wheels that will identify the tires associated with a specific vehicle.
Source: http://www.autoidcenter.org.

ports. It uses RFID and GPS to enable real-time chassis/tractor tracking. E-seals (metal bolts with embedded RFID devices) are being tested in the ports of Tacoma and Seattle to prevent container tampering. If a seal is tampered with, an alert is sent to a central communications center. The integration project will read the e-seal as it is placed on the chassis. The e-seal number will then be linked with the chassis identification information so a cargo can be tracked through its delivery cycle, whether on rail, truck, or in terminals. In 2002 combined system was expected to be in operation by the end of 2003.

Strategic Implication. To be effective, RFID systems must also operate across the regulatory boundaries of countries and global regions.

- **Automobile tracking and compliance.** A system is now available that uses windshield sticker e-tags to enable electronic toll collection and electronic vehicle registration [Anon., 2002f]. Automation of vehicle registration and of compliance and enforcement information frees up manpower from labor-intensive work. The windshield sticker e-tag is priced under $10, enabling its distribution on a large scale to all registered motor vehicles in a state. Although they still face legal hurdles, if implemented, law enforcement agencies can use RFID readers to screen traffic, and automatically identify vehicles that are compliant or non-compliant with federal or state regulations regarding registration, emissions, mechanical safety, valid insurance, and outstanding unpaid violations.

  Strategic Implication. This system is the first that meets the high performance demands of toll collection applications. It makes practical new business models for open road tolling and mCommerce that were previously impossible.

- **Equipment inspections.** Indiana now uses read/write e-tags for inspections of amusement rides [Albright, 2002a] Tags link together all pertinent data concerning a ride, eliminating the need for paperwork. A ride registration system is in place and 1,200 amusement rides in the state are already tagged. Inspectors and operators noticed improved data integrity and a considerable reduction of clerical work and paper documents.

  An oil and gas refinery in the UK uses RFID to monitor and maintain pressure safety relief valves in vessels, pipe work, and process equipment [Alexander et al, 2002]. This technology has reduced re-certification and repair cycle time by 64%.

- **Military use.** The Department of Defense (DoD) operates the largest RFID system in the world [Anon, 2002h]. It is used extensively to track containers of materiel in the field and to know what they contain at a distance. The DoD uses tags that can identify the entire manifest of items in a specific container. The DoD is also developing four new projects using RFID:

  1. **Materiel location.** This project aims to identify materiel at all stages of its lifecycle, e.g., in process, storage, in transit, or in use.

2. **Weapons deterioration.** This project is exploring using special sensor e-tags for predicting the deterioration of explosives, propellants, and pyrotechnics. E-tags would be affixed during weapons manufacture.

3. **Hazardous materials tracking.** Federal regulations require local authorities be notified when hazardous materials in an area reach a certain threshold. This project will use RFID tags to record the chemical content of the materials in an item and report them automatically.

Strategic Implication. With government's increasing concerned about the environmental impacts of products, RFID technology will help companies comply more easily with legislation mandating recycling and waste reduction.

4. **Asset tracking.** An e-tag project is being developed to ensure that parts for items under repair remain together, e.g., all parts for a helicopter. High value items are to be tracked automatically so lost items will be easier to find.

IV. POTENTIAL CLASSES OF RFID APPLICATIONS

MIT's academics, working with the Auto-ID Center's sponsors, have identified several generic classes of applications that could emerge in the near to medium term, as RFID technology becomes less expensive.

Supply Chain Management Applications. These applications are of particular interest to manufacturers and retailers. Three key types of applications are envisioned in this area:

1. **Perpetual inventory management.** While many companies use inventory management systems, current systems involve considerable leakage. Companies tend not to track items on the shelf, only when they move through the system, since counting inventory is expensive. With RFID, every item can be tracked regardless of where it is. RFID also enables companies to know what inventory is coming to them. Finally, it helps retailers keep perpetual inventories at the store level. Thus, real time inventory will be possible throughout the supply chain. Real-time inventory data could enable improved replenishment, reduced order cycle times, in-transit tracking of items, better forecast accuracy, increased flexibility in responding to unexpected demands, improved item locating and easier recalls [Albright, 2002b, Alexander et al, 2002].

   Strategic Implication. As e-tags are used to maximize information flow in a supply chain and minimize physical material flow, inventories will be reduced and cost savings realized. E-tags could help reveal problem areas in a supply chain [Brock et al, 2002].

2. **Automatic scanning.** Scanning items with barcode readers as they are received, shipped or sold is labor-intensive. Labor is also used to take pallets apart to check shipments. RFID could reduce the costs involved in these functions by scanning shipments automatically and rapidly, reducing time and effort in the warehouse. Manual scanning will no longer be needed for store checkout,. All items in a shopping cart could be scanned automatically when a customer leaves the store [Brock et al, 2002].

   Strategic Implication. Ultimately, "intelligent" products may be able to share usage information, and help change product attributes (i.e., help develop new products), phase out unpopular product lines, or modify transportation routes. Thus, RFID could help companies avoid system shocks and disturbances [Brock et al, 2002].

Product/asset identification. RFID will help companies identify a variety of assets, from items in a shipment to equipment in a hospital. It can also be used to track component parts in finished goods. This ability could be especially useful when parts are hidden and therefore impossible to barcode scan, e.g., items assembled into cars. RFID can also facilitate return management, helping retailers know if they sold the item being returned. Finally, access to a product's history could enable product-based accounting according to different production or distribution routes [Alexander et al, 2002].

Strategic Implication. RFID technology has the potential to separate aspects of traditional supplier-distributor-retailer-customer relationships. Business relationships, processes and information will all likely be affected. Although no one is sure exactly what changes will occur, these possibilities should not be ignored.

Logistics and Transportation Applications. Companies that move large numbers of items every day need tools to track and locate them cheaply. Initially, logistics providers can use RFID to track specialized containers and trace reusable containers (e.g., palettes, cylinders). As e-tags become cheaper, it will be possible for postal services and package delivery companies to track small parcels in this manner. Ultimately, it is conceivable that a tag could be part of every postage stamp [Alexander et al, 2002].

Healthcare Applications. Tags could be used to prevent the sale of expired medicines and to track mobile medical equipment, e.g., wheelchairs, incubators, and surgical instruments. Tracking pharmaceuticals could also assist companies in complying with FDA reporting requirements. Non-digitized medical charts, records and films could also be tracked electronically. E-tags could make the job of monitoring, controlling, and tracking radioactive material in hospitals – from transport to administration to disposal – much easier, while increasing safety and security [Brock, 2002].

Other potential medical applications include patient and medication identification. Through e-tags on medical bracelets, systems could be developed which could coordinate medical treatment wherever patients go. E-tags could also be placed on pill bottles to prevent drug counterfeiting and to monitor compliance. Some even suggest putting small, removable electronic tag "strips" on individual doses of medication [Brock, 2002].

As e-tags become more sophisticated, they could be used to monitor and transmit patient data (e.g., temperature, respiration, pulse) through wireless sensors that will interoperate within a broad network of generic readers, eliminating the need for some specialized equipment and specialized training of medical personnel. The single user interface will reduce the confusing array of devices often used in complex cases. The common standards represented by RFID technology could facilitate the sharing of medical information across devices and healthcare providers (within appropriate privacy constraints). These applications could be extended for use at home to monitor vital signs and signal any important changes to a patient's physician [Brock, 2002].

Customer Service Applications. Companies that handle products owned by customers (e.g., repair and storage services) could use e-tags to log the receipt of goods, track their progress, and prevent lost items – all electronically. E-tags could also effectively act as proof of purchase and include warranty and service history information [Brock et al, 2002].

Strategic Implication. RFID technology will eventually enable manufacturers to extend their effective supply chains to include service and maintenance of their products. Thus, for example, products might not be sold individually but offered in monthly or yearly packages that include services.

Theft and Waste Prevention Applications. E-tags on products will be able to report when products are stolen, as well as serve as a homing device to report their exact location. Tags could also be used to report when products are reaching their sell-by date, so that they can be quickly sold or returned to the manufacturer [Agarwal, 2001].

Personal and Asset Status Applications. Some companies are considering adding two-way tags to their ID cards. Then, if an employee feels unsafe or needs help, pressing this button will instantly report his or her location and bring assistance. This feature could also be used in hospitals and other facilities that are open to the public [Werbe and Sereiko, 2002].

Two-way tags could also be used on electrical equipment to provide a log of whether it is operating or not, to schedule maintenance based on actual usage, and to compute equipment charges based on usage. Similarly, motion sensors could trigger an alarm if equipment is moved. Temperature sensors can also be included in e-tags on containers of temperature-sensitive goods to alert monitors if temperature is not in a desired range [Werbe and Sereiko, 2002].

IV. COST AND IMPLEMENTATION CONSIDERATIONS

RFID tags cost less than half of what they did five years ago and prices are continuing to drop. However, the cost of RFID tags is currently one of the main barriers to the immediate implementation of this technology. In 2002, low-end tags sold for about ten cents a tag. Low end readers cost between $300-$500 U.S. Higher end tags can cost $10 or more each and readers can cost up to $5000 U.S. [Alexander et al, 2002]. This technology is therefore still substantially more expensive than barcodes and barcode readers. Open standards for codes and readers will likely promote lower prices by increasing direct competition among vendors. If a five cent read-only e-tag can be achieved, it will make RFID a viable alternative to barcodes.

SIX TYPES OF RFID COSTS

- The cost of the tag itself
- The cost of applying tags to products
- The cost of purchasing and installing tag readers
- System integration costs
- The cost of training and reorganization
- The cost of implementing application solutions.

The deployment and development of an infrastructure from scratch will likely add significantly to the cost of implementing RFID technology. RFID will require a new breed of data management and network services because substantial volumes of item level EPCs will need to be processed and communicated throughout a value chain. Data management software must capture data from readers, manage data storage, aggregate data and make it meaningful by processing it into useful information and reports. Finally, applications will be needed to use EPC and item tracking information to create business value. Legacy applications will need to be modified to integrate with new EPC systems and to handle the large volumes of data generated.

Clearly, at 2002 prices, companies must use RFID selectively for appropriate applications e.g., expensive equipment or products, or small numbers of items to detect system delays, bottlenecks, sorting errors, and misassembled orders. It is also appropriate to track reusable containers where the tag cost is amortized over many uses. Reduced errors, waste, and shrinkage can often justify the costs involved. Such selective deployment is likely to be effective at showcasing proof-of-concept and accelerating future applications development by building support for more widespread types of RFID applications. It can also help companies to discover innovative and unexpected uses for this technology.

V. CONCLUSION

This paper provides an overview of RFID technology and tries to give readers some understanding of its potential applications and implications for business strategy. As with any new technology, it is extremely difficult to anticipate the full scope of these applications and implications until it is more widely used. Furthermore, whole sets of broader possible impacts, e.g., on privacy and security, are even less clear at present. It is hoped that by clarifying some of the early uses of RFID and documenting the road ahead for organizations as far as we can see, others will find it easier to think through how best to manage and exploit this technology’s potential, while avoiding some of its negative repercussions.

ACKNOWLEDGEMENT

The research reported in this article was supported through a grant from the Advanced Practices Council of SIM, International (www.simnet.org)

Editor's Note: This article was received on May 21, 2003 and was with the authors approximately two months for one revision. It was published on September 8, 2003

REFERENCES

EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers who have the ability to access the Web directly from their computer or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
2. the contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
3. the authors of the Web pages, not CAIS, are responsible for the accuracy of their content.
4. the authors of this article, not CAIS, are responsible for the accuracy of the URL and version information.

Agarwal, V. (2001) "Assessing the Benefits of Auto-ID Technology in the Consumer Industry", MIT Auto-ID Center White Paper WH-003, September 1, www.autoidcenter.org/publishedresearch (downloaded July 2003).

Albright, Brian (2002a) "This Ambitious RFID Roll Out Uses Portable Readers, *Frontline Solutions* (3) 9, September, p.55.

Albright, B. (2002b) "Will RFID be the Answer People Want it to Be?", *Frontline Solutions*, (3) 12, November, p. 8.

Alexander, K. et al. (2002), Focus on Retail: Applying Auto-ID to Improve Product Availability at the Retail Shelf, MIT Auto-ID Center White Paper BC-001, June 1, www.autoidcenter.org/publishedresearch (downloaded July 2003).

Anonymous (2001a) "Supermarket Chain Implements RFID in DC", *Frontline Solutions,* (2) 8, February, p. 46.

Anonymous (2001b) "ExxonMobil Expands Speedpass Systems to Exxon sites; Phillips Testing RFID Program" , *National Petroleum News*, (93) 10, September, p. 14.

Anonymous (2001c) "Windshield Maker Chooses RFID", *Material Handling Management* (56) 9, September, p. ADF12.

Anonymous (2001d) "Two RFID-Based Applications", *Fleet Owner*, (96) 12, December, p. 67.

Anonymous (2002a) "Making Waves: Deveron Milne – Information Systems Division, VTLS", *Library Journal*, March 15, p. 45.

Anonymous (2002b) "RFID Assists Toyota-South Africa, *Control Engineering*, (49) 3, March, p. 10.

Anonymous (2002c) "Florida Airport Gets First RFID system", *IIE Solutions*, (34) 7, July, p. 14.

Anonymous, (2002d) "Northwest International Trade Corridor & Smart Border Crossing Program Deploys TransCore System in Support of Homeland Security Initiatives" www.transcore.com/news, August 26, (downloaded November 28, 2002).

Anonymous (2002e) "Parking, Security and Access Control Parking Systems", www.transcore.com/markets/parking_security_access_control.htm (downloaded November 28, 2002).

Anonymous (2002f) “Electronic Vehicle Registration”, www.transcore.com/markets/electronic_vehichle_registration.htm (downloaded November 28, 2002).

Anonymous (2002g) “Woolworths on Course for Real RFID Success”, *Frontline Solutions (Pan-European edition)*, (11) 8, October, p. 28.

Anonymous (2002h) “CTL Meeting Summary” Auto-ID Technology: Transportation and Logistics Adoption Forum, October 28, www.autoidcenter.org/media/minutes_transportation.pdf (downloaded July 2003).

Bednarz, A. (2002) “Wireless Technology Reshapes Retailers”, *Network World* (19) 32, August, p. 23.

Brakeman, L. (2001) ”RFID Baggage Tracking Solution Helps Keep SFIA Secure”, *Frontline Solutions*, (2) 8, July, p. 15.

Brock, D. (2002) “Smart Medicine: The Application of Auto-ID Technology to Health Care”, MIT Auto-ID Center White Paper WH-010, February 1, www.autoidcenter.org/publishedresearch (downloaded July 2003).

Brock, D. et al. (2002) “The Physical Markup Language Core Components: Time And Place” MIT Auto-ID Center White Paper WH-005, June 1, www.autoidcenter.org/publishedresearch, (downloaded July 2003).

Hodges, S., et al. (2002) “Auto-ID Based Control Demonstration Phase 1: Pick and Place Packing with Conventional Control, MIT Auto-ID Center White Paper WH-0061, www.autoidcenter.org/publishedresearch, June 1, (downloaded July 2003).

Mayfield, K. (2002) “Radio IT Tags: Beyond Barcodes” www.wired.com, May 20 (downloaded September, 2003)

Langnau, L. (2001/2002) “Applications in RFID”, *Material Handling Management,* (56) 10, p. A48.

SIM Advanced Practices Council (2002) Verbal Communication., September.

Tierney, S. (2002) “UK Home Office Still Chipping Away at RFID Doubters”, *Frontline Solutions (Pan-European edition)*, (11) 8, October, p. 24.

Werb, J and P. Sereiko (2002) “More than Just Tracking”, *Frontline Solutions*, (3) 11, October, p. 42.

Wilson, J. R. (2001) “RFID Offers Inside Track for Baggage Security”, *Air Transport World*, (38) 10, October, p. A7.

ABOUT THE AUTHORS

Heather A. Smith is Senior Research Associate with Queen’s University School of Business, specializing in IT management. A former senior IT manager, she is a founder and co-facilitator (with James McKeen) of the IT Management Forum, the CIO Brief, and the KM Forum, which facilitate inter-organizational learning among senior executives, and co-author (with James McKeen) of *Management Challenges in IS: Successful Strategies and Appropriate Action* (1996). She is also a Research Associate with the Lac Carling Conference on E-Government, the Society for Information Management, and Chair of the IT Excellence Awards University Advisory Council. Her research is published in a variety of journals and books including *CAIS, JITM, Information and Management, Database, CIO Canada,* and the *CIO Governments Review.* Her book, *Making IT Happen: Critical Issues in IT Management* with James McKeen was published by Wiley in

January 2003 and she is co-author of a new book, Information *Technology and Organizational Transformation: Solving the Management Puzzle*. which will be published shortly by Butterworth-Heineman.

Benn R. Konsynski is the George S. Craft Distinguished Professor of Business Administration for Decision & Information Analysis at the Goiseta School of Business at Emory University. He is a Hewlett Fellow at the Carter Center. He came to Emory in 1993, following six years on the faculty of the Harvard Business School. Prior to HBS, he was a professor at the University of Arizona where he was a co-founder of the university's decision support laboratory. He holds a Ph.D. in Computer Science from Purdue University.

Professor Konsynski specializes in issues of information technology in relationships across organizations, including electronic data interchange (EDI), channel systems, electronic integration, information partnerships, and the electronic marketplace. He uses field work as a basis for analysis of best practice and theory development in areas related to the leverage of information technologies. His papers appear in *Communications of the ACM, Harvard Business Review, IEEE Transactions on Communications,* and *MIS Quarterly* among others.

Communications of the Association for Information Systems

ISSN: 1529-3181