Fall 11-28-2006

Three Phases RFID Adoption: A Road Map to Success

Waiman Cheung

Sung-Chi Chu

Timon C. Du

Three Phases RFID Adoption: A Road Map to Success

Waiman Cheung[1], Sung-Chi Chu[2], and Timon C. Du[3],
[1]*Professor, Department of Decision Sciences and Managerial Economics*
The Chinese University of Hong Kong, Hong Kong, wcheung@baf.msmail.cuhk.edu.hk
[2] *Adjunct Associate Professor, Department of Decision Sciences and Managerial Economics, The Chinese University of Hong Kong, Hong Kong, scchu@baf.cuhk.edu.hk*
[3] *Professor, Department of Decision Sciences and Managerial Economics, The Chinese University of Hong Kong, Hong Kong, timon@cuhk.edu.hk*

Abstract —Radio frequency identification (RFID) uses radio frequency technology for automated identification. The use of RFID brings the second source of information to enterprise management. It is said the second source is because, in the conventional approach, the information is shared among the various units through an integrated enterprise system. In this study, we define three layers of networks, i.e. Intranet, Extranet, and Internet, can be used to share RFID data and the adoption of RFID technology can be recognized into three phases: standalone adoption, supply chain adoption, and global adoption. Issues in each adoption will be address as well as road map to the success will be included.

Keywords —RFID, Supply Chain, Technology Adoption

I. INTRODUCTION

Radio frequency identification (RFID) using radio frequency technology for automated identification has been acknowledgement in many uses such as inventory control and asset tracking to replace the use of traditional barcode technology [9] [11]. The technology allows multiple objects to be identified without line of sights by embedding with a product for a unique identity to be imprinted. Further, transient information can be updated or changed during the transition throughout production systems, warehouses, airliners, trucks, distribution centers, retailers, and finally to the end customers [9] [12] [5] [2].

In fact, the impact of this technology goes far beyond the benefits gained by individual parties when it integrates with supply chain partners. With adoption of global identification standards such as the Electronic Product Code (EPC), an identification scheme for the universal identification of physical objects, the applicability of this technology can be fell from the supply chain, to the logistics chain, the distribution network and finally to the end-user [3] [6] [1]. Services such as warranty or maintenance can be verified and carried out in a timely manner. After-sales services can also be monitored, providing effective customer relationship management; other possibilities are location-based commerce, product tie-in promotion, or cross-sales with minimum efforts. The EPC Network, hosted by EPCglobal, was originally developed by the Auto-ID Center (now called Auto-ID Labs) to manage the EPC. Note that EPC is a encoding scheme in which an identification scheme for universally identifying physical objects is defined. On the other hand, EPC Network includes the physical layer capturing the location and other information, and information layer to provide name service, such as object name service (ONS) and EPC Discovery Service (EPCDS) [10].

The use of RFID brings the second source of information to enterprise management. It is said the second source is because, in the conventional approach, the information is shared among the various departments through an integrated enterprise system or is shared among the partners to enhance the performance of the whole supply chain. However, very often, the information is not synchronized with the physical flow until track and trace function is activated. A familiar scenario is that a production line is eager but cannot use some parts on dock since the arrival of the parts has not been input into the enterprise system yet. With RFID, the logistic information of the arrival parts can actively pull the information from the system. In this case, two sources of information are synchronized at all time.

In this study, RFID related data can be shared via three different layers of network: Intranet, Extranet, and Internet. The data kept in Intranet is mainly shared among departments of a company while in Extranet is for collaboration over supply chain partners. In contrast, the data kept in Internet are designed to be shared with publics. The adoption of RFID technology can be recognized into three phases: standalone adoption, community adoption, and global adoption. However, the greatest concern remains on both privacy and security issue and global standard issues [4] [7] [8]. The later sections will introduce the advantages of three phase's adoption.

II. STANDALONE ADOPTION

The standalone adoption is implemented in a company without involving external parties. The adoption of RFID can improve internal operations such as synchronized manufacturing, real-time inventory management, and valued-added logistics. The advantages are obtained mainly because the information flow is synchronized with and is activated by logistic flow. That is, the logistic flow will (1) precede track and trace when the goods reach to particular workflow nodes, (2) synchronize with the information in database, and (3) extract additional information from previous workflow nodes or networks. Note that in conventional approach, without using RFID, both information and materials flow across departmental units following predefined workflow separately and independently. These two flows are synchronized only when track and trace function is activated.

We can use inventory check as an example to illustrate the advantages because the use of RFID in house. In conventional way, a manager classifies ABC types of inventory items and monitors A type items closely and frequently. The full scale of inventory check cannot be executed too often since it demands time and resources and interrupt operations. The execution normally takes hours or even days depending on the scale of the check. In fact, the inventory report is obsolete when the check is completed if it takes too longer time. However, this is not the case when RFID is adopted. With the use of RFID, both sources of information can be synchronized, i.e. "what you see is what you get". This provides real-time traceability, responsiveness, flexibility, reliability, and accuracy. In summary, the use of RFID in a standalone adoption can:

(1) Automate identification and data capture. RFID can provide the states of materials in real-time. The RFID-enabled operations can update the states of materials to database actively to expedite internal operations. For example, in the manufacturing process, what stage of process and current owner of the materials, expecting completing time as well as other useful information such as size, weight, and shipping and handling requirement can be obtained in real-time. The automatic data capture and identification can help both a company to acquire the most updated information and the states of orders effectively. Moreover, the adoption can prevent undisciplined human interference, such as the delay of data updates or incorrect barcode reading.

(2) Reduce latency gaps between material flow and information flow. To measure the performance of operation management, the responsiveness indicates how soon the system can respond to a user's request, such as inventory check. The punctual and efficient reading of RFID-enabled operation can respond can provide better operational flexibility that is possible to adjust inventory levels, regulate capacity, use alternative sources of supply, vary the lead time to the customer, and introduce new products.

(3) Enhance reliability and accuracy. The real-time and punctual data can help to improve reliability and accuracy in many aspects. For example, in manufacturing execution system (MES), production of product or change of order policies can be revised according to just-in-time information. Or, the forecasting, customer order promising, purchasing, costing, shipping, and the shop floor functions of advanced planning and scheduling (APS) can be tightly integrated. This integration realizes accurate supply chain execution in which several plants and warehouses are incorporated. Moreover, the real-time and responsive data can also help to determine which plant should make which products to maximize customer service and profitability accurately.

III. SUPPLY CHAIN ADOPTION

In the collaborative resource planning that supports on-demand business involves functions of financial and support integration, customer integration, executive decision integration, engineering integration, and manufacturing integration. The collaboration is achieved through the integrated logistic flow and information flow. When a product is shifted from one company to another using integrated logistic flow, the embedded RFID data can synchronize the corresponding information flow between companies. The information thus can be used to enhance different degree of resource planning. For example, the information can be applied to manufacturing integration for advanced planning and scheduling, supplier integration, and quality management systems, or to product integration for product design management and project management. Mainly, three advantages can be derived.

(1) Synchronize sharing of exact information. The conventional supply chain promotes the pull-type supply chain which builds up partnership to maximize the total value of the supply chain. It is important that the information on sales, operating, and financial data can be shared in real-time to enhance high degree of trust among partners. The RFID-enabled supply chain equips the supply chain with the information sharing via corporate database as well as RFID. The second source of information carried by RFID can only be acknowledged when the materials are physically arrived. Upon arrival, the data carried via RFID can activate the data kept in the company Intranet and supply chain Extranet. Ideally, the data in Intranet is used for internal use while the data stored in Extranet are shared among partners with appropriate access control, and the useful and related data stored in Extranet are activated and extracted from the information provider upon request, which can be either up stream or down stream partners.

(2) Polarize physical and information flow of partners. In the conventional enterprise system, the unmatched material flow and information flow is particularly a problematic issue when both information and materials are moved across supply chain partners separately. Fortunately,

RFID can help logistics information system to acquire real-time data of logistics and distribution, field service, warehouse, shipping, and transportation from partners. In this way, many activities can be synchronized and thus many benefits, such as competent make-to-order or engineering-to-order manufacturing, efficient vendor management inventory, and better demand management for customers, can be derived.

(3) Standardize on-demand services. When both information flow and materials flow are standardized over the supply chain partners, many serviceable events can be provided because of easily reconciling orders, generating shipping reports, providing pallet verification and inventory status, enhancing service and sales, and integrating account payables and receivables. This can achieve full sales support, forecasting integration, order integration, quoting and promising deliveries, and strategies planning.

IV. GLOBAL ADOPTION

As supply chain adoptions across industries, the focus shifts, i.e., from supply chain integration to the integration of supply chains, or business chains in general. Other new opportunities that are not feasible will no doubt come into play in this global adoption phase. In this phase, as physical flows trigger data capturing from each business chain, product movement will be filtered into a repository in the Internet. As is now proposed by ECPglobal, such a neutral service-oriented (Web-based) information agent, the EPC Network, will act as a repository, directory and broker of EPC-RFID-based data and information. The EPC Network collects all RFID on-tag information from individual EPCIS's, tracking all physical movements of products in business chains, and product consumption around the globe. This information, when combined with product-specific, corporate-specific, chain-specific and market-specific data and information, could provide a powerful much-needed knowledge base that has evaded management decision-makers before.

There are domain-specific information agents currently online and under development that are vital to enrich the knowledge mineable from the product-based EPC Network and vice versa. For example, a logistics service platform (such as DTTN in Hong Kong) can provide additional service that facilitates the sharing of information on the top of logistics services. As e-Business moves into global adoption phase, we will find the following advantages in the RFID Internet:

(1) Targetable global information sharing. Information sharing in a global scale with hooks (EPC) to allow the mapping of any specific business process in terms of

a. time – bottleneck, and loose ends?
b. demands – continuous, real versus expected?
c. supply – scalable supply chains?

This definable sharing of any targets will be a welcoming information source for businesses to further reduce uncertainties (if and when the product arrives, consumes and returns in a different time zone) in global trade.

(2) Scalable Business Chain Network. The physical flow and information flow of business chains can now provide a clear and present view of existing business chain networks. At the same time, other competitive players, in a global sense, can now be comparative, complementary, and substitutive with respect to existing networks. Business chain network can now be scalable and no doubt flexible.

(3) Weaveable knowledge and services. Knowledge generation is no longer pre-set and based on static and/or past information. Knowledge can now be multi-dimensional with common glue (i.e., EPC or its derivatives). That is, EPC-RFID-based information can now be mined at different levels of details and at different aspects. Thus, knowledge can be weaved from different dimensions accordingly and glued into an information mesh. This mesh of multi-dimension provides comprehensive business intelligence to enterprises, or to third-party information agents that brokerage on-demand targeted services to individuals.

V. A ROAD MAP TO THE SUCCESS

The current proposed EPCglobal network addresses the issues of data exchange standards, infrastructure standards, and physical object exchange standards. For data exchange services, issues such as tag data schema, ONS service and directory service will be defined while data capture and filtering are managed in infrastructure standards and physical object exchange standards will resolve reader and tag management issues. However, the framework focuses on the approach suitable for standalone adoption and global adoption rather than supply chain adoption since it does not considered the needs of specific industries and partner access control. More important, the framework is a top-down approach that forces the adaptors to be bound by this standard in the first place. It is also noticed that ONS, similar to the domain name service on the Internet, introduced by the Software Action Group of EPCglobal is hosted by VeriSign (www.verisign.com) since January 2004. The inquiry is designed to send to the Root ONS to locate the data owners, and then re-directed to the local ONS of the data owner. This approach involves an issue is that unlike the neutrality in operating Internet IP service, the RFID ONS service involves content service. It is a kind of sensitive to a company that its corporate information is maintained by a service provider. In contrast, the three phase's adoption approach presented in this study argues that only minimum information to be maintained in each layer of RFID Network, i.e. intranet, extranet, and Internet. That means, only minimum data are kept in extranet database to expedite the company collaboration and in Internet database for providing various web services.

We can expect the standalone adoption become more popular in 1 to 3 years. In this phase, the factory layout, workflow process, and some technical issues (readers, materials, software, etc.) of a company need to be resolved. For example, the layout should be designed to capture the tag information and streamline the operations smoothly. The workflow needs to consider the real-time information sharing among different departments. It is important to note that the workflow will be changed dramatically since the physical flow will drive information flow upon adopting RFID. Furthermore, the RFID tag standard, format, readers, hardware, materials, and access privilege are all important issues needed to be resolved. However, adopting the proprietary hardware and standards eventually will hinder the adoption in the next phase. From IT perspective, both enterprise resource planning (ERP) and manufacturing execution system (MES) are benefited from the responsive and accurate of data. An intranet should be built to share information and interfaces to both users and machines. Therefore, both event management and query optimization for the information sharing are managed. Although cost remains the major concern in standalone adoption, the company that wishes to adopt RFID individually should aware that innovative business models can be implemented after streaming internal operations.

The supply chain adoption will happen in 3 to 5 years. The adoption will start from those companies producing high value and short life cycle products. A RFID Network to share information associated to RFID among partners for track and trace and information sharing will be built. The extranet can be limited to close partners at the beginning of adoption, such as suppliers or buyers, and can be extended to all parties in the industries. The access control for sharing data among partners is an important issue in this phase. However, to successfully build the community, having the determination from a strong initiator, such as Wal-Mart, or an organization, such as Rosetta Net, is crucial. The cost can be justified by the benefits gained from participating the RFID Network easily. However, how to set up a well accepted standard is a difficult issue to be resolve, especially when some well established partners have operated by their proprietary standards.

The RFID-enabled supply chain is a pull-type supply chain which involves two sources of pulling forces: information and materials. Therefore, two platforms need to be built and integrated: a platform connected community partners for information sharing and the other is RFID Network that mainly serves as providing regional object name services (ONS). It has to be pointed out that ONS should accomplish not only the name services associated to RFID tags but also fundamental information retrieved via the object names. In this case, a web-base integrated information platform is needed while services such as query processing and help desk services are provided. The query processing is operated as an even-driven management system where the event can be triggered by either machine or human query. Similarly, the help desk service can respond to requests and resolve conflictions. Moreover, to successfully adopting RFID in the supply chain, on-tag data management is important. This is because the RFID tag itself is both physical and information venerable and therefore a tag should not keep highly sensitive information. A proper design of access control to protect both privacy and security of participants is crucial.

The global adoption in phase 3 adoption expects to be completed in 5 to 10 years. There are issues that stemmed from this wealth of information in an open network. Two most pressing issues, if unresolved at the outset, could be the barrier of entering into RFID global adoption.

(1) Privacy and security issues. If privacy is not properly defined and enforceable online, then information sharing in a global scale would lack the important trust factor, and on-demand services would not be possible.

(2) Global standards issues. Data and its format must be properly specified to remove inconsistent decoding and incorrect interpretation, while information item must be properly label to avoid fictitious knowledge generation. These are just two undesirable characteristics in the RFID Network if standards are not developed and sanctioned by the global community.

VI. CONCLUSIONS AND DISCUSSIONS

The adoption involves the participation of four pillars, i.e. peoples, public policy and standards, organizations, and web services. Peoples include buyers, sellers, end consumers, intermediaries, and other service providers. The peoples need to be willing to accept the benefits brought up by the new technology with the price of compromising some degree of privacy invasion. No double, the adoption of RFID brings up the privacy issue that was raised whenever a new technology is introduced. However, it should be notices that the adoption of RFID will not sacrifice more privacy than the use of Internet and mobile phone where the users' behaviors and locations are traceable at all time. Public policy is crucial to the success because the real-time location information should not be abused to become the intruder to human's life, such as receiving spam mail. This relies on the effort of setting considerable and sound public policy. Organizations include supply chain entities, associations, government who are the key entities to move forward the use of RFID technology. Having good reference cases are always good way to promote the acceptance. For example, Hong Kong airport adopts RFID to streamline the baggage handling, Singapore uses it in public libraries, and Japan applied to construction industry. These reference cases are encouraging and are benefited to the followers. Finally, the intelligent web services allow the information to locate and share among users efficiently. This relies on having good IT infrastructures and technical standards.

References:

[1] D. Engels, The Use of the Electronic Product Code, February 1, 2003, Auto-ID Center.

[2] A. Fano, and A. Gershman, The Future of Business Services in the Age of Ubiquitous Computing, *Communications of the ACM*, December 2002, **45(12)**, 83-87

[3] P. Helo, and B. Szekely, Logistics information systems: An analysis of software solutions for supply chain co-ordination, *Industrial Management & Data Systems*, January 2005, **105(1)**, 5-18.

[4] P. Jones, Clarke-Hill, Colin, Comfort, Daphne, Hillier, David, and Shears, Peter, Radio frequency identification in retailing and privacy and public policy issues, *Management Research News*, August 2004, **27(8-9)**, 46-56.

[5] M. Karkkainen, Increasing Efficiency in the Supply Chain for Short Shelf Life Goods Using RFID Tagging, *International Journal of Retail & Distribution Management*, 2003, **31(10)**, 529-536.

[6] W. Kohn, V. Brayman, and J. Littleton, Repair-control of enterprise systems using RFID sensory data, *IIE Transactions*, April 2005, **37(4)**, 281-290.

[7] M. McGinity, RFID: Is This Game of Tag Fair Play?, *Communications of the ACM*, January 2004, **47 (1)**, 15-18.

[8] G. Pottie, Privacy in the Global E-Village, *Communications of the ACM*, February 2004, **47 (2),** 21-23.

[9] A. Smith, Exploring radio frequency identification technology and its impact on business systems, *Information Management & Computer Security*, January 2005, 13(1), 16-28.

[10] Uo, Yojiro, Suzuki, S., Nakamura, O. and Murai, J., Name service on the EPC network, *Auto-ID Labs Workshop*, 2004.

[11] Want, Roy, Enabling Ubiquitous Sensing with RFID, *IEEE Computer*, April 2004, 84-86.

[12] Wyld, David, Jones, Michael, and Totten, Jeffrey, Where is my suitcase? RFID and airline customer service, *Marketing Intelligence & Planning*, April 2005, **23(4)**, 382-394