

The Diffusion and Use of RFID Technology in India

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Abstract

Radio frequency identification(RFID) is a system of technology that transmits digitally coded identity information in the form of a unique serial number of an object or person wirelessly, using radio waves. The primary use of RFID has been in asset tracking. This makes it highly useful across various industries for effective and efficient conduct of different business processes like supply chain management (SCM). As the use of RFID expands, the use of this technology is observed in such industries as transportation, traffic payment, hospital and medical care, education, and retail. Although this technology offers immense potential, it faces multifarious roadblocks, particularly in developing countries like India. Under this backdrop, this paper attempts to present an overview of the use and application RFID technology in India with a highlight on business-ecosystem for RFID in India. We also present various technical and non-technical challenges in the implementation of RFID in India.

Keywords : Barcodes, ICT, India, Process, RFID, SCM

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I. Introduction

Radio Frequency Identification Technology (RFID) is the state-of-the-art information and communication technology (ICT) that uses radio waves for automatic processing of identification of people or objects. This technology relies on storing, capturing, and remotely retrieving data using devices called RFID tags and readers. Its main application in present times includes tracking products along a supply chain in warehouses, factories, retail stores, and transportation facilities. Nowadays the use of RFID is rapidly expanding into education, medical, public transportation, and other service and manufacturing industries. Despite its rapid expansion of use, research on the use and management of this technology is yet sufficient to guide successful implementation and adoption by users. Especially, in developing countries, where the socio-technological infrastructure surrounding the use of RFID is not sufficiently prepared, a more extensive review of RFID eco-system is required to guide development, implementation, and use of this technology.

RFID¹⁾ technology consists of tags,

readers (also known as interrogators), network infrastructure and enterprise implementation. Tags, also known as RFID transponders, contain at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other specialized functions. This microchip can be read-write or read-only. The second part is an antenna for receiving and transmitting the signal. It enables the chip to transmit the identification information to a reader.

There are three types of RFID tags. An active tag uses its own battery power to contact the reader. The power source is used to run the microchip's circuitry and to broadcast a signal to a reader. It works over a greater distance, but its larger size is its main drawback. Second kind of tags is called as passive tag which does not require a battery. They derive power from the electromagnetic field created by the signal from the RFID reader. This generates enough power for the tag to respond to the reader with its information. The read range (20 feet) a passive tag is smaller than active tags (300 feet). At the same time, its life

1) It was invented by Harry Stockman with the publishing of his report "Communication by Means of Reflected Power" Proceedings of the IRE, pp1196-1204, October 1948.

is much longer and size is much smaller than active tags. The third kind of tags are called as battery assisted passive(BAP) tags (also known as semi-passive tags), which use a battery to run the chip's circuitry, but communicate by drawing power from the reader. Active and semi-passive tags are useful for tracking high-value goods that need to be scanned over long ranges but they are expensive than passive tags.

The reader converts the radio waves reflected back from the RFID tag into digital information, which can then be passed on to computers for further processing. Readers can be classified into two categories. An intelligent reader runs on different protocols, filters data, and even executes applications. Essentially, it is a computer that communicates with the tags. A “dumb” reader is a simple device that might read only one type of tag using one frequency and one protocol. With very little computing power, such readers can not filter, read and store tag data. RFID software performs numerous functions like data filtering, integration, application, analytics, and security.

Globally, structured efforts to develop such technology were started with set up of Auto-ID Center in 1999 as a not-for-profit consortium. This center was originally supported by the EAN International - Uniform Code Council²⁾, Procter & Gamble and Gillette, and was based at the Massachusetts Institute of Technology in Cambridge to develop a system for using the Internet to identify goods anywhere in the world, using the Electronic Product Code(EPC).

In October 2003, the center closed its doors and was transitioned into two separate organizations: EPCglobal took over the commercialization of EPC technologies, while Auto-ID Labs continued the research and development role of the Auto-ID Center. The EPCglobal Network uses RFID to enable true visibility of objects in the supply chain. The network has five fundamental elements:

1. The Electronic Product Code (EPC) is a unique number that identifies an item in the supply chain, whether an individual product or a case, or pallet being

2) European Article Numbering-Uniform Code Council (EAN-UCC) was the supply chain standards family name that included product barcodes, printed on the great majority of products available worldwide. In 2005, its name was changed to GS1. It is a leading global organization dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across sectors.

shipped.

2. Each silicon chip of RFID tag is encoded with a unique EPC that identifies the product. The silicon chip is wired to an antenna, and using RFID, tag communicates its EPC to RFID reader. EPCglobal has classified RFID tags into four categories. Passive tags are referred as Class 1 (Identity Tags) and Class 2 tags (Higher-Functionality Tags) while BAP tags and active tags are called as Class 3 and Class 4 tags respectively.
3. The Object Name Service(ONS) collects the EPC that is passed on from the reader. The ONS resides on local application system and guides the computer system to locate information on the network about the item, whose EPC is encountered. This information is normally kept on the internet so that it can be used globally.
4. Physical Markup Language(PML) is an XML-based language used to define data on objects.
5. Middleware technology (named as SAVANT initially) coordinates the movement of information over the computer systems. It coordinates several tasks such as data smoothing, reader coordination, data forwarding, data storage, and task management.

In industry as well as in academia,

discussion over RFID begins with the comparison between the two technologies as follows. First, unlike barcodes, RFID tags can be read from a larger distance. Second, RFID chips can be read from outside of the line of sight. Third, different from a barcode scanner which a person scans products one at a time, an RFID reader can read hundreds of chips instantaneously without human interruption, speeding up the loading and delivery processes. Fourth, readability of bar codes can be impaired by dirt, moisture, abrasion or packaging contours. RFID tags are much less affected by these conditions. RFID tags can be read as long as they are undamaged and within the range of a reader. Since radio waves pass through plastic, tags can be better protected from damage. Fifth, RFID tags have the potential to be combined with data to monitor the status of the product. However, RFID is still relatively expensive and its deployment is quite complex. Therefore, despite the evolution RFID technology, the use of bar codes is not likely to be affected significantly in the short run.

II. Literature Review on the Use of RFID in India

As market for RFID is still at a nascent stage in India, not many researches have been done in Indian context. However, some literatures available are reviewed here. Acharyulu(2007) examines the aspects of RFID technology use in health-care supply chain. According to him, the technology can be used to ensure a complete visibility of data and thus efficient delivery of patient care. Asghar and Vaidyanathan(2008) suggest that RFID have great potential in augmenting four business processes, i.e. demand management, order fulfillment, manufacturing flow management, and return management. These applications can lead to a significant improvement in effectiveness and efficiency of supply chain management. They also highlighted that as companies develop their RFID strategies, they must look beyond mere compliance for ways to implement these initiatives into their total supply chain strategy and harness the true business value of the technology, hastening profits.

Chandan and Shilpa(2009) using their exploratory study conducted on 30 organised retailers, revealed that among

the various benefits of RFID, retailers perceive better in stock, inventory reduction, safety and integration of system to be the priority benefits. They also presented the challenges faced by Indian retailers for implementing RFID. Kamaladevi(2010) analysed the problems of privacy and security related to RFID and presented a five phase life cycle model using a case of Radionuclide Transportation Agency(RTA). These are initiation, acquisition/development, implementation, operation/maintenance and disposition. Kanak(2008) observes that optimization solutions can be implemented easily in organizations using inventory optimization software.

Paper by Raviprakash et al.(2009) explores how the RFID technology is used to solve problems in healthcare SCM (including telemedicine), the barriers for adopting RFID, the implementation methodology, and some relevant case studies. Sameer et al.(2009) narrated the potential benefits and challenges of RFID implementation for consumer packaged goods companies and retailers. Samridhi et al.(2008) have presented a snapshot of current usage of modern ICT (EDI, POS, RFID, ERP etc.) in leading Indian organized retailers. Shirish(2009) examines the implementation

of a new technology including RFID for tracking individual freight railcars (wagons) by Indian Railways.

Srivastava(2007) presents an overview of technological benefits of RFID while expressing a balanced approach as to its potential concerns and implications. Whitaker et. al.(2007) proposes a theoretical framework for RFID adoption and benefits, and tests the framework using data on US firms. Their analysis suggests that firms with broad IT application deployment and a critical mass of RFID implementation spending are more likely to report early returns from RFID deployments. They also found that a partner mandate is positively associated with expectation of an early return on RFID investment. Study also revealed that the lack of industry-wide RFID standards result into a delayed return on RFID investment. Paper by Wyld(2006) examined how leading pharmaceutical companies are seeking to protect their brands, bottom lines and patients through the use of RFID to ensure the integrity of their products. They also provided the legislative efforts to improve pharmaceutical supply-chain security.

Based on the above review, it can be interpreted that there is too much hype about RFID in India but its im-

plementation is still on embryonic stage. Due to limited adoption and usage of RFID, there is very little literature available on this subject. Focus of most of these researches is on one or other sectors and thus they lack comprehensiveness. Authors could not find data about RFID implementation in even one sector. Further, publicly available cases belong to companies belonging to different industries. In view of these issues, there was no scope for primary research. Due to this gap, authors have made an attempt to investigate the diffusion and the use of RFID in India. For collection of relevant information, secondary research was undertaken mostly through case study method. Relevant cases and research articles were collected from online resources and journals. This paper attempts to achieve following objectives:

- a) To assess the current applications projects (both public and private) having RFID implementations in India.
- b) To understand the business ecosystem for RFID in India.
- c) To review the challenges of RFID implementations in India
- d) To draw lessons for international business community from Indian scenario.

III. Applications of RFID

RFID systems can be implemented anywhere requiring a unique identification system. Globally, it has been used in some part or throughout the supply chain to automate and speed up inventory identification and for movement of items. Its broad scope of activities is as follows:

Proactive control of business processes:

RFID helps in improving asset utilization and inventory management by tagging raw materials, finished products and fixed assets across the value-chain. This real-time view enables the company to take proactive control of forecasting, production scheduling and customer relations.

Real-time inventory and asset visibility:

RFID improves inventory tracking, enhances logistics and distribution, strengthens field communications and reduces labor costs. By optimizing production and maximizing asset utilization, organization can increase its bottom line. Managers can make more informed decisions about production, inventory and delivery promise dates and quickly adapt to fluctuating market demands.

Synchronizing business:

With the aid of RFID, the entire life cycle of a product can be tracked from its creation to its sale, service and even disposal. With better supply chain management with RFID, organization can improve its relationships with both suppliers and distributors.

1. Industry Specific Applications

Application in pharmaceutical industry:

This industry is under continuous pressure of rising input cost, growing need for product safety and brand protection, threat of counterfeiting and tight legal requirements. Here, RFID improves raw material tracking for the manufacturing audit trail right from the factory floor to avoid counterfeiting and speed up clinical trials. E-pedigree product of Siemens makes pharmaceutical products visible and traceable on their way along the value chain through volume serialization, ensuring continuing safety.

Combating retail shrinkage:

Better tracking of inventory of inventory in retail industry reduces the retail shrinkage to a significant level. Retail shrinkage is the difference between

book stock and actual stock. It is the unaccounted loss of retail goods mainly caused due to theft by employees, administrative errors, shoplifting by customers or vendor fraud.

RFID improves promotional efforts:

Retail giants such as Kimberly-Clark and Procter & Gamble are using RFID to track the location of promotional displays in the supply chain and within RFID-enabled stores. RFID also has the potential to improve in-store marketing by enabling retailers to advertise to shoppers depending on where they are in the store. Consumer Product Goods(CPG) and retail companies are using RFID to track promotional displays, reduce out-of-stocks and improve shipping and receiving accuracy.

Other uses of RFID tags in India and abroad are given below:

- In libraries, books are being tagged for self-automated checkout, freeing up librarians to perform other tasks. This also allows a librarian to easily locate a book misplaced on the wrong shelf.
- Hospitals and health-care providers are using RFID technology to track patients and high-value as-

sets, as well as ensure patient safety.

- Pet owners have begun implanting their cats, dogs and other livestock with RFID chips to locate them if they are lost.
- The US Department of Agriculture (USDA) is in the process of implanting every cow in the United States with RFID, making it easier to track diseases.
- The Japanese Ministry of Internal Affairs and Communications is planning to use RFID for tracking disaster survivors. They intend to sprinkle disaster affected areas with RFID tagged sensors that would form a mesh network to detect heat and vibration.
- One of the most difficult jobs for any army around the world is to keep track of its soldiers during wars. Due to loss of time, many lives are lost in the process. Realizing this, SkyTek is working in association with military of few countries for shrinking handheld readers for identification of injured soldiers and transmitting the data. It will help in reading the RFID wristbands of injured soldiers and collect the important data for saving lives and other operations.

IV. RFID Business-ecosystem in India

Business-ecosystem³⁾ for RFID in India consists of government, private players and its association, academic institutions and industrial customers. A brief role played by each player for proliferation of RFID is presented here.

Government Support:

Government plays a pivotal role for growth of any industry. For RFID industry, government plays a significant role of regulator, policy-maker (including standardization) and customer also. Thus, progressive governments can make or mar this industry. In U.S., Department of Defense(DOD), Department of Homeland Security(DHS) and Food and Drugs Administrator(FDA) have even issued mandates to deploy RFID to their suppliers. A large number of countries have initiated RFID enabled e-Passports. Indian government is also planning to launch RFID passports soon, which

would set the momentum of growth in the technology in areas of security.

To kick-start RFID adoption among Indian companies, regulators in India designated ultra high frequency(UHF⁴⁾) RFID spectrum in year 2005. The Wireless Planning and Coordination (WPC) wing of India's Ministry of Communication assigned the 865-867 MHz UHF band for use by RFID devices. This outcome is the result of a process initiated by EPC global India, a joint industry-government initiative that is leading the development of EPC to support the use of RFID in India. India had originally considered allocating 2.4 GHz as the spectrum for UHF RFID, but due to its incompatibility with the operators in the United States, Europe and other key markets, decision was taken in favor of 865-867mhz spectrum. Originally this spectrum band was allocated to India's military and railways for its applications.

Department of Information Technology is providing RFID based technological solutions to the Indian industries. Its ambi-

3) A widely accepted strategic planning concept introduced by James F. Moore in year 1993. According to Moore, It is an economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. Book: *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*, 1996.

4) http://www.epcglobalinc.org/tech/freq_reg/RFID_at_UHF_Regulations_20090318.pdf provides an overview of the Ultra High Frequency (UHF) regulations used worldwide. It contains data like country, status, frequency, power, techniques, comments and regulator.

tious "National RFID Program" project was initiated in April, 2007. It is being implemented jointly by Indian Institute of Technology(IIT) - Kanpur, Center for developing Advanced Computing(C-DAC) - Noida and SAMEER⁵⁾ - Mumbai. The major highlights of the project are software/hardware development, middleware integration and development of end-to-end solutions. Research component is mainly undertaken by IIT Kanpur, application development including deployment and support is provided by C-DAC while SAMEER is focused primarily on RFID antenna design and other RF related issues. C-DAC and IIT - Kanpur will also undertake RFID related manpower development programs.

Academic Initiatives:

Large number of Indian universities offers RFID subjects in electronics, computer science and electrical engineering as well as in other technical courses. EPCglobal India is also hoping to see an Indian university become one of the Auto-ID Labs. AIDC Technologies, a non-profit organization with a nation-

wide network of manufacturers, system integrators, consultants, and software experts and AIM India, affiliated with AIM Global Inc, regularly conducts hands-on training and RFID certification for professionals across India. In August 2008, AIDC signed a partnership agreement with Montreal's Academia RFID Centre of Excellence, North America's fastest-growing network of university professors specializing in RFID courseware development and vendor-neutral business case development.

Industry Association:

The RFID Association of India(RFIDAI) is a dynamic RFID professionals association whose members come from both government and private industry. In April 2005, RFIDAI was found as a not-for-profit society under the Companies Act to promote the adoption of RFID technology, standards and applications across industry, government and academia. It focusses on networking and information exchange-conducting meetings, educational seminars and activities based on the needs and interests of our

5) Society for Applied Microwave Electronics Engineering and Research (SAMEER) was set up as an autonomous R & D laboratory at TIFR, Mumbai in year 1984 under the Department of Electronics, Government of India with a broad mandate to undertake R & D work in the areas of Microwave Engineering and Electromagnetic Engineering Technology.

membership.

RFID Implementation:

Indian information technology companies are stepping up initiatives to promote RFID in India. SAP has set up an RFID Centre of Excellence(CoE) in Bangalore. The center will help Indian organizations choose the right products for their environment and later deploy solution. All leading software giants of India i.e. Wipro, Infosys, Tata Consultancy Services TCS, Patni, Cognizant, IBM and Satyam offer services such as track and trace, asset tracking, cold-chain tracking vehicle tracking, document management and inventory management based on RFID technology. In addition, many of these companies have developed several filters and adaptors for software components, as well as a basic middleware tool developed on an open source platform.

Gemini Traze RFID facility is a first among the SAARC(South Asian Association for Regional Cooperation) nations. It had capacity to roll out 100 million ultra-high frequency(UHF) tags annually in year 2007. Indian companies are currently actively evaluating the deployment of RFID, with numerous pilots under way. Indian companies such as

Pantaloon, Madura Garments and Ashok Leyland were among the first to run Pilot projects related to RFID for process excellence. Mahindra & Mahindra, an automobile company in the country was also one of the early adopters of RFID and now is in full swing for utilizing it in areas ranging from warehousing to vendor tracking.

Wal-Mart is credited with revolutionizing the US retail industry by mandating the use of RFID. Experts are optimistic about transformation of Indian retail industry too with presence of Wal-Mart. It is likely to improve the complementary industries as the company would adopt the latest technologies to ensure operational efficiency besides competitive differentiation.

V. RFID Application Projects and Cases in India

This section summarizes selected projects initiated by public sector as well as private companies. These projects are representative cases of RFID application in India.

e-Passport in India:

Ministry of External Affairs of India launched an ambitious e-Governance

project named 'e-Passport' in the year 2008 under National e-Governance Program(NEGP). The consular and passport division(CPV) of the external affairs ministry plans to set up 77 Passport Seva Kendra(PSKs) across the country by 2011 in partnership with TCS at an estimated cost of INR100 crore⁶⁾. The new passports have been designed by the Central Passport Organisation, New Delhi, India Security Press, Nashik, and the Indian Institute of Technology(IIT), Kanpur. First pilot center opened at Bangalore in 2009. The other five PSK centers have been set up at Hubli and Mangalore in Karnataka, one each in Chandigarh, Ludhiana in Punjab and Ambala in Haryana. The PSKs will dispatch RFID enabled biometric passports in three working days (unlike current 35-40 days) subject to police verification and on same day under the tatkaal (Hindi word for Immediate) scheme. First e-passports is issued in March 2010. Initially, e-passports would be issued to diplomats only and the scheme would be extended to other citizen from September 2010. The e-passports have an electronic chip that contains relevant personal data of the holder to simplify procedures at

immigration.

RFID Pilot at HPCL:

IBM has implemented a RFID-based solution for Hindustan Petroleum Corp. Ltd(HPCL), a Fortune 500 company and a downstream petroleum organization in India. This pilot project executed at HPCL's Nashik plant is part of \$2.2 million deal, signed in March 2008. It is one of the single largest implementations in India for RFID-based tracking solutions and involves infrastructure services, business consulting services and middleware solutions. Under this agreement, IBM designed, deployed and integrated the RFID solution for tracking LPG cylinders from plant to the end-consumer. It had the objective of streamlining the process of identification of LPG cylinders during bottling, distribution and supply chain, and was expected to cover 500,000 cylinders in the initial phase. HPCL intends to evaluate the technology and deploy the same in a phased manner to cover the entire supply chain from bottling plant, logistics, and distributors to the end-consumers.

RFID Tagged Marked sheets:

6) 1 USD = 46.87 Indian Rupees on 21-5-10 (<http://www.exchange-rates.org/history/INR/USD/T>) ; 1 Crore = 10 million

Fake resumes and documents have posed big challenge for companies during recruitment and selection. RFID-tagged certificates and marked sheets have potential to beat forgery and resume fraud and can be used to identify the culprit. Hyderabad Central University(HCU), in collaboration with TCS has been offering RFID chip-embedded degree certificates to its students since year 2007.

RFID at India Post and Railways:

India Post and Indian Railways tests RFID for various operations. Indian railways have invested INR 2 crore in tagging 1,000 wagons. If successful, the railway ministry may invest up to INR 250 crore in putting RFID systems on all its wagons. As the railways run over 2.16 lakh wagons carrying more than a million tons of freight a day, RFID industry has big potential in future. The Delhi Metro Rail Corporation(DMRC) uses a secure microcontroller-based RFID chip called the MiFare DESFire, designed by NXP Semiconductors, Netherlands to offer RFID based tickets at more than 100 stations in Delhi.

Indian Railways is also exploring the same chip for its automatic unreserved ticketing system(AUTS). The technology will facilitate the adoption of contactless

smart-cards for automatic fare collection using automatic ticket vending machines (ATVMs). Computerized Reservation Information System(CRIS) of Indian Railways developed an ATVM as part of UTS. These ATVMs will be rolled out across five major cities in India-New Delhi, Secunderabad, Kolkata, Bhubaneswar and Pune.

Indian Post office handles about 60,000 sacks of mails every day and there is mechanism to track them manually. The department has launched a pilot project for its Speedpost service between Mumbai and Delhi. If successful, India Post may invest close to INR100 crore on RFID. Presently, C-DAC, Noida is in the final stage of developing and testing pilot project of Parcel Tracking System for Department of Posts. The pilot will be implemented at selected Speed Post Centers. The software will be later integrated with the existing Speed-Net software of Department of Posts. SAMEER, Mumbai has provided technical support to CDAC in field trials in terms of the characterization and modifications of RFID.

RFID at Sabare International:

Sabare International, a home furnishings textiles exporter headquartered in

the small South-Indian town of Karur with five manufacturing facilities and 10 warehouses, is using RFID tags to reduce its operating costs. Sabare's \$25,000 pilot project was implemented by Gemini Traze RFID. The passive, read-write laminated RFID tags are used in the raw material section to keep track of inventory and in the stitching department for quality monitoring. Data from the tags is used to update the ERP system and to give managers information they need for making decisions such as how the work-in-progress should be matched to shipping and customer order schedules and what measures need to be taken to reduce manufacturing defects.

RFID at ICC Champions Trophy:

On November 2, 2006, NXP Semiconductors, Smartag and Gemini Traze have collaborated to implement a "hands-free" RFID ticketing solution as a pilot for a sporting event—the semifinal of ICC Champions Trophy Cricket tournament 2006—hosted by the Rajasthan Cricket Association(RCA) in Jaipur. NXP has provided the IC chips based on the proven ICODE technology, Gemini installed the reader terminals and "walk thru" gate antennas, and provided the system integration expertise while Smartag pro-

vided the tickets into which the chips are embedded. Spectators holding special tickets entered the stadium quickly and conveniently. RCA became the first state cricket association in India to have adopted electronic ticketing system for an international cricketing event.

RFID Highway Tolling System:

Indian government plans to adopt a nation-wide RFID-enabled Open Road Tolling(ORT) system, which enables a one-time toll payment per trip. On October 31, 2009, the ministry of road, transport and highways(MoRTH) began a pilot project testing the merit of three different ORT systems. Toll fees is deducted either from the users' bank account, or collected at the beginning of the journey, in the manner of pre-paid or post-paid phone connections. The Indian government expects the new toll system will expedite highway traffic and greatly reduce queuing time of vehicles at toll booths. One of the highways hosts an active RFID system, the second a passive RFID system, and the third an infrared system. The active tolling system (a microwave tag-based system that sends or receives signals) will be tested on the Gurgaon- Jaipur stretch. The passive system (also microwave-based, but only

send signals) on the Panipat-Jalandhar stretch. The calm ORT system, an infra-red-based system that works on an optical fiber network, will be tried on the Surat-Dasihar stretch.

United Nations Initiative for Postal Efficiency:

The Universal Postal Union (UPU) - the UN arm that coordinates international postal services - has kicked off a project to use RFID chips to track the speed of international mail deliveries. It began a test phase of the project in 21 countries in August 2009 using tag processing systems from Reva Systems. The objective is to improve the UPU's ability to monitor the speed of postal deliveries of letters. The system uses inexpensive Gen2 RFID tags hidden inside envelopes that will be read automatically as they pass through RFID portals at the international gateway offices. India and South Korea are among the countries participating in the 21-country trial. The UPU wants to extend the system to 100 countries by 2012.

Cost Saving by RFID at Cognizant:

Cognizant, a leading global IT and business process outsourcing services provider, has successfully deployed a

RFID based asset-tracking system at one of its primary data centers located in Kolkata, India. The company installed readers in the data center racks and attached RFID tags to the servers, network gears, laptops and other assets.

Google India's RFID Application for Locating Shared Equipment:

Google India is using an RFID system to track up to 100,000 of its assets at its offices. Google's staff members share the use of thousands of electronic devices, including laptop computers, projectors, monitors and external hard drives. To foster a company climate of open sharing of tools without bureaucracy, Google India wanted a wireless tracking system. ARIES Visualizer, provided by Cincinnati based RFID middleware company Analytica USA, enabled Google employees in Indian offices to locate their electronic assets on a Web-based platform that includes a Google Maps feature.

When an employee carries an ARIES handheld RFID interrogator, the device reads all tag ID numbers. Each asset is then linked with the cubicle or room RFID tag, which allows the system to pinpoint the asset's location. When an authorized person uses a computer to

log onto the Web-based server, the computer screen shows the asset's location on a floor plan of the facility, allowing that person to drill down to a very specific location when seeking a piece of equipment by simply pointing and clicking the mouse on an item or location. Google India installed the system at its Hyderabad campus in early 2008, and in six months, it has tested it in three buildings at that location with a total of eight floors. Based on the success of this pilot, the company has begun deploying the system in Bangalore and eventually will expand it to all the Google India offices.

Adani's RFID Application in Logistics:

Adani Grain Logistics, which operates several grain storage facilities in India, has implemented an automated RFID-based system for receiving, testing and tracking food grain harvested in the states of Haryana and Punjab. The system was tested in April 2007, and was deployed permanently three months lat-

er at two grain depots, located in the cities of Kaithal and Moga.

Animal Tracking at Kopordem Farm:

The Kopordem farm at Valpoi in Sattari Taluk in North Goa has become the first farm in India to use RFID microchips that can be injected into the animal's body. While 50 cows from the farm have been injected with the RFID capsule under a pilot project for the state government's animal husbandry department, the device will be implanted into 500 more cows at different state government farms soon.

RFID Pilot at Citibank:

Global financial giant Citibank has conducted a pilot project based on Near-Field Communication(NFC)⁷⁾ payment at Bangalore, India and found that participating consumers use their mobile phones to pay for purchases at a higher rate than consumers using traditional credit cards. The Citi Tap and Pay project, which launched in June 2009 and

7) NFC is a short-range wireless connectivity technology standard designed for intuitive, simple, and safe communication between electronic devices. NFC communication is enabled by bringing two NFC-compatible devices within a few centimeters of one another. Applications of NFC technology include contactless transactions such as payment and transit ticketing, simple and fast data transfers. The NFC Forum is a not-for-profit industry organization whose mission is to advance the use of NFC technology by developing specifications, ensuring interoperability among devices and services, and educating the market about NFC technology. About 140 companies have teamed up to achieve this goal.

is slated for completion in early 2010, involves approximately 3,000 consumers and 250 merchants. The pilot employs NFC-enabled Nokia 6212 phones, mobile network operator Vodafone's wireless communications service, MasterCard's PayPass contactless credit card system and security infrastructure, and ViVOtech's NFC wallet software (based on RFID), mobile coupon software, smart poster software and NFC readers.

Infosys Initiative in RFID-based Tracking:

Infosys Technologies has implemented a pilot to enable a client in the health care industry to tackle supply chain problems for high value items and to automate supply chain processes. Infosys has also assisted CHEP, a global pallet and container pooling services company that handles more than 2.5 million equipment movements per day, with an RFID-based track-and-trace solution.

Canada-India RFID project to improve traffic flow and reduce pollution:

A research collaboration project is established by the McMaster RFID Applications Lab (MRAL), the Indian Institute of Technology (IIT) - New Delhi, IPICO Inc. and Strategic

Consultants, New Delhi for environmental cause. The \$2.5 million initiative has received \$1.2 million in matching funding by International Science and Technology Partnerships Canada (ISTPCanada) and the Global Innovation & Technology Alliance (GITA). The funding will be used to continue the development of a technology solution to power an intelligent transportation system framework. The goal of the project is to create an economically-viable RFID solution to capture and analyze data related to traffic use and capacity, without a corresponding increase in investment in road infrastructure.

RFID Use for Rural Banking in India:

NXP Semiconductors has partnered with seven banks to offer its RFID based mobile payment solution in more than four hundred and fifty villages in four states in India. The RFID-based cell phone will be working with a micro banking platform from 'A Little World'. With this, more than forty five thousand rural populations will be able to avail services such as deposits and withdrawals, micro insurance and cashless payments without visiting the bank branches. The smart card in the phone will biometrically store identity details

of the customers coupled with details of their bank account.

VI. Challenges in RFID Implementation in India

RFID has the ability to transform many applications and operations in large number of industries. Despite numerous benefits over manual practices as well as computerized bar-code systems, RFID is yet to fully take off in India as well as in many parts of world. Following are some of the reasons for the status of scenario.

High Cost of RFID:

Actual RFID deployments in the country are few as compared to the hype that was created. In transition from bar-coding to RFID, cost turned out to be a big hurdle. Companies are unable to justify the ROI of the new technology as large investments are required for it. Active tags are very expensive but cost of relatively inexpensive passive RFID tags added with the cost of reader, software, and infrastructure may not be affordable to organization as well as end-customers. But, with gradual decline in the cost of RFID tags, the technology is becoming more affordable.

Small Scale:

Compared to bigger corporate houses of western world, Indian businesses lack scale to justify ROI from RFID. Manual labor savings from RFID deployment are also not attractive enough in India where labor costs are already low.

Lack of Standard:

There are well-developed standards for low-and high-frequency RFID systems, but most companies want to use UHF in the supply chain because it offers longer read range—up to 20 feet under good conditions. UHF technology is relatively new, and standards got established very late in India.

Lack of Mandates:

Unlike western countries, India does not have any mandates from retailers or government to drive the adoption of RFID. Exporters that do not have any mandate from buyers such as Wal-Mart in the United States and Metro Group in Germany or regulatory bodies such as the U.S. Food and Drug Administration(FDA) to implement RFID do not feel any motivation to implement RFID. Even other global retail giants like Tesco, Marks & Spencer and Carrefour of UK have also mandated the use of RFID for its major vendors.

With Indian companies in the sourcing radar of these giants, we may see some companies adopting RFID in near future. For example - Ranbaxy Laboratories Limited has chosen Acsis to implement a RFID tracking system to meet Wal-Mart's RFID mandate for its Class 2 pharmaceutical suppliers

Lack of Optimal Readability:

Accuracy in the case of RFID depends on three factors: signal strength, frequency, and the surrounding environment. Most tags have limited readability in RF impaired environments or when placed near metals or liquids. Researches have shown that RFID scanners successfully read tags 85 to 90 percent of the time. Some RFID tags cannot be detected by the antennas if they are shielded by the hand or the body. A solution suggested is that the RFID label should be integrated in the package or the product itself so the exact location of the tag is not known.

Privacy Issues in RFID:

Due to the lack of industry standards regarding the use of personal information that could be encoded on the chips, many privacy advocates have called on companies to state their in-

tended use of the technology. RFID can be used to trace customer behavior or find customer specific information. The tags can be read even if they are kept in the cars or homes of the customer.

Short on Skilled Workers:

Despite the presence of reputed software companies and pool of engineers passing every year, there is still a shortage of software developers in India who know how to develop end-to-end mission-critical RFID applications.

Abundance of raw, unprocessed data generated by sensor networks and many diverse device types with differing functionality, usage and interfaces are some of other obstacles. Much of the data generated is of no use and unnecessarily takes up disk space. According to a study conducted by Akash Deep Batra, RFID solutions consultant, Infosys Technologies Ltd, approximately 70 GB of data is generated by 50 RFID readers in a day taking its toll on disk requirements.

Problem of high cost can be taken care by economies of scale and use of RFID solutions for high value items only. Additional output of RFID solutions can be exported from India to other developed countries as the cost of production is surely going to be lower compared

to western world. Standards for RFID are now well-developed in India. Aspect of mandate for RFID may come subject to entry of big retailers like Wal-Mart. Following in lines of US DOD, subsequently, Govt. of India can also issue mandate for RFID for defense purchases for better tracking and tracing. Issue of optimal readability is an international phenomenon and is not related to India alone. Similarly, privacy breach occurring due to RFID usage is also a global concern. For India, skilled labour cannot be a major concern as it produces one million engineering graduates every year that can be provided with necessary knowledge and skills to work in the RFID environment.

VII. Conclusion

According to product life cycle(PLC), the RFID market in India can be considered under the introduction or early growth stage. However, with the semiconductor industry and mobile communication technology maturing in India, RFID is expected to enter the market in a big way. IDC estimates that the Indian RFID market will grow at a CAGR of 70.2 percent between 2005 and 2009. As RFID grows at a rapid pace across

the world, Indian software firms are targeting the global market in retail, logistics and manufacturing. There is a big opportunity for the Indian software industry in the development and implementation of RFID-based software solutions. Gartner states that RFID adoption continues to gather momentum and spending on related hardware and software is expected to amount to \$3 billion by 2010.

VDC Report suggests that, the RFID market for North and South America in 2007 was \$415 million, and is expected to expand to \$1.28 billion by 2012. In the combined Europe, Middle East and Africa(EMEA) region, the RFID market was valued at \$428 million, and expected to rise to \$960 million by 2012. In the Asia-Pacific region, the RFID market in 2007 was \$379 million and will reach \$1.6 billion by 2012. According to "Global RFID Market Analysis till 2010", a new research report from RNCOS, global RFID market is projected to grow at a CAGR of over 28% between 2010 and 2013. The report states that Asia-Pacific will witness the highest RFID revenue generation owing to rapid adoption of RFID applications in several countries, including China, India, South Korea, Taiwan and Thailand.

According to Ravi Mathur, CEO of EPC Global India, “The greatest opportunity for India will be the middleware segment, where IT companies can develop software to pick up RFID data, and also work on network security”. Adoption of RFID technology is also desirable, especially since the country is gradually becoming a sourcing destination for global supply chains. This will push Indian companies exporting their products to an international market, to adopt technologies such as RFID to comply with overseas mandates. In domestic market also, RFID shows good potential due to success of large number of pilots conducted by public as well as private sector organizations. For developing countries like India, companies need to target RFID for high priced consumer durable industry, automobile industry as well as business to business(B2B) market rather than focusing on price sensitive FMCG markets. Projects of national significance in recent times are also likely to fuel the growth of this industry. NXP Semiconductors’ Ashok Chandak, expects 600 million unique ID cards, 50 million e-passports, 100 million health cards, 50 million transport and ticketing cards and 50 million banking cards likely to be issued over the next seven years.

Overall in current terms, this market may not look attractive to international players but success of RFID pilots as mentioned above, pragmatic policies and strategic directions of government, matured software and telecommunication industry, likely entry of multi-brand retailing in India, rising scale of Indian companies coupled with low cost and growing concern for quality of products, India can be a big market for RFID technology in future. It is needless to mention that its current status needs quantum leap from entire business ecosystem. And this status casts an open opportunity for future international collaboration in developing and deploying RFID hardware, software, flow of systems, and procedure development with developed countries like USA, Germany, UK, South Korea, Japan etc which have developed advanced capabilities and are much ahead in terms of diffusion and usage than India.

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