

CHAPTER 1

The Emergence of a New Key Technology

The essence of innovation is the blending of ideas with the science and practice of engineering. Nowhere is this process more active than in the area of identification technologies. Taking full advantage of improvements in microcircuit design and production, computer science, the Internet, and other mechanical technologies, the EPCglobal Network™ seeks to establish a large-scale computer infrastructure for merging data, information, and physical objects together. This will create a new, networked physical world that is similar to the Internet.

The power of the EPCglobal Network involves the combination of knowledge from many different fields ranging from computer science and engineering to supply chain management. Within the next ten years, practitioners and researchers alike envision the EPCglobal Network as becoming the predominant means of object identification within business.

The Bar Code and Beyond

Considered one of the greatest innovations of the 20th century,¹ the bar code represents the first large-scale, automated effort to identify objects. For retailers, the implementation of the bar code has led to improved pricing accuracy, greater labor efficiency, and reduced checkout time for customers.² In addition to these operational efficiencies, the bar code has come to represent an icon present on the package of nearly every consumer good marketed in the United States.

Given these early successes, manufacturers began to adopt the bar code as a means of improving inventory accuracy and to coordinate supply chain operations. Product level data on time and place obtained from bar code systems greatly improved temporal and spatial utility within supply chains.^{3, 4} During the 1980s, this was an important element in better management of inventory deployed at forward warehouses along with

enhanced customer service. The decreasing cost of computing hardware along with improved Enterprise Resource Planning (ERP) systems used to organize and communicate data combined to accelerate the adoption of the bar code by many firms.

Since bar codes are now a mature technology, it is natural to look forward to the next stage in the commercial use of identification systems. The historical focus of bar codes has concentrated on identification of an object type. For a consumer goods item, this means the brand and size of an individual product, or the brand, size, and quantity contained in cases shipped from manufacturers to retailers.

Product type data, obtained with the ease of a laser scanner, provides enough information to automate checkout lines or to improve inventory management. The Universal Product Code (UPC), established by the Uniform Code Council (UCC) in 1973, serves an important role in establishing uniformity and order concerning the product type data read from bar codes.⁵ As of 2005, over 1,000,000 organizations use the EAN/UPC on their products.⁶ This has unlocked enormous amounts of data to retailers and firms in other industries.⁷

With an increase in the intricacy and sophistication of products, the needs of business are moving beyond identification of product type to unique identification of individual objects by serial number. This represents a significant transition because unique identification introduces a much greater degree of complexity in system management.

Yet at the same time, unique identification also offers a number of possibilities that include greater visibility and real-time control of objects located anywhere between the manufacturer and the customer. The full realization of these capabilities will most certainly revolutionize the practice of supply chain management.

Organizing for Unique Identification

The EPCglobal Network is a system that builds on the tradition of automatic identification first established by the bar code. At the core of this system is the Electronic Product Code (EPC[™]), a serial numbering system designed to handle unique identification of trillions of objects. This numbering system forms a standard, uniform basis for linking physical objects

together within a network that applies to all levels of the supply chain and across industries.

The means of creating such a network involves the placement of low cost Radio Frequency Identification (RFID) tags on objects such as cases, pallets, or individual products. In addition, RFID technology provides the capability for these tags to communicate with the Internet, secure Intranets, or point-to-point communication between organizations, through readers situated at various points within the supply chain. In the future, this type of network will form the base for "pervasive computing capabilities embedded in our everyday environments."⁸

Given such a computer infrastructure, it becomes possible to manufacture smart objects that can "sense," "do," and "understand." Resembling tiny robots, smart objects are things that can make decisions independently based on external data gathered through sensing technology combined with computer logic imbedded into the object. Examples might include consumer products that can automatically change price based on sensing supply and demand conditions on the retail shelf and the likelihood of going out of stock.

The foundation for creating smart objects is unique identification that only the EPCglobal Network can provide. In simple terms, the goal is to make new connections between physical objects regardless of location within the supply chain.

Positioned to be one of the major advances of the 21st century, this "web of things" is a significant innovation that has the potential to affect nearly all of commerce.

Creating a Global Standard

An important aspect of the EPCglobal Network is the development of common standards. Considered the bedrock of commerce, standards enable interoperability and the free flow of various business transactions. Often following technological breakthroughs, standards setting efforts have a positive record in driving economic growth that dates to the origins of trade in the ancient world.

During modern times, the co-development of new technologies along with the establishment of common standards represents a complex activity

involving many different groups that must depend on each other for mutual success. Given expanding trade between countries, the interaction between new technologies and standards setting bodies will play an increasingly critical role in guiding the direction of innovation and future economic development.

As businesses begin the process of discerning the importance of the EPCglobal Network to profits and revenue growth, it is essential to know the fundamental aspects of the technology and to be able to abstract these capabilities to the practical applications of the present and future.

The Basic Elements of Unique Identification

The original designers of the EPCglobal Network had a predetermined idea of how to use the Internet as a means of implementing unique identification.⁹ Early researchers also introduced the goal of interoperability across all levels of the supply chain.

The basic design called for three components. First, and perhaps most important, a low cost RFID tag serves as the base of the system. To reduce the cost of the tag, researchers focused on new methods that would turn the manufacture of tags into a mass production process.

A second major development involved placing a unique serial number on the RFID tag capable of identifying trillions of objects. This task involved the calculation of the size of the number to ensure adequate coverage. The numbering system developed during this phase of research became the EPC.

The last step was to build a computer infrastructure capable of processing identification data and information. Since initial designs of RFID tags called for minimum functionality as a means of reducing costs, the EPC became the only data contained on tags. It served as a pointer to greater amounts of data and information held in a network. In this way, an efficient balance was struck between the limited functionality (and cost) of RFID tags, and the ability of computer networks to hold important data and information about objects.

With these components in place – low cost tags, the EPC, and a network infrastructure for handling data – the EPCglobal Network is capable of new

types of data and information exchange as compared to current bar code systems. In business, it is a general rule that the value of information increases when it moves beyond the four walls of a firm. Many firms from a wide range of industries are convinced collaboration provides extensive benefits and are looking for new technologies to enhance its application with trading partners.

The greatest value of the EPCglobal Network may be the set of standards necessary for supply chain wide communication of unique identification data. In this way, collaboration between trading partners can take place on a more sophisticated level and it becomes theoretically possible to monitor and communicate with objects at any step of a supply chain. This type of collaboration and control has definite benefits that are quantifiable once the EPCglobal system is in place.

RFID versus the EPCglobal Network

The use of RFID tags to identify and track objects is not a new technology. The beginning of modern RFID traces to WWII where the military used transponders for the important purpose of identifying a returning aircraft as friend or foe.^{10, 11}

Since the 1940s, businesses have applied RFID in a number of industry situations, mostly in the area of asset tracking, collection of highway tolls, security access, and consumer convenience. It is important to note that at least one inventor proposed the use of RFID during the 1970s as an alternative to the bar code.¹² At that time, RFID was about seven times more expensive than bar codes, prompting supermarkets to choose the latter.

Perhaps one of the most famous RFID applications to date is the ExxonMobile SpeedPass. With this service, consumers can purchase gasoline using a key chain fob that contains an RFID tag. When the customer arrives at a gasoline station, and begins pumping, an RFID reader located nearby automatically identifies the customer and charges their account upon completion of the transaction. This all happens without ever inserting a credit or debit card into the card-reading unit located at the pump. As a testament to its popularity, there are currently over 6 million users of ExxonMobil SpeedPass in the United States.¹³

A common characteristic of these early applications involves a "closed loop" approach. In this situation, RFID communication is tightly coupled and applications are highly specific. Proprietary standards dominate these systems and limited interoperability exists.

This is in contrast to the EPCglobal Network, where open standards enable supply chain wide interoperability. With this approach, there are many more opportunities to exchange data across multiple levels of a supply chain or across different industry sectors.

Charting the Future

There is no question that the EPCglobal Network and RFID technology have great potential to provide detailed data about objects within a supply chain. Current forecasts put the build-out of the technology on a gradual pace with the first comprehensive applications being in place by 2007.¹⁴ As companies install dense ubiquitous reader networks within manufacturing facilities and supply chains, greater amounts of data will become available with improved accuracy and timeliness.

This represents a growth industry for vendors of RFID technology. ABI Research of Oyster Bay, NY estimates that RFID hardware and software sales alone have reached \$1.53 billion in 2004, up from \$915 million recorded in 2000.¹⁵ Forecasts for the future size of the RFID industry vary a great deal with some predicting sales as high as \$4.6 billion by 2007.¹⁶

Mandates in the retail industry¹⁷ along with interest by the Department of Defense and the Food and Drug Administration will almost certainly ensure growing demand, although the near-term value to retailers and manufacturers remains unclear. If the past is any guide, one author predicts that in a high tech gold rush like RFID, it is usually those who sell the picks and shovels who make all of the money.¹⁸ In this case, RFID tags, readers, and supporting software are the modern day equivalents of the picks and shovels.

The development of the EPCglobal Network and RFID technology will undoubtedly take many turns in practice. It is seldom that new technology finds application without a great deal of experimentation and a number of failures. However, the process of creative destruction, an economic principle first put forth by Joseph Schumpeter, ultimately means that mature

technologies like the bar code will eventually make way for new innovations like the EPCglobal Network and RFID technology.¹⁹ Though the bar code will be a mainstay of business for many years to come, its replacement is inevitable.

The task that business, academia, and non-profit standards organizations now face is the true measure of any innovation; initiating widespread application through a convincing argument of commercial value. Those who deal firsthand with the everyday problems of business will be instrumental in this effort.

Initial Application Ideas

During the early stages of development, practitioners and researchers have identified a number of applications that utilize the data and information anticipated from the EPCglobal Network. Some applications include track and trace within entire supply chains,^{20, 21} theft detection,²² improved service parts inventory management,²³ product obsolescence control,²⁴ and the management of production and logistics within military and civilian supply chains.²⁵ With almost all of these initial application ideas, the aim was to use information as a way to improve supply chain control.

In some cases, the EPCglobal Network holds the potential to go beyond information-based applications by changing basic business processes that have historically formed the structure of commerce.

For example, in the consumer goods industry the business model of manufacturers producing products that are sold to retailers, which in turn sell to customers, has remained essentially unchanged since the rise of department store chains during the late 19th century. With the supply chain visibility that the EPCglobal Network enables, it is possible that manufacturers can "own" products until the time of purchase by consumers in retail stores. Often called scan-based sales, this approach would redefine the consumer goods industry, turning retailers into providers of real estate for multiple stores within a store, and allowing manufacturers to make basic merchandising decisions involving price and promotion.²⁶

This type of potential application highlights the inherent characteristic that networks often transcend the established boundaries of organizations.²⁷ Ocean shipping, roads, railroads, air transportation, telegraph, radio, tele-

vision and the Internet are all examples of networks that contributed a great deal to economic growth, yet have the unique characteristic of cutting across significant business, governmental, social, and geographical boundaries.

As a final note, innovations like the EPCglobal Network also have a powerful transformative property. Some argue that networks often alter new inventions and ideas into something much more influential.²⁸ Steam power is one example. During the early stages of the Industrial Revolution the greatest changes did not come from the steam engine itself but rather from the invention of the railroad network, which utilized the steam engine to increase the average speed within a land-based transportation network.²⁹ Without the railroads, the agricultural and manufacturing capabilities of the 19th and 20th centuries would never have fully developed, and the United States would never have emerged as a world power.

While it is hard to predict what other technologies the EPCglobal network might transform, a precedent exists that such transformations will take place with the result of improved productivity.

The History of Technological Advances

Taking something new like the EPCglobal Network and RFID technology from an initial idea to wide-scale industrial application requires an appreciation of the history of technological advances. An understanding of this history will help to form the perspective that only the past can provide.

Seldom originating from a single source, innovations like the EPCglobal Network are often the result of many incremental improvements in technology that in total add up to big things. This type of process, which thrives in a free market economy, depends on communication and information sharing through various means, such as academic journals and the business literature, to stimulate ideas among individuals or small groups that possess a competitive desire to make something better. Historically, the result of such a process, as apparent with most of the significant mechanical inventions of ancient times, the middle ages, and the early stages of the Industrial Revolution, is that many innovations bear little resemblance to anything that had happened previously.

Archimedes' levers and pulleys, Gutenberg's printing press and movable type, Watt's steam engine, Whitney's cotton gin, and the Wright's airplane, were all innovations that changed the course of economies and history but had no prior equivalent. Though these engineers seldom created their devices without building upon the work of others, their unique insights about the potential of applied technology served to harness existing knowledge in new ways. Breakthroughs occurred primarily because of incremental innovations and the ability and focus of a single person to create something of economic value.

One invention alone, the printing press, accounted for massive increases in productivity and represented the first case where a mechanical device became an integral part of data and information creation through the manufacture of newspapers, pamphlets, and books. By a single account given in the late 18th century, a book would have cost 100 times the present price had the efficiencies of the printing press not existed.³⁰

In situations where innovations are successful, it sometimes takes years to recognize applications. Inventive inspiration, often rooted in the idea of incremental improvement, sometimes focuses on the potential of what is, rather than the expectation of what might be. This means that inventors tend to overlook the practical applications of the things they create. Some researchers go as far as to assert that new technologies are not productive until nearly a generation after introduction.³¹ The argument is that it takes time to learn how to use the technology in new ways and for new ideas to diffuse through the economy.

A case in point is the invention of air flight.³² The Wright brothers first flew their machine on December 17, 1903, yet it was 1906 before issue of the first patent and 1909 before the US Army took delivery of the first aircraft.

Another important aspect of innovation is relevance along with the source of the initial inspiration for design. During the age of the Industrial Revolution, the great innovations in devices involving the manipulation of force and mechanical power frequently traced to a close relationship with the practical problems of everyday life. For example, the design of machines that replaced the backbreaking work of agriculture often mimicked the observed physical motions of humans working in the fields.

In perhaps one of the best descriptions of this type of innovation, Sherwood Anderson put forth a compelling fictional account of agricultural innovation in a small Midwestern town during the late 19th century. With a single sentence, he sums up the prevailing attitude of this time of great American innovation, "Do little things well and big opportunities are bound to come."³³

Parallels with Identification Technology

The EPCglobal Network shares all of the characteristics of innovation that have previously occurred in the Industrial age. The technology carries the mark of its predecessor the bar code and the Uniform Product Code (UPC), first invented in 1948 (bar code) and fully implemented in 1974 (bar code and UPC).³⁴ Yet the idea of unique identification at the object level with RFID tags that communicate over a distance was beyond anything remotely considered by those who initiated the first bar codes.

Through the combination of RFID tags and a sophisticated information technology infrastructure, the EPCglobal Network has the potential to create a revolution in the quantity, quality, and timeliness of data generated within supply chains. In this way, the EPCglobal Network is a groundbreaking technology much like the printing press, which revolutionized communication, learning, and information sharing. Improving the quantity, quality, and timeliness of data has the potential to lead to better planning and control internal and external to business organizations, and the widespread application of automation.

Even though the EPCglobal Network has impressive potential, there also exists the risk of failure because of infrastructure complexity. To date, considerable theoretical development has taken place and prototype applications of the EPCglobal Network have proven successful in practice. However, the viability of large-scale implementation across a number of industrial sectors remains an unanswered question.

It is also true that other technologies might supplant the EPCglobal Network before full implementation. Though few such technologies are currently on the horizon, businesses in a free market economy have exceptional capability to identify and put into practice least cost alterna-

tives that might include non-technological solutions to the various aspects of object identification within supply chains.

Finally, because it is a new technology, the most innovative applications of the EPCglobal Network are in the future and will probably have an origin in the everyday problems of commerce that cause loss of productivity. Much like the advent of air flight, it might take years to comprehend the full potential of the EPCglobal Network and RFID Technology. Taking the bar code as an example, more than 25 years passed between the invention of the bar code and widespread commercial application.

Productivity Through Information

The essential nature of the EPCglobal network differs from the devices developed during the age of industrial revolution in that the primary goal is production of data and information. Lacking the tangible aspects of mechanical innovation, this new technology depends on using data and information to enhance practical decision-making in business rather than a focus on improvements in equipment, training, or methodologies, which were the traditional ways of increasing manufacturing productivity.

In support of the productivity potential of the EPCglobal Network, evidence exists that the information economy has created significant results. According to a Federal Reserve report published in 2000, productivity growth has increased an average of one percent when comparing the first half (1990–1995) to the second half (1995–2000) of the 1990s.³⁵ Two-thirds of the increase has been traced to better use of information technology and increasingly efficient production of computers.³⁶ Further, a significant portion traces to better supply chain management in the retail industry, an outcome of increased data about operations.³⁷

Conquering the dynamics of supply chains can only happen through the innovative use of information. As Harvard psychologist Donald Cox once stated, "information is the antidote to uncertainty."³⁸ Having real-time information on the location of an object within a supply chain improves visibility and enhances such critical business functions as inventory control and the delivery of customer service. To date, various information technologies including the bar code have already had an important impact on the

US economy by helping to mitigate inventory imbalances that often caused deep recessions.³⁹ The EPCglobal Network and RFID technology have every prospect to strengthen this trend.

Global RFID

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Schuster, E.W.; Allen, S.J.; Brock, D.L.

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