AC 2008-2843: A WORLD WHERE EVERYTHING IS AUTOMATED: THE CHALLENGES AND OPPORTUNITIES OF THE ROBUST RFID INFRASTRUCTURE THAT WILL MAKE IT A REALITY

Okechi Egekwu, James Madison University

Okechi Geoffrey Egekwu obtained his PhD in Industrial & Systems Engineering from the University of Nebraska, Lincoln. He is currently a Full Professor in the Integrated Science and Technology (ISAT)program at James Madison University, Harrisonburg, VA, where he teaches undergraduate and graduate courses in the manufacturing and technology management areas. He also teaches operations management at MBA programs at James Madison University (JMU) and Eastern Mennonite University. Professor Egekwu worked in industry for 11 years and joined JMU in 1993 as one of the core faculty that started the ISAT program.

A World where Everything is Automated: The Challenges and Opportunities of the Robust RFID Infrastructure that will make It a Reality

Abstract

To achieve the full benefits of RFID implementation in any industry requires that organizations develop and carefully manage complicated RFID networks. A robust RFID network platform will be necessary to support the different devices and software that will lead to an event-driven environment. In place of the familiar process-driven approaches, RFID networks will allow enterprises to build *event-driven* applications that will react to real-time information that are then used to make intelligent business decisions. Managing the data from RFID tags and readers still remains one of the major challenges that impede the diffusion of this technology. Building scalable and secure data and information infrastructure are among the problems identified by early adopters**.** This paper will present an overview of industry (individual companies and partnerships) and government activities aimed at solutions for a robust RFID infrastructure. This paper will also discuss efforts at the Integrated Science and Technology (ISAT) program at James Madison University to expose students to the various aspects of this technology.

Introduction

The road to ubiquitous computing has taken many paths in the past, but it has always bordered on the use of intelligent wireless connections. For this reason, RFID technology holds a very real promise of being a silent technology – one that is so pervasive that one is not aware of its use. A robust RFID network platform will be necessary to support the different devices and software that will lead to an event-driven environment. In place of the familiar process-driven approaches, RFID networks will allow enterprises to build event-driven applications that will react to real-time information, that are then used to make intelligent business decisions. This will be a fundamental shift for a lot of organizations, but its benefits will be equally enormous. An intelligent, event-driven RFID and sensor Network will:

- Integrate different devices under a user-friendly common environment – broad hardware support for many hardware families of passive and active RFID readers, RFID printers, barcode scanners, mobile devices, location tracking systems, etc.
- Integrate RFID, location, and sensor tracking data at different locations in the enterprise; and offers a configuration that supports edge processing
- Possess a runtime environment that can host multiple business processes
- Support multi-protocol RFID tags – support across many product features for EPC, ISO, and custom tags.

A major cause for excitement in RFID technology is the high levels of efficiency gains expected in enterprise supply chain management – real-time inventory data, real-time supplier information, and benefits from sharing business data along the value chain. Most of the early adoptions of RFID technology are for this application, but an even greater benefit will come when the control capabilities of this technology are fully implemented. One of the defining

characteristics of RFID tags is their operating frequency – in general the higher the operating frequency, the more one can use them for advanced applications. Active (powered by batteries) higher frequency tags, combined with precise and accurate sensors, and also combined with micro-electromechanical devices (MEMs) "make it possible for any object to be smart" and "information-rich, aware and even active in responding to their environment." Wireless technology makes it possible for smart RFID-enabled objects to sense and communicate with other smart objects. At this level of interaction, experts predict that one will begin to see not only *ubiquitous computing* but also *proactive computing* – that is, "systems that anticipate what we need and provide it without forcing us to do a lot of work first."[1]

This paper will present an overview of industry (individual companies and partnerships) and government activities aimed at solutions for a robust RFID infrastructure and the challenges that must be overcome to ease adoption pains. The paper will also discuss efforts at James Madison University to expose students to the various aspects of this technology.

RFID Networks

At the enterprise level, an RFID system will comprise many different technologies, including barcodes systems, passive and active tags, GPS/GIS systems, and chain of smart software – the hardware and software from different vendors must be seamlessly integrated. See Figure 1 for representative auto ID technologies that one will find in a robust enterprise system.

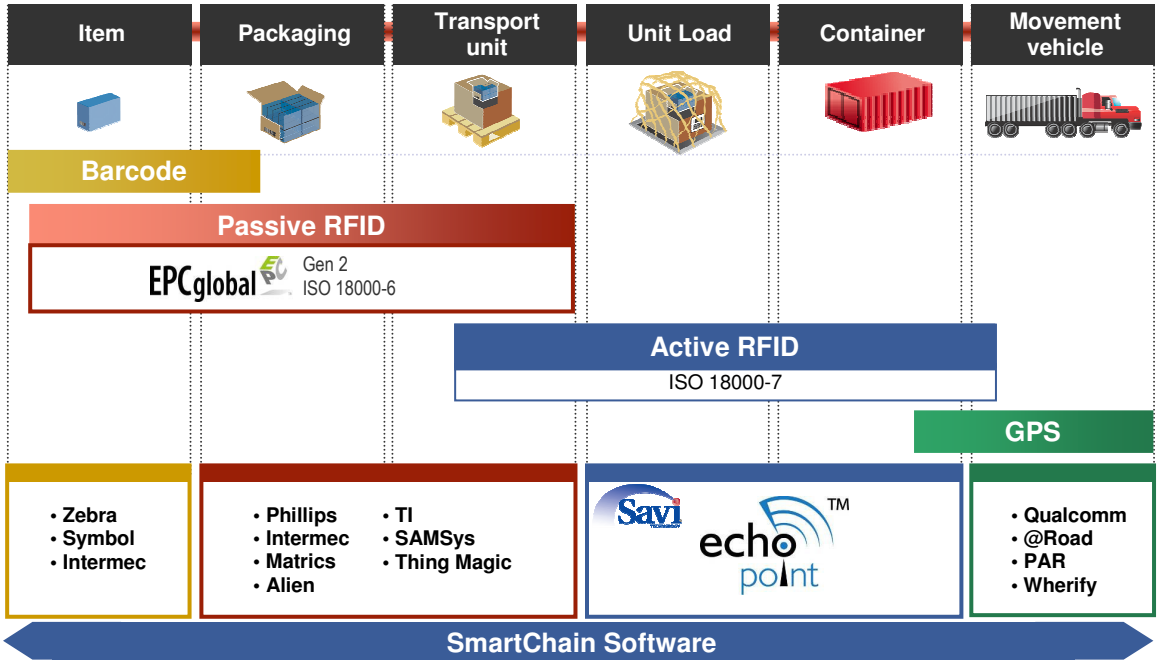

Figure 1: Multiple Auto ID Technologies Integrated within Enterprise Software [Adapted from Savi Technologies; http://www.savi.com/index.shtml]

Typical enterprise architecture is shown in Figure 2 below. This representative enterprise architecture will be a small part of a much larger RFID network that handles large amounts of data/information between many enterprises.

Figure 2: RFID Enterprise Integration [Source: Sybase; *SOA – service-oriented architecture*]

Figure 3 below shows a very simple RFID architecture, but the challenges for implementing RFID solution in a more complicated situation are many and depend both on existing and new technology. A key technology issue in most enterprises is how to process and manage the large amounts of data that enter into their information systems daily. It is believed that the quantity of data will increase exponentially with an RFID system where there are different RFID tag choices, multiple protocols, different data encoding formats, and choices of standard and custom data formats – hence the need for a reliable, scalable, and flexible encoding and decoding system architecture. RFID system developers, integrators, and vendors agree that the following obstacles must be overcome before large-scale adoption can take-off:[2]

- Multiple and diverse device types, with differing functionality, usage and interfaces
- Technological diffusion challenges that are compounded by fragmented standards and protocols
- Challenges of managing and controlling distributed sensor networks
- Hardware that are in multi-locations within the organization
- The share number of "raw, unprocessed data generated by sensor networks"
- Difficulty in troubleshooting or simulating the complex production environments
- Difficulty in maintaining real-time visibility and
- Developing the necessary business intelligence (intelligent business processes and logic) that would take advantage of real-time data

The goal of a robust RFID network (like the EPC Network) is to allow enterprises to leverage their RFID infrastructures by capturing and sharing real-time business information (asset/inventory locations, quantities and histories) across enterprise layers and with outside business partners. Earlier EPC data structures had limited use and served as a "license plate" that basically pointed to a product data with an association to an item stored in a back office database system.

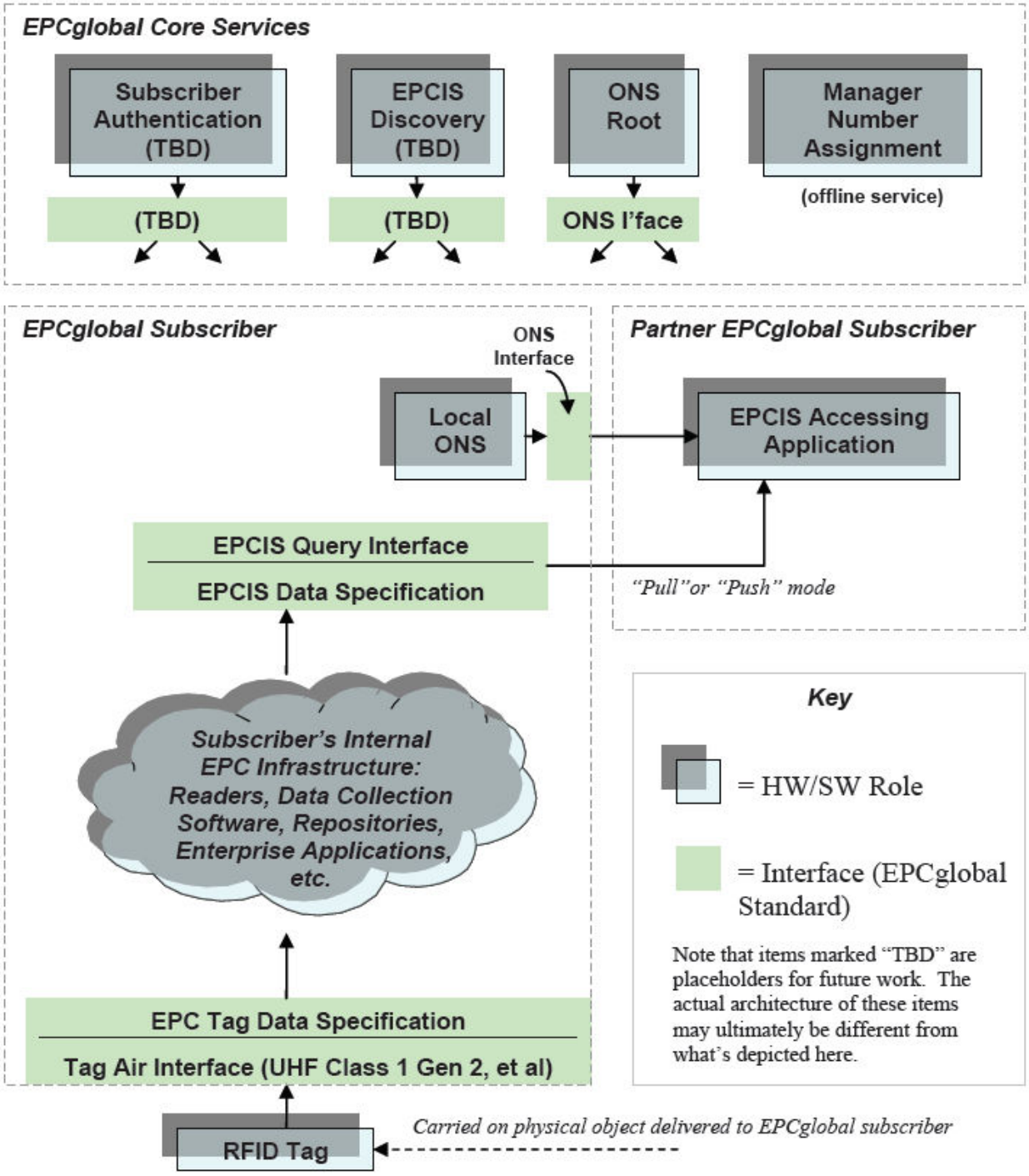

Figure 3: RFID Network [Source: http://www.EPCGlobal.com]

Gen 2 specification provides more EPC memory on the chip – a lower end of 96 bits and maximum of 256 bits are specified. This is beginning to lead towards the ultimate goal of operational efficiency and flexibility. For control and information management purposes then, tags themselves can become mini databases of important information that can be integrated into the enterprise information network. If anything can be tagged, it can be controlled.

Ratification of EPCglobal's Class 1 Generation 2 (Gen2) RFID standards for the ultrahigh frequency (UHF) range has not resulted in wide RFID deployments or led to the system component inter-operability that was expected. It is safe to say the Gen 2 standards define the physical and logistical requirements for the supply chain RFID systems - that is, mostly the RFID tags and readers necessary to meet the mandates of big-*box retailers*. Gen 2 standard is also the supporting platform for EPCglobal's electronic product code or EPC.

Turning RFID Data into Business Intelligence

There is substantial programming that takes place at the bit level to convert raw tag data (binary or Hex numbering system) in an RFID tag to useable business information. For a fairly complex RFID system which must track multiple tag encoding formats (ISO, EPC, or others) Matt Teskey[3] states that "tag decoding tasks can involve significant research and low-level programming resources. To accomplish this task correctly, developers must work with fairly complex specifications – often for multiple tag formats – within their application, all of which can add up to significant amount of new code". The complexity, risk, and investment in resources that is required to build a flexible RFID system can be reduced to adopting a middleware platform that perform the decoding functions from a vendor.

Operational needs at most enterprises, sometimes require the capability to write custom data onto RFID tags as tagged items or persons move through the value chain. These custom tags can be totally different from the better understood (known) standardized data encodings – like ISO and EPC tags. Examples of custom information that could be written onto tags are: shelf-life, last maintenance check or calibration status of an asset, tracking patient through surgery in a hospital, managing hazardous materials, and others. It is at this level of network complexity that the full benefits of RFID can be realized, and as a consequence permit *event-driven* applications that react intelligently to accurate real-time information.[4]

Most enterprise management systems (Enterprise Resource Planning, Inventory Systems, and Supply-Chain Management Modules) are all *process-driven*. They are not agile and always react late after an event has occurred. A shift to an event-driven enterprise management system would mean that business applications would only run when an event triggers it instead of either running all the time or at specified intervals. It will be challenging and cost prohibitive for the individual user (company) of RFID systems to develop the robust RFID network components of the type that have been described above. The encouraging development is that individual systems developers and partnership arrangements among large technology companies are emerging. Some of these efforts are discussed herein.

Initiatives that Address RFID Network Solutions

In general, most of the promising work in this area focuses on the development of network solutions that incorporate end-to-end services for RFID networks across diverse hardware platforms, operating systems, business applications, and databases. Following are few examples:

- **SYBASE *iAnywhere*** – Network platform allows edge processing, manages and monitors distributed sensor networks, and also allows multiple location data coordination and management.
- **Auto-ID Lab's Accada RFID prototyping Platform** – This free, open-source reader protocol, ALE middleware, tag data translation engine and EPC Information Service (EPCIS) implementation that allow researchers to explore benefits of the EPCglobal Network. The EPCIS software receives RFID "data from the middleware module, translates the data into relevant business events and makes those events available to back-end systems"[5]
- **SAP's Object Event Repository (OER) Software – This platform is designed to** aggregate RFID, sensor and other ID data. SAP also has another RFID network platform product called Auto-ID Infrastructure (AII) which will allow users to integrate all automated communications and sensing devices (PLCs, RFID readers, label printers-encoders, and bar-code (UPC) readers, etc) in an enterprise physical network.
- **Siemens and Ekahau Communications Partnership** – This partnership allows Siemens and Ekahau to jointly offer Wi-Fi-based real time locating system (RTLS) and a wireless network system and a single product offering for their customers.
- **AT&T, Symbol Technologies, Intel, and BEA System Partnership** – aimed at supporting RFID networks across multiple and diverse hardware and software platforms
- **Accenture Partnership** – This is targeted at the pharmaceutical industry and is called *Pharma Jumpstart Program*. Partners with 14 retailers, distributors and manufacturers to develop enterprise solutions that they estimate may save the healthcare industry over $8 billion.

Exposing Students to RFID Technological Complexities

Because of the unique process of technological development for RFID, it is often difficult to offer a traditional course that meets the prescriptions of curriculum and instruction (C&I) guidelines in most engineering and technology programs. We have adopted different methods to introduce students to the relevant knowledge units in the RFID technological space in both undergraduate and graduate course offerings. There is a real need to train qualified technology professionals to adequately support the anticipated increase of RFID implementation projects.

In June 2007, the Computing Technology Industry Association (CompTIA)[6] reported results of two workforce studies that suggest that the available pool of RFID talent is grossly insufficient to meet the demand for qualified RFID technology professionals. One of the studies specifically indicated that "end users prefer workers with industry-specific hands-on experience. Seventy percent of CompTIA survey respondents believed that employers currently have an insufficient pool of skilled workers while sixty eight percent stated that lack of qualified workers has impacted their decision to delay adoption of RFID technology. The Integrated Science and Technology (ISAT) program at James Madison University allows us the flexibility to seamlessly insert knowledge units in RFID technology at different levels of our curriculum. Listed below are some specific courses where the author has incorporated RFID technology in the past three years:

1. ISAT 303 – This is an Instrumentation and Measurement course for sophomores and junior in our program. The course focuses on the use of sensing and measurement devices, processing the data for manufacturing process automation and control. Basic principles of RFID technology are introduced – system components, overall benefits and adoption challenges, lab exposure of the data formats (especially standard formats), and broad implications of the technology for the future.
2. ISAT 331 – This manufacturing automation course investigates, primarily through lectures and class projects, specific uses of RFID technology in automation systems. Specific topic areas like CIM, automated material handling, vulnerability of automated systems, and even robotics are used to introduce critical technological challenges that students will face in a real-world environment.
3. ISAT 433 – This is a project-based course and makes it easy to focus students' attention in researching technological issues in specific industries. It requires regular technical presentations throughout the semester by student teams and a comprehensive project paper and presentation at the end of the term. Students thus learn different implementation issues from other teams and are required to evaluate other project teams over a range of criteria.
4. MBA 642 (at James Madison University) and MBA 621 (at Eastern Mennonite University, Harrisonburg, VA.) – These are operations management courses in a traditional MBA program and an Information Security MBA program at two different universities where the author teaches. Students have received valuable exposure to RFID technology through lectures and class research projects. The students have shown the greatest excitement about the RFID projects mainly because most of them were involved at some level of an active RFID project (or at least a discussion of impacts of RFID) at their places of employment.

The experiences of the author and the number of inquiries that we get from different companies, both within the state and nationally, point to the fact that a more focused student instruction leading to an in-depth understanding of RFID technological space is needed. In spite of the challenges in developing instructional labs and curriculum in this emerging and volatile technology, the cost of lack of exposure to the students would be very high and would not result in providing the technologists needed to support a large-scale RFID implementation.

Glossary of Terms[7]:

Auto-ID Center: "A non-profit collaboration between private companies and academia that pioneered the development of an Internet-like infrastructure for tracking goods globally through the use of RFID tags carrying Electronic Product Codes. The center closed its doors in September 2003. EPCglobal was set up to continue the work of commercializing EPC technology, and the center's research work is carried on by Auto-ID Labs at universities around the world."

EPCglobal: "A non-profit organization set up the Uniform Code Council and EAN International, the two organizations that maintain barcode standards, to commercialize EPC technology. EPCglobal is made up of chapters in different countries and regions. It is commercializing the technology originally developed by the Auto-ID Center."

Bibliography

[1]Roy Want, "RFID: A Key to Automating Everything" Scientific American, January 2004.
[2]"RFID Anywhere Enabling intelligent, event-driven RFID and sensor networks" , SYBASE www.iAnywhere.com.
[3] Matt Teskey, "Turning RFID Data into Information" Printed from http://www.devx.com/enterprise/Article/32251.
[4] Hersh Bhargava, "Building Smart RFID Networks" *RFID Journal* at http://www.rfdjournal.com/article/.
[5] Mark Roberti, "Auto-ID Lab Releases Accada RFID Prototyping Platform" *RFID Journal* at http://www.rfidjournal.com/article/
[6] Mary Catherine O'Connor, "Two Studies Describe the RFID Workforce" *RFID Journal* at http://www.rfidjournal.com/article/
[7] Definition of terms from: http://www.rfidjournal.com/article/glossary/