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Examining RFID Applications in Supply Chain Management

Technology infrastructure, business process, and managerial issues must be addressed by IT practitioners as they adapt to the business changes associated with the diffusion of RFID technology in the supply chain.

Radio Frequency Identification (RFID) is an emerging technology recently in the news as a result of large organizations, most notably Wal-Mart and the U.S. Department of Defense, requiring shipment of goods identifiable by RFID tags. In Europe, the Metro Group, the fifth-largest retailer in the world, has teamed with SAP, Intel, and IBM to form the Future Store Initiative (www.future-store.org). This group is using a combination of different technologies in a test store to learn whether an integrated information system can lower cost by improving inventory management, consumer information gathering, and checkout procedures. As of March 2006,

Illustration by Peter Hoey

Wal-Mart reported establishing RFID programs with more than three times the 100 major suppliers initially targeted in 2005 [10]. Extensive RFID programs have also been established by the U.S. Department of Defense.

Operationally, RFID allows data from a tag attached to a pallet, case, or individual product to be captured by a reader device. Functionally, this data can be used to identify all of these items passing the reader's location at a point in time. This technology provides a means of tracking items from supplier through the distribution network to the point of consumption. Recent advances have lowered the cost of tags such that passive (not battery powered) tags are beginning to approach commercially viable levels.

The goal of RFID technology applied to the retail supply chain is to streamline inventory management by providing views of product shipments and inventory levels at unprecedented levels of detail [11]. By providing precise data on product location, product characteristics, and product inventory levels, RFID promises to eliminate manual inventory counting, warehouse mispicking, and order numbering mistakes. The ultimate goal is the reduction of inventory and increased product sales in the retail supply chain.

From an information systems perspective, RFID can be viewed as another technology for capturing source data. But the characteristics of RFID in the supply chain context—that it can be read unattended, in groupings of various sizes, through some materials and with a level of flexibility regarding orientation and positioning between tag and reader—creates the possibility that RFID use will become transformational. Rather than simply substituting for existing technologies such as bar codes within current processes, it holds the promise of process innovations that create orders of magnitude improvements in supply chain business models. Achieving such benefits will require integrating RFID technology into supply chain operations.

Currently, from a supply chain perspective, several major technical challenges exist for firms wishing to initiate RFID programs. These challenges revolve around the mechanics of reading RFID tags in the context of "shop floor" realities. Some of these challenges are due to difficulties with deflection and refraction from materials such as metal, glass, and liquids; difficulties with angles and reception; and difficulties attaining the levels of volume and speed required to support industrial supply chain information requirements. As these technical challenges find engineered solutions, organizations will have a new longer-range set of challenges to create significant economic value. These will revolve around justifying initial investment in the technology that would appear to involve tangible costs but less tangible benefits; developing the information systems solutions that would integrate data derived from RFID into business processes; and developing the "feedback-loops" such that new sources of information generate more efficient and effective business processes and decision making.

Here, we identify the range of issues IT practitioners are likely to confront in fully implementing RFID technology. These issues and ideas are discussed within a data life cycle framework to help organize the wide range of topics into related sets. Because this technology was relatively new and the authors knew of no examples of fully instantiated RFID-integrated information systems in supply chain management, the framework is presented as a helpful viewpoint rather than as a validated optimal approach.

The key issues organizations will face in deriving maximum benefit from RFID technology as it matures are previewed here. Most prior research found in the ACM digital library pertaining to RFID application development falls into two categories. Either it demonstrates the potential of futuristic applications such as the use of RFID in ubiquitous computing for outdoor educational experiences (see [12]) or focuses on issues of privacy and ethical use of RFID information, (see [1, 4]). Although both are important topics, they do not need to be discussed again here; instead, we focus specifically on RFID use in supply chain management.

RFID Background

RFID technology is derived from World War II-era techniques to allow aircraft to identify themselves to other friendly aircraft and commanders on the ground. Before the invention of the transistor and the evolution of microelectronics, the technology was large, heavy, and consumed massive amounts of power. In the 1970s, Sandia National Laboratories began incubating commercial applications and launching businesses. One of these was the Amtech Corporation, which commercialized animal tagging (still used today to identify pets), and the motor vehicle account tag used on some toll roads starting in the 1980s. At about the same time, industrial applications in manufacturing automation, ware-

Data Life Cycle Framework

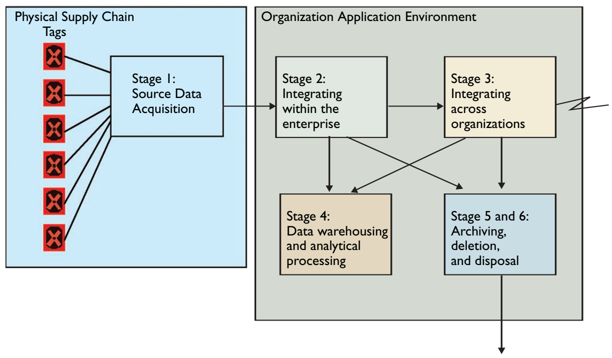

Figure 1. Data life cycle stages for RFID-generated data in supply chain management.

house automation, and asset tracking were deployed. In the 1992–1994 timeframe, the North American rail industry deployed the Amtech technology for tracking rail equipment, tagging over 30,000 locomotives and 1.2 million rail cars and deploying reader devices at key control points along the railroad right-of-way.

From 1998 through 2003, leadership of retail initiatives has been centered at MIT where in 1999 the AutoID center was established. In late 2003, the AutoID Center at MIT officially closed and transferred its intellectual property to EPC Global. (It is important to note that EPC Global standards relate only to the deployment of RFID into the retail supply chain.) The pressure is intense within enterprises facing a mandate to comply with the Electronic Product Code (EPC) Global standard, a joint venture of the Uniform Code Council and European Article Numbering (EAN) International, the body that administers the EAN standards worldwide. (See www.epcglobalinc.org for a comprehensive description of the EPC Global mission, strategy, and objectives.)

EPC Global standards are attracting significant attention because of the Wal-Mart mandate that its top suppliers begin adopting them. Also, several other large retailers have joined the initiative, and the U.S. Department of Defense has issued a policy directing its suppliers of similar product to comply as well. The standard is also important in establishing the potential for use of RFID information across organizations in a standardized format. Today as suppliers struggle to implement RFID solutions, they are just beginning to grapple with the issue of how to integrate new RFID with existing enterprise data [11]. Considering the investment in the mechanics of using RFID is significant and tangible, the leverage gained from that information being able to streamline not only internal business processes but to create efficiencies between business partners is also important in shaping the discussion of ultimate costs and benefits of diffusion of this technology.

RFID Data Through Its Life Cycle

In order to examine the challenges and opportunities for IT professionals in RFID implementation, it is useful to follow the data generated by reading an RFID tag and to consider the journey of that data as it travels through the data life cycle. Understanding the data life cycle is important to understanding the nature of data. (Note also that we present something of an ideal view of the journey of particular data from beginning to end of the life cycle while recognizing that at each identified stage technical and organizational issues must be resolved before such a journey can become routine and cost effective.) Redman proposed a data life cycle that includes two cycles: the data acquisition cycle and the data usage cycle [5]. Recently, there has been a renewed interest in the data life cycle as IT vendors are developing policy-driven automated storage architectures that are able to manage data from beginning to end [2]. For the purposes of this article, we view the data life cycle in a series of six stages:

Stage 4: Warehousing and analytical processing

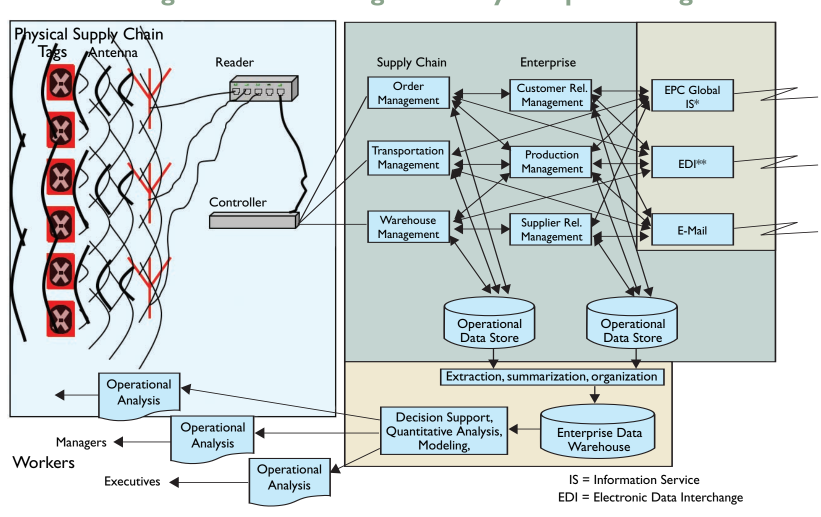

Figure 2. Typical applications and data within the supply chain data life cycle.

- Source data acquisition (reading RFID data and integrating with other source data);
- Integrating source data with enterprise transactions systems;
- Integrating data across organizations;
- Data warehousing and analytic processing;
- Data archiving (backup and replication); and
- Data deletion and disposal.

DATA LIFE CYCLE	Technology Infrastructure	Application Logic	Business Process	Management
1. Source data acquisition (reading data and integrating with other source data)	Performance, speed, and capacity Optimal processor, data storage, and network bandwidth elements Accuracy	Business logic – capturing the range of valid actions Missing data Unwanted data Information overload and filtering (too much wanted data) Generate metrics	Integration with physical processes/ logistics/industrial engineering Identifying elemental logical operations – definition of business events Timing so that reading occurs at correct point(s)	Responsibility for investigating exceptions/ recognizing new problems Responsibility for standard variations in process/organizational learning Metrics/evaluation (error rates, throughput)
2. Integrating within the enterprise (integration with enterprise systems and supply chain applications)	Performance, speed, and capacity Timing Reliability Optimal processor, data storage, and network bandwidth elements Middleware	Integration with business units' information Cross references between RFID information and other enterprise system keys Normalization and concentration of information by logical entity	Discovery of business logic exceptions Application design/ development Covering basic operations Imaginative new programs Potential performance implications of enterprise update on operational process	Availability of programmers for maintaining manufacturing system Responsibility for investigating exceptions/ recognizing new problems Responsibility for standard variations in process/ organizational learning Company specific architecture knowledge Metrics/evaluation

Table 1. Issues in implementing RFID applications: Data life cycle (stages 1 and 2) vs. system layers.

These stages are illustrated in the supply chain management context by Figures 1 and 2. Each conceptual stage presents challenges and opportunities for the use of information to enhance supply chain activities within and among organizations. Though this sequence is logical in terms of aggregation, it should not be taken as literally describing the sequence of actions in actual usage. For example, in some scenarios RFID data might be used along with interorganizational data concurrently in performance of a particular business task. Nevertheless, the stage framework provides a logical way of decomposing the potentially highly complex and recursive nature of using RFID data.

It is a reality of RFID deployment that, to be successful, it involves changes in organization, business processes, and application systems. Therefore, analysis of the data life cycle involves examination along these dimensions. Dividing application systems into infrastructure and logic, we present our analysis in subdivisions: technology infrastructure; application logic; business process; and management. Details regarding RFID at each stage on each dimension are presented in Tables 1 and 2.

Source Data Acquisition. An IT perspective on RFID begins with initial handling of the data generated by the RFID reader. All readers and controllers must be able to distribute data to the operational applications in distant locations. This implies that all devices capturing data must be connected either through wired or wireless networks. The key will be to ensure all physical elements of the system have sufficient capacity so that data is received, processed, and moved without bottlenecks that inhibit the organization's ability to maintain the speed of the business activity where the RFID is deployed.

Once elemental data (originating from RFID) has been received and validated, it is likely that additional information will be added including time, temperature, location, and similar indicators. This extension of data surrounding RFID messages is being called "sensor-based computing" by practitioners at Oracle [7]. For the item being identified, it is self-evident to human workers where the tag is being read, but for downstream use of this data, time and location information needs to be added.

Programming logic for the disposition of expected and unexpected RFID-generated data will need to occur at each stage in a supply chain both internally to an organization and among organizations. Accurate timing of such messages will also be critical. As a simple example, timing calculation must account for time zone changes so that items don't appear to arrive before they are sent. Further, the meaning of each tag reading may need to be clarified with additional information. For example, does a message indicate shipment of goods, receipt of goods, movement into or out of inventory, or temporary removal for inspection by a customer versus permanent removal for sale or disposal?

From an application logic perspective, much work needs to be done handling too much, too lit-

DATA LIFE CYCLE	Technology Infrastructure	Application Logic	Business Process	Management
3. Integrating across organizations (communication and coordination with EPC Global, EDI and/or email applications)	Performance, speed, and capacity Timing and Reliability Optimal processor, data storage, and network bandwidth elements Architecture and Security	HW and SW engineering Standard Web tools Transaction information standards Translation of firm specific information to commonly accessible languages	Imaginative new programs / value added services Potential performance implications of partner system response on operational process	Deciding what to share and what not to share (and with whom) Negotiation with partners Ethics, liability, public perceptions/ privacy Metrics/evaluation
4. Data warehousing and analytic processing	Massive amounts of data and potential capacity issue DSS, data mining, visualization, knowledge management tools	Aggregating the data Data cleansing	Add decision systems at multiple new levels Knowledge creation (Smart shelves, in-store customer behaviors, end-to-end supply chain analysis	Emphasis on knowledge management (creation, storage, transfer) Allow new layers of drilldown in operational events Metrics/evaluation
5. Archive (backup and replication)	Telecom -- middleware			Metrics/evaluation
6. Deletion and Disposal	Automated storage solutions	Policies for when data no longer needed	Processes for deleting and disposing of data	Legal issues Records management

Table 2. Issues in implementing RFID applications: Data life cycle (stages 3 through 5) vs. system layers.

tle, and unexpected data. For example, the tag will respond repeatedly to a reader's request for data as long as the two are in proximity. In many cases, only the ultimate arrival and departure of the item (change of state) will be useful to downstream applications.

To the extent that semantics of the data are accounted for, some strategies found to be useful in other high throughput, online tasks, such as the distribution of financial data, can be employed with RFID. Palmer identifies seven such strategies including process data close to its source, cluster various pieces of data into logical events, utilize data concentrators, cache contextual information, federate data locations for more efficient distribution of data among sites, continuously filter data events, and automate exception handling [3]. While it certainly doesn't pay to store redundant or non-useful data, the planning for these strategies, particularly filtering, must be undertaken carefully so that elements necessary for later analysis are not removed permanently.

From a management perspective, it will be important to build systems that are robust enough that such data will be collected and integrated even when pressured human operators are more concerned with "getting the job done" than ensuring accurate acquisition of information needed only at later stages in the business process. Capitalizing on imaginative supply chain applications may require extremely close to 100% accuracy in upstream operations and millisecond (or faster) time frames for downstream analysis of incoming orders.

Integration with Enterprise Systems. Organizations will face different sets of issues in integrating RFID with existing systems depending on the type of systems they already have. We anticipate four basic scenarios: organizations with relatively ad hoc business processes will generate flat files from RFID and sensor data and provide this data for manipulation by existing applications; organizations will build new relational databases, systems, and processes (manual and automated) to interact with existing enterprise systems; organizations will work with vendors to build capabilities into the enterprise systems such that they handle the data originating from the RFID sources; or organizations with custom legacy systems will take this opportunity to convert to enterprise systems and simultaneously address system integration and utilization of RFID capabilities. Each of these scenarios presents opportunities and risks. Similarly, the amount of investment in and optimization of bar code scanning technology will affect the distribution of costs and benefits from shifting to RFID. In the long run, however, as RFID becomes pervasive and is integrated with other sensor information, opportunities may arise to use this richer information to create innovative new business models.

Vendors such as SAP, Oracle, Sun, Peoplesoft, IBM, and Microsoft are currently deploying various middleware approaches toward the integration of RFID with their existing product offerings. For example, SAP is reported to have developed a middleware layer, named the Auto-ID Infrastructure, that routes data from readers to applications (including multiple communication and sensing devices such as RFID readers and printers, Bluetooth devices, embedded systems, and bar-code devices) and triggers appropriate events using a rules engine [6]. This approach is likely to emphasize reformatting incoming data for use with legacy systems of various types.

From a technology infrastructure perspective, accuracy and planning for contingencies will be critical. Downstream operations cannot be stopped without undue cost if data from upstream operations has been lost, misdirected, or become inaccurate. This also raises issues of capacity and assuring that storage, processing, and network capacities are sufficient for handling with the vast quantities of data generated by RFID and the processes with which they may interact.

A key issue in implementing such a system will be developing appropriate business rules, particularly for handling new exceptions that arise from having the increased amount of data generated from RFID use. It can be expected that in many cases explicit rules will need to be created for programming business activities where informal methods are currently in use.

From an application logic perspective, it will be critical to normalize data. This is significant for dealing with dependencies and assignment of attributes to proper entities and in the managerial sense of ensuring that terms are unambiguously and appropriately defined for business needs.

While it addresses ways to automate data input into current business processes, in the long run, it is likely that the presence of RFID will present opportunities to develop innovative business models and to reengineer existing supply chain processes. Examples can be found for many common supply chain activities. The ability to determine time and location of reading from unique items will provide opportunities to identify bottlenecks. When combined with value of shortened cycle time, this information can also potentially influence delivery priorities where resources are constrained. The ability to determine where a particular object is and has been can solve many supply chain problems including the ability to shorten the time to effect product recalls and removal of outdated products, programs to decrease product counterfeiting, decrease occurrences of out-of-stocks, and reduction of shrinkage, and diversion of products. The ability to locate inventory can shorten the time for finding a product as it moves between production floor, warehouse, and showroom floor. Use of RFID-generated information may allow the clustering of small packages from various sources heading toward the same destination early in the distribution channel or automate dynamic rerouting as information regarding travel conditions or package priorities change. One related challenge will be dealing with the dynamic aspects of systems change—designing the structure and content of RFID messages (integrated with other sensor data) while simultaneously reconsidering business processes and the IT supporting them.

From a management perspective, the key issue will be balancing innovation and the effort to achieve competitive advantage against the risks and costs associated with groundbreaking activities. The costs of handling the vast amount of data generated by RFID will be largely tangible and occur early in the data life cycle while the benefits will depend on the quality of data collection, will require added effort and investment, remain largely intangible, and be recovered later in the business cycle. Moreover, those firms aggressively committed to analysis and reorganization of business processes will have the risk that improvements will either not be found or be too difficult to implement.

Integrating Across Organizations. Much of the rationale for adopting the EPC Global architecture in the retail supply chain is to facilitate sharing of information among supply chain participants such as supplier, manufacturer, shipper, and customer in order to provide near-real-time inventory visibility. The value created by this process is reduced cost and improved competitiveness of the cooperating enterprises. Cost reductions will result from reducing the amount of inventory and increasing logistics efficiency in the supply chain. These include the cost of carrying the asset, direct network costs such as warehousing and transportation, and obsolescence. Better visibility will also reduce the incidence of expensive interventions to avoid undesirable shortages. Improved competitiveness will result from higher customer satisfaction and market responsiveness, and from the ability to differentiate commodity products with creative logistics and marketing programs.

The EPC Global architecture originated at the Auto-ID center at MIT. Key principles underlying this architecture included minimizing functionality on the chip (and thereby lowering the cost); a product identification scheme that involved the enterprise, the product, and the item; using the Internet to store and share information about the item; and open standards. The core component of this architecture is the product identifier, now called the Electronic Product Code (EPC). The EPC is a set of format standards for encoding product identification data on the tag. In the original concept, the EPC had four components, header, EPC manager (the enterprise,) object class (the product,) and serial number (the item). The original standard is being replaced by a more complex structure to ease the transition from existing standards. The other components of the architecture include:

- Information Service (IS). A repository of the enterprise's product information, indexed by EPC and accessible via the Internet;
- Object Name Service (ONS). A global registry of EPC information; and
- Product Markup Language (PML). A markup language specific to EPC data storage and retrieval.

Plans for an ONS that mirrors Internet domain name addressing present a nearly overwhelming set of opportunities and challenges. For example, infrastructural challenges of integrating across organizations will include creating and supporting applications that enable other enterprises to access their information systems. This will likely require the development of additional security capabilities.

The IS can be viewed essentially as a new application. It must be designed and implemented either by the participating enterprise or by a third-party service. In addition to the core function of the IS, application logic will be required to support a multidimensional security model, and to maintain ONS registration. Full compliance with the EPC Global architecture will also include PML support, and this may impact the logic of existing internal applications.

Business process impacts include the coordination of PML dialects with trading partners and the administration of the multidimensional security model mentioned previously. Two decades of experience with EDI have demonstrated that even with a relatively rigid format standard for interenterprise message management, trading partners must coordinate their individual implementation of those standards. The use of PML will create similar requirements such as developing understandings with partners regarding the definition of exchanged information, the timing of messages, and the investigation and resolution of apparent exceptions resulting from operational mistakes, data entry errors, and true business misunderstandings. Since the EPC Global architecture provides for the access of one enterprise's data by another enterprise, each party will need a process to administer the security of its information. At a minimum, the identification, authentication, and authority of each participant in the relationship must be specified with respect to what functionality may be used and what data may be accessed.

Finally, the management impacts of EPC Global compliance will include the need to set policy with respect to the trading partner relationships and negotiating with trading partner management. There will also be a need to manage cultural expectations at all levels as trading communities move from a world of point-to-point relationships to massive collaboration. The current initiatives of Wal-Mart and others constitute a limited step toward the full EPC Global vision. There are no current plans to tag and identify individual inventory items, only transportation units (pallets, cartons, cases, and other packaging). Until inventory is identified at the item level, the benefits of and requirements for the IS, ONS and PML are limited.

Data Warehousing/Analytical Processing. To this point, expected benefits from the addition of RFID-generated data have been discussed in terms of efficiencies in supply chain operations and new applications that could provide new services or provide additional efficiencies. However, the separation of physical products and information about them may have its most dramatic influence in supporting decision making and other managerial activities. The RFID data warehouse must maintain a significant amount of data for decision making. Historical and current data is required from supply chain partners and from various functional areas within the firm in order to support decision making in regard to planning, sourcing, production, and product delivery. Supply chains are dynamic in nature. In a supply chain environment it may be desirable to learn from an archived history of temporal data that often contains some information that is less than optimal. In particular, these environments are typically characterized by variable changes in product demand, supply levels, product attributes, machine characteristics, and production plans.

Though there is cost associated with storing this data, there is potential value as a raw material for knowledge creation, decision support, and data mining. The nature of this data is threefold: items can be identified at finer levels of individuality; there are many more business events for an item (events can be disaggregated into parts); and being serialized, individual steps in a sequence have an identity. This opens whole new fields for analysis. Not just 20 items leaving a warehouse and 10 arriving at another location, but which items arrived, by what route, and how long they were stored.

From a technology infrastructure perspective, issues will involve selecting and implementing the right set of decision support systems and knowledge support tools as well as organizing the data to maximize the trade-off between capturing all possible data and retaining a size that is manageable for ad hoc as well as programmed queries. Application logic will be important in assuring the cleansing and structuring of data as it enters the data warehouse and in the design of standard management reporting processes. Although the motivation for using RFID in large part revolves around streamlining operations, Shapiro estimates that 80% of the data in a transactional database that supports supply chain management is irrelevant to decision making, and that data aggregations and other analyses are needed to transform the other 20% into useful information [8]. The value of the data warehouse and the collection of RFID process will primarily be in the discovery of new relationships and opportunities for process redesign. Specifically within the supply chain context, this information can aid in logistics network design, supply chain planning, and vehicle routing and scheduling [9]. It can potentially also provide new business insights. IT managers will need to consider trade-offs in developing standalone RFID-oriented data warehouses versus integrating RFID-oriented data with other organizational information from marketing, finance, and accounting areas. From a management perspective, RFID information provides the potential to move companies toward the integration of marketing and operations and financial information. The dissolution of barriers in these areas will have significant implications for the way organizational structures are drawn, the range and type of skills needed by managers, and the approach toward business problems and service of customers that organizations can take.

Archive (Backup and Replication). Archiving data is a fairly well understood process throughout organizations. By their very nature, RFID applications will be generating large amounts of data. For some organizations, RFID data will shift their data archiving function to another level of complexity as it handles the significantly increased volume. IT managers will seek to shrink storage requirements through strategic use of summarization. Strategic logical and physical data organization will be needed to balance complete data storage with efficient retrieval. Will data be more effectively stored based on real-world entities, based on time and sequence, or some other categorization method? This is likely to be a company, perhaps even application-specific decision. Otherwise, we would not expect much difference in issues of archiving from other transaction systems that are critical for business operations, received in high volume, and of high short- and long-term value.

Deletion and Disposal. The automated deletion and disposal of data records could be a significant issue in an RFID-saturated IT environment. Because of the volume of data, it will almost certainly be necessary to use automated storage technologies based, in all likelihood, on rules ranging from simple time-oriented to complex subject- or source-oriented differentiations. These rules will be critical for maximizing the value of historic data and meeting legal obligations without incurring disadvantageous data storage costs. Organizations will need to perform risk assessment to consider issues such as: How likely is it that we will need this data again? What are the consequences of not having this data? What is the cost of keeping the data? And does the data have potential future research value of a currently unknown type?

Conclusion

We have used a data life-cycle framework to discover and illuminate key issues that will face IT practitioners as they approach business changes resulting from the diffusion of RFID technology. We have considered these issues along the dimensions of technology infrastructure, application logic, business process, and managerial concerns. In conducting this analysis, we also noted some issues that persist across the life cycle, particularly in the case of scalability and performance. However, it is important to note that at each stage in the data life cycle, managers will need metrics related to both business and technical performance. These metrics will vary with the stage but in all cases should relate to the overall value created from the use of RFID technology as well as the efficient operation of information services at each stage. Additionally, security issues abound. Though they are probably similar to other e-commerce security issues, the sheer scale may present new issues that must be addressed at a system level. From the perspective of an organizational level, part of the business process management will be deciding on and implementing various levels of access for different stakeholders under dynamically changing circumstances. Ethical issues also are present as the potential for adding customer information and profiling becomes attached to the creation and distribution of products. These may be similar to the potential for privacy violation with the creation and distribution of intangible goods such as financial products (stocks, bank deposits, credit card records) and entertainment products (music and movies).

Although there is no guarantee that RFID technology will spread in usage throughout the economy, the potential benefits from continuing to replace manual labor associated with the distribution and storage of physical goods suggests a strong future for this technology. The immediate impact of RFID technology will probably be experienced primarily in the warehouses, loading docks, and transportation assets, and in the long run full utilization of RFID technology will require significant business process redesign and associated development of new and retooled IT. Clearly, RFID holds the promise of significantly affecting the handling of physical products throughout the supply chain. However, issues of security and privacy must be adequately addressed to balance market effectiveness with fair practices for that promise to be realized.

Although we did not approach this topic from the perspective of the issues that confront the particular IT leader in undertaking an end-to-end RFID project, we recognize that such a perspective would highlight additional issues and difficulties that IT leaders would need to master for successful implementation. For example, at each stage IT leaders will confront make/buy trade-offs considering differences in cost, timing, functionality, long-term support, and project risk in selecting packages versus building new applications. We would anticipate that some organizations will likely move slowly applying RFID technology only as required by larger business partners or not adopting the technology at all. Others, however, are likely to move aggressively adding RFID capabilities in their operations and develop new applications based on the opportunities presented.

We also did not directly address the topic of what discipline within an organization would be most effective at having responsibility for the introduction of RFID and related capabilities. An informal poll of local supply chain managers suggested a partnership of supply chain and IT specialists as a promising model. It isn't clear if organizations will be better served by housing responsibility for RFID technology in supply chain or IT departments (with consultation and inclusion of members from both areas) or if setting up a new organizational component with members drawn from each area would be more effective. This may depend on the size of the organization and the scope of its commitment to utilization of RFID information. It can be anticipated that in reality organizations implementing RFID will utilize a variety of governance structures and future research would be needed to determine under what circumstances each is most effective.

It is our hope that having identified and cataloged some of the expected IT challenges and opportunities associated with the diffusion of RFID technology, IT managers will be able to anticipate issues and measure the risks associated with its implementation more knowledgeably. C

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