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Quality Decision Making, Input Technologies, and IT Education

by Farhad Moeeni, Arkansas State University

You have perhaps experienced scanning your own grocery items, or bagging and paying without needing a store clerk. A number of grocery store chains have installed self-serve checkout technologies and some people like me are frequent users. It took about 30 years to transform the point-of-sale operations from manual keying of item's price by the cashier to where the customer could automatically scan the bar code and pay simply by sliding a card through a card reader. Implementing the automated data entry technologies will continue to spread globally and it appears that the retail will lead the effort ahead of other sectors such as manufacturing, and healthcare.

Developments in Input Technologies

Input technologies are a class of information technology (IT) that is commonly referred to as automated identification and data capture (AIDC). The AIDC family includes bar code, radio frequency identification (RFID), real-time locating systems (RTLS), card technologies (magnetic and smart), voice data entry, biometric identification, and several others (Exhibit 1). Accuracy and efficiency are the primary motive for implementing these technologies, but ergonomics and security also play a role. According to practitioners, a good typist on the average makes one error per 300 characters typed. Bar code scanning, on the other hand, may produce one error per three million labels scanned—10,000 times quality improvement. This is a simple example as why more industries are adopting automated input technologies. Some of the technologies with business applications are briefly explained in Exhibit 1.

Business Applications of AIDC

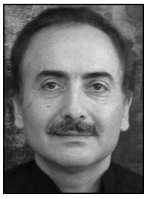
Generally speaking, bar code and RFID are predominantly used for monitoring and processing items. On the other hand, biometric and card technologies are used for processing people. RTLS has been used for monitoring items, and in certain applications to monitor people. A summary of the business applications of these technologies are presented in Table 1.

Two members of the family, that is, bar code and RFID, will continue to dominate supply chain applications. One should note that bar code is currently the most robust and effective input technology for most applications. A number of important developments have stimulated the market for both technologies.

Bar Code

With respect to bar code, a standard referred to as the Global Trade Item Number (GTIN) will consolidate the U.S. and European standards into one globally unique identification system for the consumer-level products of the same type. In other words, products of the same type carrying GTIN label would be uniquely identified in the world. This is the extension of the famous U.P.C. code and facilitates streamlining the global supply chain transactions. Companies need to also upgrade their database design by 2005 in order to become GTIN compatible.

In another ongoing development, the healthcare industry is being pressured by internal as well as external forces such as the U.S. Food and Drug Administration (FDA) to implement bar code at the unit-of-use packs or unit-dose packages. This allows a system for bar code scanning of every dose to check for right physician, right nurse, right medication, right patient, right dose, and right time at the point-of-care, whether it is the patient's bed in a hospital or at a pharmacy. This effort is expected to eliminate many of the needless 44,000 to 98,000 annual deaths and a large



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number of unaccounted injuries that occur because of medical errors.

Recent technological improvement includes the development of symbologies with higher density. The effort includes the development of 2-D symbologies (such as PDF 417, Data Matrix) with large storage capacity and Reduced Space Symbology (RSS) that can encode data in a smaller area using a linear bar code scheme. Some applications consider the composition of linear and 2-D symbologies into one symbol. Lack of real estate for affixing the label on small products such as electronic components or pharmaceutical products are driving these efforts.

RFID

A number of developments are making the applications of RFID more attractive. One relates to the continual decline in the the main ingredient of tags—cost of integrated circuits, which is a major cost component in any supply chain implementation. The other corresponds to the development of new protocols and standards that allows interoperability of hardware and software.

The most interesting and promising event in this area is the recent development of the Electronic Product Code (EPC) network by Massachusetts Institute of Technology (MIT) and several leading retailers and manufacturers. The EPC network concept has inspired the current surge for implementing RFID. A number of large retailers, government agencies, and suppliers are in the process of implementing RFID and the EPC standards within their supply network.

The EPC network specifies low-powered wireless networks based on RFID technologies for linking objects and things, similar to an ordinary network that links computers. The data acquired through tags and readers will be transmitted from one place to another through the local-area and wide-area networks and the Internet. Ultimately, the EPC network allows an item be identified uniquely in the world. In other words, in the full-blown version of the standard, a 96-bit identification format will be used that allows every identical bottle of shampoo be numbered uniquely. This will allow an item to be traced globally in real time and virtually be visible to business applications unless its tag is destroyed or

Bar Code. Bar code systems encompass a number of components. Symbologies that encode data using visual arrangement of lines or dots, printing devices to publish encoded data onto a substrate such as paper or metal, scanning technologies to capture the visual image, decode, validate, digitize, and transmit them to a host computer or a mobile device. There are more than 200 symbologies (e.g., the famous U.P.C.) of which only a handful are in common use. Most of these symbolgies are linear, that is, encode data in bars and spaces, and have limited data capacity per unit area. A new class of symbolgies referred to as two-dimensional code is emerging in many applications and offer substantially higher data density per unit of area they occupy. These symbologies are either using dots instead of bars or using multiple rows of short bars to encode data. The scanning device uses either the visible light or infrared frequencies in the EM spectrum.

RFID. RFID is an old technology (radio) but with new interesting applications. Like bar code, RFID technology is used for identifying items. RFID has two major components: tags or transponders with memory chip that stores data, and a read-write device that interrogates the tags in order to read the data off the tag and/or to write back new data on the tag. RFID tags are implanted or attached to things for proper identification. Both the tag and reader have antenna and the communication between them occurs through radio signals. Therefore, line of sight, which is a major requirement for bar code scanning, is not necessary.

RTLS. Real-time locating systems are based on the RFID technology. The system uses active (battery powered) tags or transponders to boost the communication range. Transponders are attached to high-value inventory items for monitoring. Several antennas are also installed in strategic positions in the warehouse to receive signals from the tags. The system monitors the position of items in real time and continually updates the database with current tag locations. RTLS shares the same principle used by GPS but GPS is typically used for outdoor tracking of vehicles. RTLS is more cost effective and more accurate for monitoring thousands of small items in an enclosed area. In addition, Navstar satellites signal may not easily penetrate the construction materials of many warehouses.

Biometric. Biometric refers to a class of technologies for identifying people based on physiological and behavioral characteristics. Various systems are designed to digitally encode features such as finger print, hand geometry, voice, facial features, hand-writing, iris, and several other characteristics. Usually, the digitized characteristics are initially stored in databases. During the identification process, the scanned characteristics are digitized and compared with those stored in the database for authentication.

Card. Commonly used card technologies include magnetic stripe and smart card. Magnetic stripe technology encodes data in the tiny magnetic particles embedded in a resin (e.g., dark brown stripe on a credit card) with the polarity of the particles determining 0-bits and 1-bits. A reader detects polarity changes and decodes and transmits data to the host computer.

Smart cards are credit-size cards but with embedded microchip. There are two types of smart cards, one with only a memory chip and the other with a microprocessor on board in addition to memory. Smart cards have much higher data capacity and the one with microprocessor can be programmed to run applications and perform security check. One version of the card has gold contact plates for data transmission to the reader. Another version of the card is contact-less and data can be transmitted to the reader when the card comes to a close proximity of the reader.

Exhibit 1: Important members of the AIDC family and their descriptions.

dismantled. The EPC network may act as the nervous system of the global supply chain by linking the physical world to the business decision-making process. Whereas bar code was an adaptive technology, RFID is said to be a disruptive technology. In other words, bar code technology immensely improved the quality and speed of data entry, but RFID may revolutionize the nature of supply chain information systems. Nevertheless, much hype has been generated regarding this technology and its potential.

Despite great promises associated with RFID, there are many other issues that need to be addressed through research. One issue is the amount of data that will be generated by the network. Processing enormous sums of data and transmitting them in real time from one location to another will greatly increase the traffic on the Internet. It is not clear that to what extent the traffic generated by the network will adversely affect the current Internet or the future generations of the Internet when (and if) the full blown version of the EPC network is implemented.

Furthermore, transforming these data into intelligence for aiding the decision-making process may require the use of a new generation of mathematical, optimization, and artificial intelligence techniques. Other issues relate to the consumer acceptance, privacy concerns, and customer protection—especially if the RFID technology is implemented at the consumer-level goods.

AIDC Education in Academia

The lack of academic focus on these technologies has prompted a number of professional organizations to co-sponsor a program initiated by Ohio University in Athens, Ohio. The Association for Automatic Identification and Mobility (http://www.aimglobal.org/) and the Uniform Code Council (http://www.uc-council.org/) are sponsoring the 18th annual meeting of the Automatic Identification and Data Capture Technical Institute to facilitate AIDC education for college professors. The goal has been to increase awareness and to spread out the know-how of the AIDC technologies to other schools, curricula, and programs. The sponsorship clearly indicates that there is a need out there in the real world for AIDC education and that academia is not paying attention.

Regardless of these efforts, the numbers of institutions of higher learning that offer AIDC education are still limited. Table 2 shows a number of schools with AIDC focus. Some information has been provided by colleagues at Ohio University, and the rest has been extracted with difficulty using a search engine on the Internet. Indeed, there may be a few more schools that should be included. The fact that a variety of keywords search only produced a handful of schools indicates that the coverage of the subject may not be widespread among universities. Another observation is that schools of engineering and computer science were traditionally more likely to focus on the technologies. We are not aware of any business school, other than the one mentioned in the table, to have focused or developed curriculum in this field.

Technology	Business Application	Capability	Comments
Bar Code	POS, materials, logistics and distribution management, supply chain transactions	Read only, line of sight needed	Least cost and very robust AIDC; new applications using 2-D and RSS, well developed standards.
RFID	Everything that bar code can do plus it can be combined with various sensors (temperature, pressure, etc.) for unorthodox and innovative applications	Read only, WORM, or RW, line of sight not needed	EPC network has created a new wave of supply chain implementation; standards being evolved and perfected.
RTLS	Tracking and locating people and items in real time	Usually RW, line of sight not needed	Can dramatically change inventory management in certain applications, proprietary standards.
Biometric	Access control, Authentication	Capture physiological/ behavioral features	Technology is being perfected; high rate of false rejection; can be integrated with other technologies such as smart card.
Magnetic Card	Debit/credit card, ID, time/attendance, access control	Can be RW	Low cost, wide-spread infrastructure, especially in the U.S., less popular in Europe; well-established standards.
Memory Card	Stored value, transportation tickets, long distance telephone, debit/credit card	RW	Technology of choice when large database must travel with the individual.
Microprocessor Card	Secured ID, secured access control, recording patient histories, scramble pay television signal, credit/debit, multifunction	RW and Process	Technology of choice when large database must travel with people, very popular in Europe, slowly becoming available in the U.S.

Table 1: Business applications of selected AIDC technologies.

Given the rate of growth in the applications of AIDC technologies, it is wise for academia in general and business schools in particular to revamp the curricula. The need for the education of AIDC technologies may be rationalized from two perspectives. From a philosophical perspective, one may reason that students' understanding of computer systems has been incomplete because the traditional computer-related courses have not addressed input technologies. This shortcoming can in part be attributed to all of us as educators who ignored the automated input technologies by unintentionally assuming that inputs are always through keyboards.

From a pragmatic point of view, AIDC technologies, especially RFID, would offer new opportunities for research and development. From this perspective, business schools have dropped the ball by not paying attention to AIDC education and research, thus falling behind the real world. I'm not sure how many business schools or MIS programs teach the subject. Should we be surprised that there is no related research tracks in any MIS conference? Academia should make sure that the new generation of graduates is capable of managing this not-so-new breed of information technology.

What mentioned above inspired us to initiate an AIDC course as a part of the MIS program at Arkansas State University. The course has been offered for the last four years, and we learned more every semester. The good news is that a vast quantity of information about the subject is available on the Internet. On the other hand, what has impeded the delivery process has been the insufficiency of funds to acquire hardware, software, and lab spaces. However, the support for this initiative is growing as faculty and administration become aware of the role of AIDC technologies in an integrated supply network.

Gaining Additional Insights

Plans are underway to convene an AIDC panel as a part of the "Emerging Information Technology" track at the 2004 DSI annual meeting in Boston (November 20-23). The purpose is to continue this dialogue among the DSI members and business educators in an interactive mode. The current plan is to invite a panel of experts from academia and industry to lead the discussion. The panel will examine the most important technologies with business/supply-chain applications, discuss issues associated with curricula development, address some research issues and opportunities, and inform the participants of available learning and faculty development opportunities.

But there is some immediate opportunity for those who are interested to learn about these technologies right away. The AIDC Technical Institute (mentioned above) is open to professors in all disciplines. Academic participants receive free room and limited travel reimbursement. There is no tuition. Subject matter covers all AIDC technologies, including bar coding, radio frequency identification, biometrics, and smart card. A significant portion of the institute is devoted to hands-on lab time with state-of-the art AIDC technology. For additional information and to apply on-line visit http://webit.ent.ohiou.edu/it/autoid/.

Summary

The purpose of this article was to initiate a dialogue among IT educators as to the importance (or lack) of AIDC education within the business curricula. Interestingly, the theme of the 2004 DSI Conference in Boston is "Facilitating Quality Decision Making." A famous and inspiring phrase

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School	Department	Contact Person	Emphasis
Ohio University	Center for AIDC Industrial Technology, Engineering and Technology	Jim Fales, Bruce Philpot	All AIDC Practical applications
Purdue	Biometric Standards, performance and Assurance, Laboratory, Industrial Technology, School of Technology	Steve Elliott, Mat Sutton	Biometrics Practical applications
West Virginia University	Center for Identification Technology Research, Computer Science and Electrical Engineering	Larry Hornak	Biometrics Statistical approach
Kansas State	Animal Science	Dale Blasi	RFID animal tagging
MIT	Auto ID lab	Sanjay Sarma, David Brock	RFID, EPC Develpment Pure research
San Jose State	National Biometrics Test Center	Jim Wayman	Biometrics Statistical approach
Oregon State	Industrial & Manufacturing Engineering	Rick Billo	AIDC applications
Wisconsin, Madison	E-Business Consortium / multidisciplinary	N/A	RFID, Pure Research
Stanford	Computer Science and Engineering	N/A	RFID, Pure Research
Arkansas State	MIS / College of Business	Farhad Moeeni	Bar Code, RFID, and Card Technologies

Table 2: Schools with AIDC program, lead person(s) within the program, and the technology emphasis.

ANNOUNCEMENTS *(see more info & updates at http://www.decisionsciences.org/announce.htm)*

Institute Meetings

The 35th Annual Meeting of the Institute will be held November 20-23, 2004, at the Boston Marriott Copley Place Hotel in Boston, Massachusetts. The submission deadlines were: Refereed papers, April 8, 2004; abstracts and proposals, May 1, 2004. Contact: Kenneth E. Kendall, Program Chair, Rutgers University, School of Business-Camden, 227 Penn Street, Camden, NJ 08102, 856-225-6586, dsi2004@crab.rutgers.edu.

The 2005 International Meeting of the Decision Sciences Institute will be held in July 3-6, 2005, at the IESE Business School, University of Navarra, in Barcelona, Spain. Submission deadline is February 1, 2005. Contact Marc Sachon, IESE Business School, University of Navarra, Barcelona, Spain, dsi2005@iese.edu.

The Asia Pacific Region will hold its 2004 Annual Meeting on July 1-4, 2004, in Seoul, Korea. Submission deadline was May 1, 2004. Contact: Tae H. Kim, Program Chair, Yonsei University, 134 Sinchon-dong, Seodaemun-gu, Seoul 120-749, KOREA, 82-2-2123-2515, fax: 82-2-2123-2515, thkim@yonsei.ac.kr; Somboonwan Satyarakwit, General Co-chair, Dhurakijpundit University, sboonwan@dpu.ac.th; Sang Hyung Ahn, General Co-chair, Seoul National University, shahn@snu.ac.kr. See the APDSI Web site at http://www.calpoly.edu/~eli/apdsi/

The Mexico Region will hold its 2004 Annual Meeting on October 11, 2004, at The University of the Americas in Cholula, Puebla, Mexico. Submission deadline was June 30, 2004. Contact Program Chair Felipe Burgos, The University of the Americas, Cholula, Puebla, Mexico, dsi@mail.udlap.mx.

The Midwest Region will hold its 2005 Annual Meeting on April 14-16, 2005, at the Radisson Hotel in Toledo, Ohio. Submission deadline is January 21, 2005. Contact Program Co-Chairs Janet L. Hartley, Department of Management, Bowling Green State University, Bowling Green, OH 43403, (419) 372-8645, fax: (419) 372-6057, jhartle@cba.bgsu.edu; Mark Vonderembse, Department of Information, Operations and Technology Management, University of Toledo, 4044 Stranahan Hall, Toledo, OH 43606, (419) 530-4319, fax: (419) 530-2365, mark.vonderembse@utoledo.edu.

The Northeast Region will hold its 2005 Annual Meeting on March 30-April 1, 2005, at the Sheraton Society Hill Hotel in Philadelphia, Pennsylvania. Submission deadline is October 1, 2004. Contact Program Chair Fariborz Y. Partovi, Drexel University, Department of Decision Sciences, 101 N. 33rd Street, Academic Building, Philadelphia, PA 19104, (215) 895-6611, fax: (215) 895-2907, Partovi@drexel.edu. See the NEDSI Web site at http://www.nedsi.org.

The Southeast Region held its 2005 (35th) Annual Meeting on February 23-25, 2005, at the Raleigh Marriott Crabtree Valley in Raleigh, North Carolina. Submission deadline for regular papers and abstracts is September 20, 2004; the deadline for student papers is November 1, 2004. Contact Samia M. Siha, Program Chair, Kennesaw State University, 1000 Chastain Road, Building 17, Kennesaw, GA 30144, (770) 423-6709, fax: (770) 423-6606, siha@coles2.kennesaw.edu. See the Southeast Homepage at http://www.sedsi.org.

The Southwest Region will hold its 2005 Annual Meeting on March 1-5, 2005, at the Hyatt Regency, Dallas, Texas. Submission deadline is September 15, 2004. Contact Chang-tseh Hsieh, SWDSI Program Chair, University of Southern Mississippi, Box 5178, Southern Station, Hattiesburg, MS 39406, (601) 266-4641, fax : (601) 266-4642, hsieh@cba.usm.edu. See the Southwest Homepage at http://www.swdsi.org.

The Western Region will hold its 2005 Annual Meeting on March 22-26, 2005, at The Sutton Place Hotel in Vancouver, B.C., Canada. Submission deadline is October 1, 2004. Contact Program Chair Bruce C. Raymond, Montana State University-Bozeman, College of Business, 412 Reid Hall, Bozeman, MT 59717-0004, (406) 994-4333, fax: (406) 994-6206, braymond@montana.edu, http://www.wdsinet.org.

Call for Papers

Fourth International Conference on Electronic Business (ICEB2004) will be held **December 5-9, 2004**, hosted by Tsinghua University, Beijing, China. Conference Chair is Jian Chen, Tsinghua University. Submission deadline for papers or extended abstracts is **August 15, 2004**. See http://www.rccm.tsinghua.edu.cn/ICEB2004/.

International Journal of Flexible Manufacturing Systems seeks papers for a special issue on mass customization. Guest editors are Ashok Kumar (kumara@gvsu.edu) and Vipin Gupta (guptavi@gvsu.edu), Department of Management, Grand Valley State University; and S. Subba Rao (srao5@utnet.utoledo.edu), College of Bus. Admin., University of Toledo. Submission deadline is **January 15, 2005**.

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mentioned in any programming course is "Garbage in, garbage out." An elegant way of saying that is, "Accurate data collection and supplying them to computers and networks in a timely manner is a necessary condition for producing usable information in order to make *quality decisions*." This is one of the major aspirations of AIDC technologies: "accurate identification and data collection."

Literacy and skills in AIDC technologies, as in other areas of IT, are valuable. Fortunately, IT talents are developable. In my opinion, we as IT educators should emphasize the AIDC education in the curricula—especially if we agree with the above-mentioned famous phrase. ■

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