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"Technical Note"

RFID: A Bibliographical Literature Review with Future Research Directions

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ABSTRACT

The purpose of this article is to review some of the most prominent applications of RFID in industries and to provide a comprehensive review of the work done from 1985 through 2012 and the research trend on that. The effectiveness of RFID and the challenges facing with are also discussed. Some applications of radio frequency identification in supply chain are briefly discussed. Articles are classified by the year of publications and each case is discussed very briefly. To obtain a good understanding of the level of the researches completed up to the end of 2012 a table and graph are used to demonstrate the summary of results. In this research, author came up with 550 articles on RFID as all are listed in a single table. The findings point to this fact that research on RFID has started to pick up on year 2002 with 16 publications and then reached to its pick at year 2005 with 112 publications, and then trend went down to 42 and then up to 66 publications for years 2006 and 2007, respectively.

1. Introduction

If RFID is to achieve the level of adoption that has been forecasted, it is important to understand the capabilities and limitations of the technology as evolves, its applications areas, and various types of applications. Besides that it is important to know how various enterprises are thinking about that as it progresses and how much they will invest on the components of that and when they are going to get into RFID technology. Manufacturers can use RFID solutions to reduce operating costs through decreasing the labor costs, claims and returns. This will help them to increase the operating income. They also can reduce working capital by enabling reductions in inventory and lowering the inventory write-off from the return goods and those items that are un-saleable at the end.

The purpose of this article is to review the works published on RFID technology from 1985 through 2012. To provide a meaningful survey the following criteria are considered in this paper:

1. Works published in all journals.
2. Work done in the United States as well as abroad
3. Application areas as well as theoretical and introductory works related to the subject
4. Special articles thought to be important to the field of RFID.

A total of 401 published references on RFID technology have been compiled in this research. To make the foregoing criteria operational, a survey was made using following sources:

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- www.Sciencedirect.com (Elsevier web site [414])
- www.emeraldinsight.com (Emerald web site) [417]
- Web Directory such as Yahoo and Google [415, 416]
- This author personal knowledge on the topic.

Section 2 gives a broad overview of the RFID. Section 3 shows data distribution by publication years and the trend on publication. Section 4 classifies RFID applications into twenty different applicable groups. RFID effectiveness, future research directions, and challenges to that are discussed in sections 5, 6, and 7, respectively. Author's conclusion is given in section 8.

2. An Overview of RFID

United state is the greatest adopter of RFID and has used the largest number of cases and ordered million of tags that are among the largest in the world. United Kingdom is on the second place by the number of the cases, not the money invested. China comes the third, thereafter is Korea and Japan. Next, comes Australia and hence New Zealand (Das, 2006). A research completed by the IDTechEx (Das, 2006) using a knowledge base with 2400 cases covering 2600 organizations and 91 countries indicates that Australia has jumped from the 10th place to the 7th place due to the fact that RFID is used in the libraries, hospitals, and by law it is required to be used for tagging cattle, life animals, livestock, race horses, and others.

RFID is a term used for technologies utilizing radio waves for identifying individual items automatically. The most common way is storing a serial number identifying a product and related information on a microchip attached to an antenna. RFID is used very similar to bar codes. It is designed to track items in the supply chain without requiring a line of sight. To read a bar code its lines had to stay in sight of the scanner to identify product correctly.

Food and drug industries have enormous potential for utilizing RFID technology. This is largely because each chip is unique to the specific box of medication or food it is attached to. Therefore, tracking where each product is located becomes relatively simple. When a chip is attached to a box and manufacturer recalls a batch of products, then the RFID tags for the containers affected can be flagged electronically. Eventually, food and/or drug retailers will not be able to sell recalled products because cash register and store's computer system will not allow it. Once this technology is coupled with the power of the Internet and there is a real-time product recalls, where retailers' own inventory control systems, tied into RFID databases, alert the store manager to pull specific type of drug off the shelves while leaving the rest [Kumar and Budin [235].

Automatic identification and data collection (AIDC) had made large contributions to many companies bottom line. Radio Frequency Identification is one of the most wanted technologies in the today's large successful enterprise like Wal-Mart, Dell, Automobile Part makers, Food Stores, Computer Stores, Bookstores and so on with the hope that operating costs will decrease and products will get more accurate in both data collection and reporting. More organizations from manufacturers to government agencies, retailers to healthcare providers are introducing RFID technologies into their supply chains, for asset tracking and on time management, and for the security and regulatory purposes. However, as companies explore these significant advantages through pilot programs the impacts of RFID technologies on the company wide network must be considered.

Wal-Mart has asked its large suppliers to begin tagging all shipments starting from January 1st 2005 (Zare-Mehrjerdi, 2007). It is important to note that Wal-Mart with its enormous purchasing power can force not only its suppliers to tag the shipments, to its warehouses all around the US, but makes it customary for all the shipments all around the world. US Department of Defense (DoD) [81, 127, 366] is another big player with the influential voice that can have its words play big in the tagging and RFID business. The process of RFID developments and activities for 95 years (1906 through 2001) is listed in table 1.

Tab. 1. Early RFID developments and activities by years

Year	Authors/Companies	Activities
1906	Ernst F.W. Alexanderson [239]	Showed how the first radio wave could be generated continuously and how radio signals could be transmitted
During WWII	British [239]	A system called Identity Friend or Foe (IFF) that was the first use of RFID
1948	Harry Stockman [344]	Communication by means of reflected power
1964	Harrington, R.F. [171]	Examines the electromagnetic theory related to RFID
Late '60	Three Companies called Knogo [239]	Developed electronic article Surveillance equipment to face the theft of merchandise
1973	Raytheon Co.	Developed electronic identification systems

1973	International Bridge Turnpike and Tunnel Association and the US Federal highway Administration	Held the first conference on Radio Frequency Identification (RFID)
1975	RCA Co.	Developed electronic identification systems
Year	**Authors/Companies**	**Activities**
During '70s	Research Laboratories and Universities	RFID research
1978	R.J., King [226]	A book on microwave homodyne techniques was published that were used as the basis for the development of the theory and practice
1987	Norway	First commercial application of RFID was developed in Norway
1989	Dallas North Turnpike, USA	First commercial application of RFID was developed in USA
During '90	USA, Kansas and Georgia	Adopted a traffic management system which was based on the use of readers that could detect protocol tags
2001		RFID tagging for electronic toll collection had expanded to 3500 traffic lanes.

2-1. Active vs. Passive RFID Tags

RFID is not a new phenomenon. It has been around for decades. It was used initially for proximity access control. Thereafter, it was evolved to be used in supply chain tracking, toll barrier control, and even protecting automobiles (Potter, 2005). There are four types of tags in industry that are known as: (1) Passive tags; (2) Active tags; (3) Semi Passive tags; and (4) Semi Active tags. Passive tags get their energy from a remote RFID reader.

An active tag uses a battery for both the chip and the transmission of data on the antenna. Semi-passive tags use a small onboard battery to power the chip. Semi-active tags use the battery for powering the antenna but the chip relies on the Radio Frequency (RF) energy from the reader (Potter, 2005). To conserve power, the active tag remains "asleep" until awakened by a low frequency radio signal. This activation signal is generated by a small low frequency radio transmitter called an "Activator" connected to an application specific antenna. The power level of the Activator and the type/size of antenna determine the size/density of the activation field.

The life of active tags are limited while of passive tags are unlimited. Active tags are heavier than the passive tags and more costly as well. The use of different tags varies with the scope of applications. Active RFID tags are reusable but more expensive; they are often used in a fixed geographical location. In contrast, passive RFID tags are cheaper and disposable, often adopted in a mobile scenario (Hoffmann, 2006). Active tags, because of their power also have the ability to act autonomously (i.e. without an external activation). A tag can be configured to alarm and send an alert signal if removed.

Active tags are also used for wireless sensor monitoring. They can be integrated with different sensor types to monitor the change of conditions of such things as temperature, humidity, and pressure, as well as hazardous chemicals or radiation (Axcessinc.com [79]).

2.2 RFID Frequencies

RFID systems work at a number of different frequencies including 125 KHz, 13.56 MHz, 2.45 GHz and 5.8 GHz and for UHF 860-950 MHz. Low frequency tags work along 120 KHz-140 KHz frequencies while high frequency tags work along the 13.56MHz radio frequencies. Ultra high frequency (UHF) tags work along the 850-900 MHz. Low frequency tags are less expensive and use less power compare to other kinds of tags.

High and ultra high tags have better ranges and transfer data faster. These two types of tags use more power and are more expensive. Table 2 summarizes the areas of application of various Chips for different frequencies (Anonymous, 2004). Knowing that producers target specific industries once begin to produce a tag and try to expand to other areas as well it is important to know the producers and users at the same time.

Tab. 2. Tag frequencies used by different countries [300]

Frequencies	Tags application Areas
125-134 KHz	USA, Canada, Japan, Europe
13.56 MHz	USA, Canada, Japan, Europe
433.05-434.79 MHz	In most of USA and Europe and under consideration in Japan
865-868MHz	Europe
866-869 and 923-969 MHz	South Korea
902-928 MHz	USA
952-954 MHz	Japan (for passive tag after 2005)
2400-2500 and 5.725-5.875 GHz	USA, Canada, Japan, Europe

2-3. RFID Costs

The RFID reader acts as a transmitter/receiver. The reader transmits an electromagnetic field that "wakes-up" the tag and provides the power required for the tag to operate RFID readers usually cost around $1,000 - $2,000 and RFID tags costs are as discussed below. The tag cost can be broken down into following components: (1) Chip Cost; (2) Inlay/Substance with Antenna cost; (3) Assembly cost; and (4) Licensing cost. Chips cost is about $0.25 to $0.35 while inlay cost ranges from $0.02 to $0.10 and assembly from 0.02 to 0.04. In comparison with the price of one chip being estimated to reach $0.05 in year 2004 it is still very high (Chao, 2007).

The cost of RFID tags by frequencies is given in table 3. There exits few ways to reduce costs significantly: (1) Utilization of a universal RFID chip that can be used for many applications; (2) Capable of handling multiple applications; (3) Reducing the cost of packaging antenna to the chip; and (4) Automatic handling versus manual.

Tab. 3. Tag frequencies and Prices

Frequency range	Cost ($)
Low (120-140 KHz)	$3 - $10
High (13.56 MHz)	$0.50-$5.00
Ultra-High (868-956 MHz)	$0.75 and up

2-4. Tag Producers

RFID is a method for sending and receiving data without any contacts occurs between the interrogators and tags using electromagnetic waves (Anonymous, 2004). RFID tags can hold more information than data carrier systems such as bar code system. OMRON has announced that it will get into the RFID technology by year 2005. The technology is called "Jomful". Pictures presented by the OMRON company show two types of RFID tags with 13.56MHz and 850-960MHz (Anonymous, OMRON Report 2005). The company had received a patent for "Jomful" in the US, Europe, Korea, Taiwan, and Japan (Anonymous, OMRON Report 2005). Savi Technology has developed sensor-based security seals called SensorTag ST-646 for securing ocean shipping containers. This tag can detect both tampering and potential theft, as well as spoilage or damage of goods. The information is collected in real time (Chao, 2007).

MachineTalker a maker of active RFID tags designed to serve as wireless network nodes has partnered with Sense-Comm Technology, a developer, distributor and integrator of wireless sensor networks, to test a network of intelligent RFID-enabled tags at several large oil refineries (Bacheldor, June 2007).

Germany expands its leadership position as Radio Frequency Identification (RFID) provider for the automobile industry. Audi AG recently awarded IDENTEC SOLUTIONS a contract to provide its OIS-P RFID System for the production of the Audi TT (Anonymous, 2006).

"This contract emphasizes IDENTEC SOLUTIONS' leadership position as a leading provider of complete RFID solutions in the Automobile Industry," states Gerhard Schedler, CEO& President of IDENTEC SOLUTIONS. "With our proven product portfolio specifically designed for production environments, IDENTEC SOLUTIONS stands at the forefront of the international automobile manufacturing sector as an RFID provider. The growth potential is enormous, as is the savings potential for our customers," adds Mr. Schedler (Anonymous, 2006).

The foundation for a new class of network-embedded products and solutions at the CISCO Company is known as Application-Oriented Networking (AON). This technology help converge intelligent networks with an application infrastructure based on either service-oriented or traditional architectures (Anonymous, 2006). With Cisco RFID AON Solutions it is possible to do the followings: (1) Understand the content and context of application message and (2) conduct operations on the messages as needed. Cisco RFID solutions drive the following benefits for the users (Anonymous, 2006):

There are companies world wide that have hand on this technology. The most famous ones are: IBM, Intel, Infosys, Mobilhealth, Mobile Aspect, Hewlett Packard, GeorgiaTech, Applied Digial Solution, ExtraVera, Microfour, InnoVision Research, Parco Wireless, Precision Dynamics Corporation, and Agility Health Care Solution. Others are: Oracle, Oat Systems, Manhattan Associates, Symbol Technologies, Alien Technologies, Avery Dennison, Intelligent Systems, Zebra Technologies, Printronix, Accu-Sort, Tyco, Samsys, Intermec, AWID, CCL, Texas Instruments, Philips, and Thingmagic.

2-5. RFID vs Bar Codes

To date, RFID technology is still developing, standards are still converging, and costs are still being brought down in order to attach tags to individual customer products. However, the barcode system is deeply entrenched and will not be replaced any time soon (Wu, Nystrom, Lin, and YU, Technovation 2006). RFID is another supporting tool for automating processes and improve the operation management. It can bring powers to the decision making team by providing on time information. This technology is more sophisticated than the bar code. This is because of the following facts:

1. It will be embedded and read with no requirement for line of sight
2. Tags can be reprogrammed easily
3. Capable of working in suitable and harsh environments
4. Ready to carry 96 bits of information – compare with 16 bits for bar code
5. Fraud controlling increases
6. Cloning become non existence

7. Improves antitheft protection
8. Better supply chain efficiency
9. Cost saving
10. Profit enhancement
11. Better supply chain and inventory management
12. Reducing counterfeiting
13. Tracking work-in progress
14. Reducing administrative errors
15. Reducing rework
16. Better management of warrantee claims

Once above factors are available to users it can be seen that why stock handling, traceability and warranty also improves. Please notice that the fourth property of RFID tag gives it more power to be considered as a read or read/write device only. Regarding this technology, it is most important to be able to do the following simultaneously:

1. Reducing the cost of each chip to under $0.10
2. Producing in large quantities
3. Having customers with big demands
4. Keeping high the level of quality and reliability
5. Being ecologically concerned about the materials used in the product

The main detractors for this technology can be listed as:

1. Costs may overweight the benefits
2. Return on investment may not be possible in about 12 months
3. Customer finds difficulty to understand how RFID works
4. Difficulty in implementing RFID

Table 4 compares RFID and Bar Code on key dimensions as such as read rate, line of sight, human capital, read/write capability, durability, security, and event triggering.

Tab. 4. Comparison of RFID and bar code based upon some characteristics

Characteristics	RFID	Bar Code
Read Rate	Many tags can be read simultaneously – High productivity	Read one tag at a time and manually
Line of Sight	Not required	Certainly required
Human Capital	Once system is designed and set up then it is completely automated and do not need too much human help	Needs human capital to scan each tag
Read/Write Capability	Ability to read, write, modify and update	Read ability only
Durability	High – It can be used in harsh environments	Low – It cannot used when it is dirty or greasy
Security	High	Low
Event Triggering	Capable to trigger certain events	Not capable of triggering events

Besides of retailers like Wal-Mart and outlet stores there are many other companies that have already started using the RFID technology. We may learn from big industry users such as Wal-Mart, Deloitte Global Technology Innovation Centers, Target Corporation, The Boeing Company, U.S. Navy, Michelin, Americas R&D Corporation, Delta Airlines, United Postal Service (UPS), Sonic Software, Tyco Safety Products, and DHL Worldwide Networks to mention some.

3. Classification of Data, Results and Discussions

In the following sections, this author classifies the data into three tables as are listed below:

Table 5: Articles classification by author names and years of publications
Table 6: Published articles by year
Table 7: Top 25 Journals published articles on RFID subjects

3-1. Articles Distribution by Authors Name and Year of Publication

Table 5 lists 401 articles by the year of publication, the authors name and the characteristics of each article. These articles are all listed in the reference section of the article.

Tab. 5. List of works published on RFID

Year	Authors	Characteristics of Articles
1985	Schwind	On RFID Concepts. RFID frequency identification gets smarts
	Anonymous	RFID- a rundown on the basics
1990		
1991	Greenberg	An automated bibliography of computer supported cooperation works
	Udoko	Automated data capture technology
1992		
1993		
1994	Legg	RFID tags connects smart cars to smart highways
	Fernie	Quick response.
1995	Jaselskis et al.	Construction industry. Construction applications and limitations of RFID

		technologies in the construction industry.
	Olliver, M.	Describes developments in RFID techniques using existing examples.
	Dos, S., et al.	Rewards to investors in innovative technology applications.
1996	Byfield, I.	Development in RFID- examines the increase of RFID.
	Tuttle, T.	Integrated circuit simplifies design of RFID systems.
	Bassi, R.	Technology review.
1997	Schweber	On RFID Concepts. RFID components get more sophisticated.
	Harvey, J.	Flexibility and technology in services.
	Legg	RFID tags shrink and gain flexibility
	Anonymous, 1997a	Savi supplies military with RFID
	Anonymous, 1997b	Technology improves RFID equipment
1998	Schweber	On RFID Concepts. RFID arena expands with rugged tags and 23-cm range. RFID technology puts zip in the mail.
	Heftman Labs	RFID systems help manufacturers keep track of products.
1999	Schweber	On RFID Concepts. Passive RFID tags push to 13 MHZ embedded anti-collision techniques.
	Artmann	State of art on electronic identification system.
	Wismans	Identification and registration of animals in the European Union.
	Hicks	RFID and the book trade.
	Jansen and Krabs	Automatic identification in packaging.
	Jansen and Eradus	Future developments on devices for animal identifications.
	Kampers et al	The ISO standards for RFID animals.
	Burnell	A study predicts users will overcome obstacles and use RFID.
	Gilleo	Low cost flip chip assembly on polyester flex.
	Goldberg	Smart labels use RFID technology to speed airline baggage handling.
	Jones, J.	Working without wires.
	Kossel	Antennas for a 2.4 GHZ RFID system.
	Lee, M.	Nano-Power RFID receiver yields high sensitivity.
	Moore, et al.	Barcode or RFID
	Nie, W., et al	How professors of operations management view service operations.
	Troyk, P.R.	Injectable electronic identification, monitoring, and simulation system.
	Anonymous, 1999	RFID technology tracks sugar cane
2000	AIM	Draft paper on the characteristics of RFID system
	Anonymous, 2000	Using RFID in the electronic business
	Anonymous, 2000	RFID technology international standard reaches milestone
	Baxall	Using RFID in retail supply chain logistics.
	Bushnell	RFID's wide range of possibilities.
	Bylinsky	Hot new technologies for American factories.
	Nie, W.	Waiting: integrating social and psychological perspectives.
	Stewart,T.A.	How Cisco and Alcoa make real time work
2001	Gyger and Desjuex	Transportation. RFID tags are used for monitoring passengers access to public transportation
	Hum	Fabric area network- a new wireless communication technology.
	Ruff and Hession-Kunz	Applications of RFID systems in metal/nonmetal mines
	Takaragi et al	An ultra small individual recognition security chip.
	Chia	Transformation of libraries in Singapore.
	Yorkovich	At the forefront of technology with 3M digital ID.
	Riso, F.	Intelligence chip technology - an RFID updates.
	Rogin	RFID gets the message.
	Sarma, S.	Toward the 5 Cents tag.
	Kuldeep, K	Technology for Supply Chain Management
	Anonymous, 2001	Radio frequency identification
	Agawal, V.	Assessing the Benefits of Auto-ID Technology in the Consumer Goods Industry
2002	Johnson	Automobile SCM. RFID is used for improving quality control on a Ford automobile production line in Mexico
	Frisk et al	Chip on flex attachment with thermoplastic ACF for RFID applications. Multi-tag RFID systems.
	Deville et al.	Have your objects call my objects.
	Ferguson	RFID primer
	Alien	Technology guide
	Auto-ID center	RFID and PC technology pave way to increase profits in industries.
	Callahan	Using 3Mth Digital identification system in the UNLV Library.
	Fabbi	The future of business services in the age of ubiquitous computing.
	Fano	The smart label revolution.
	Harrop	Wireless product identification, enabler for handling efficiency, etc.
	Karkkainen, et al.	Auto-ID based control.
	McFarlane, D.	An on-site inspection support system using RFID.
	Yabuki, et al.	RFIS systems, security and privacy implications.
	Sarma, S., et al.	Ubiquitous applications using RFID tags.

	Shimizu, M., et al.	The real time economy: How about now
	Siegele, L.	
2003	Anonymous, 2003b	SCM. It is used to improve the SCM
	Anonymous, 2003c	SCM. It is used in the supply chain processing
	Anonymous, 2003a	Automobile SCM. RFID was employed in the SCM portion of the automobile industry.
	E.J.Jaselskis et al.	Construction Business. Providing owners and contractors in using RFID technology
	Biebl	RF systems based on active integrated antennas.
	Keskilammi et al.	Radio frequency technology for automated manufacturing and logistics control.
		An ultra-small RFID chip for ubiquitous recognition applications.
	Usami and Ohki	Life long automatic monitoring of insects behavior is now possible.
	Streit et al.	Implementing RFID in the construction process.
	Jaseiskis and Ei-Misalami	Increasing efficiency in SC for short life goods using RFID tagging.
	Kakkanen	Computing goes the last hundred feet with RFID systems.
	Stanford	The risks of RFID.
	Rappold	Supply chain technology tracing to the future.
	Baer, Stearn & Co.	Smart label set to soar.
	Collins, 2003a	Estimating RFID's pace of adoption.
	Collins, 2003b	Handbook of RFID fundamentals.
	Finkenzeller	Handbook - Fundamental and applications in contact-less smart cards.
	Finkenzeller	Implementing RFID in the construction process.
	Jaselskis, et al.	RFID in China.
	Min, et al.	Fairy wing: distributed information with RFID tags.
	Murakami, et al.	Smart tag for your supply chain.
	Niemeyer, et al.	RFID emerging applications.
	Pine, H.B.	Electromagnetic analysis speeds RFID design.
	Raution, J.B.	RFID-an internet for physical objects.
	Smith, H., et al.	Winning the wireless.
	Teresko, J.	RFID industry development and market trend.
	Wu, N-C., et al.	Emerging technology to support supply chain management
	Singh, N	Increasing profits and productivity
	Anonymous, 2003	Metro Group to introduce RFID across process chain
	Anonymous, 2003	EPCglobal Network
	Anonymous, 2003	Privacy and corporate data
	Anonymous, 2003	Case study - Ford Cuautitlan EMS heads south of the border
	Anonymous, 2003	Item level RFID: delivering value in retail operations
	Anonymous, 2003	
2004	Knights,Henderson&et al.	Draw-point Control.
	Graham-Rowe	On RFID concepts.
	Gildden and Bockorick, et al.	SCM. Design of ultra low cost UHF RFID tags
	Brzozowski	On RFID concepts. Tags, Tickets and labels
	Bradbrook	SCM. Wal-Mart and RFID
	Bradbrook	SCM. The use of RFID in Procter and Gamble
	Anonymous, 2004b	Retailers. To improve waiting time at the cashier at the Seahawka Stadium
		On RFID Concepts. and its costs and future
	Anonymous, 2004a	Software. Oracle Corp. launched RFID program to meet initiatives
	Ashley	SCM. Low cost UHF RFID tags were designed causing to decrease the cost of
	Glidden et al. 2004	tags in the market
		SCM. Used for inventory check
	Anonymous, 2004d	SCM. It was used for SCM management by integrating RFID systems into the
	Anonymous, 2004c	manufacturing supply chain
		SCM. It was used for SCM management
	Luckett, 2004	Library. It was used for library management
	Kern 2004	SCM. RFID was used for supply chain management
	Pentila et al., 2004	On RFID concepts.
	Nogee	Consumer perspectives of RFID.
	Juban and Wyld	In this paper, several "disruptive" technologies are considered and the paths they
	Sheffi, Yossi	have taken from the early innovation phase to full implementation are traced.
		RFID in retailing and privacy and public policy issues.
		Review of RFID technology with its opportunities and challenges.
	Jones, P., et al., 2004a	RFID for security and media circulation in libraries.
	Jones, P., et al., 2004b	Frequency doubling active antenna.
	Kern, C.	CPW fed folded-slot antenna for 5.8 GHZ RFID tags.
	Cabria et al.	Antenna for wireless power transmission at 5.8 GHZ.
	Chen and Hsu	Using text as a meander line for RFID transponder antennas.
	Heikkinen and Kivikoski	Chip on paper technology.
	Keskilammi and Kivikoski	An ink jet-deposited passive component process for RFID.
	Rasul	Indoor location sensing using active RFID.
	Redinger et al.	RFID applications for dietetics professionals.

	Ni et al.	A research note on RFID transponder effects on bloom of beef muscle.
	Hall and Hampl	Leveraging RFID technology to improve laboratory information management.
	Vorst et al.	Enabling ubiquitous sensing with RFID.
	Venkatesan and Grauer	Is this game of tag fair play?
		RFID sees all.
	Want	ARC deployment best practices – a survey
	McGinity	Super distributed RFID tag infrastructures.
	Sangani	RFID is not just for Wal-Mart retailing store.
	ARC advisort group	The RFID privacy scare in more than what really it is.
	Bohn, et al.	RFID extends to medical applications.
	Byrne	RFID is down but far from out.
	Cline	Incorporating RFID technology into the health care sector.
	Costlow	RDID and the wave of the future.
	Covert	A subset of combat identification.
	Crayton	Issues with RFID usage.
	Davis, et al.	Hospitals start pilot testing RFID to curb drug diversion.
	Dittmer, K. et al.	Tags and the questions of privacy.
	Floerkemeier	Design of ultra-low-cost UHF RFID tags for SC applications.
	Gebhart	EPC information service.
	Germain	The true cost of RFID.
	Glidden, et al.	Emerging trends and research issues.
	Harrison	Privacy in libraries.
	Highjump software	GIS in the management of library pick-up books.
	Holtjona Galanxhi-Janaqi	Working proofs for RFID tags.
	Falk, H.	Strengthening EPC tags against cloning.
	Jing-feng, Xia	RFID security.
	Jules, A.	RFID enabled medical equipment management.
	Jules, A.	On drugs and distributions.
	Knospe, et al.	A basic introduction to RFID technology and its uses in the SC.
	Kohn	Privacy and security in library RFID.
	Koleszae	RFID technology overview.
	Laran RFID	RFID technology overview.
	Molnar, et al.	RFID integration service markets.
	Mullen, 2004a	Mexico attorney general has microchips fitted in arm.
	Mullen, 2004b	RFID technology analysis.
	Ornauer, J. Et al.	Would you like chips with that?
	Reuters News	Enhancing privacy of universal re-encryption scheme for RFID tags.
	Roesner, B.	Truly innovative.
	Rusty, L., et al.	RFID market growth tied to new applications.
	Saito, et al.	Meeting new challenges with new technologies.
	Sarma, S.	Making sense of RFID.
	Schneiderman, R.	How do suppliers benefit from information technology use in SC.
	Sheck, M.	Vendors warn of RFID tag shortages in coming months.
	Smart, L.	Unique marketing challenges at the frontiers of technology.
	Subramani, M.	RFID- a key to automating everything.
	Sullivan, L., et al.	RFID privacy.
	Uslay, C., et al.	Security and privacy aspects of low-cost RFID systems.
	Want, R.	The strategic applications of Wal-Mart's RFID mandates.
	Weis, S.	RFID: the next generation of AIDC.
	Weis, S.A.	VF contracts for millions of tags
	Williams, D.H.	Automatic identification and mobility: what is RFID?
	Zebra Technologies	Consumers against supermarkets
	Anonymous, 2004	DTI basic technologies, RFID tagging for oil company
	Anonymous, 2004	EPCglobal network-overview of design, benefits and security
	Anonymous, 2004	EPCglobal network
	Anonymous, 2004	EPCglobal network
	Anonymous, 2004	Intermec Sues Matrices
	Anonymous, 2004a	New UHF regulations move forward in European RFID news roundup
	Anonymous, 2004b	Intermec spells out licensing
	Anonymous, June 2004a	Good year copes with RFID challenges
	Anonymous, July 2004	US food and drugs administration
	Anonymous, 2004	UD department of agriculture-animal identification
	Anonymous, 2004	
	Anonymous, 2004	
	Anonymous, 2004	
2005	Ranky, 2005	RFID concepts. It discusses the methods and applications of RFID.
	Romero	RFID concepts. USA DoD conference on RFID
	Sangoi and Smith et al	RFID concepts. Printing RFID tag antenna using inks containing silver dispersions
	Smith	SCM. DoD conference

Mongeon	RFID concepts. Conference on the RFID and its future as a successful tool.
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Angeles, 2005	Technology on OMRON to produce RFID tags
	SCM. Used in food and vegetable supply chain management
Anonymous, 2005	SCM. It was used for supply chain management
Anonymous, 2005c	SCM. It was used for supply chain management
Kumar and Budin, 2005	Construction. Used for construct part management
Strassner and Fleisch, 2005	Airlines. Used for passengers luggage tracking
Yagi et al. 2005	Grocery. Used in grocery stores
Anonymous 2005c	SCM. Successful RFID supply chain was launched
Peter and Fraizier, 2005	Construction Business.
Anonymuous, 2005	RFID Field Guide
Junichi et al	RFID. Incorporating RFID into the health care sector.
Manish B. Et al.	Discusses about commercial applications and privacy rights.
Potter B.	Where is my suitcase? RFID applications in Airlines
Kelly, E., et al.	The pros and cons of RFID: data analysis.
Wyle, D., et al.	Exploring RFID technology and its impacts on business systems.
Anonymous	RFID and food retailing in the UK.
Smith, A.D.	The benefits, challenges, and impacts of RFID for retailers in the UK,
Jones et al., 2005a	The impacts of RFID on SC facilities.
Jones et al., 2005b	Intelligent building with RFID devices.
Twist, D.C.	RFID tag antenna with quasi-isotropic radiation pattern.
Sommerville and Craig	UHF RFID integrated systems.
Cho et al.	Design criteria for the RF section of UHF microwave passive RFID transponders.
Curty et al.	Compact slotted planar inverted-F RFID tag mountable on metallic objects.
De Vita and Lannaccone	Security standards for RFID markets.
	Antenna design for UHF RFID tags – a review and a practical application.
Kwon and Lee	Contact-less radiation pattern measurement method for UHF RFID transponders.
	Exploring RFID technology and its impact on business systems.
Philipose et al.	?
Rao et al.	Effects of metallic plate size on the performance of micro strip patch-type tag antenna for passive RFID.
Ritamaki et al.	Virtual product design case study: the Nokia RFID tag reader.
Smith et al.	Integrated residential gateways: easy IA management with P2P community using RFID.
Subramanian et al.	Repair control of enterprise systems using RFID sensory data.
Ukkonen et al.	Management of RFID in libraries.
	UNLV libraries and the digital identification frontier.
Repo et al.	RFID enhances visitors' museum experience at the Exploratorium.
Yen et al.	What does the RFID do for the customers?
	?
Kohn et al.	RFID and the perception of control.
Coyle	RFID tags: commercial applications versus privacy rights.
Fabbi et al.	RFID privacy issues and technical challenges.
His and Fait	RFID is a X-ray vision.
Eckfeldt	Security standards for RFID markets.
Garfinkel et al.	RFID: tagging the world.
Gunther and Spiekermann	A technical overview and its application to the enterprise.
Kelly and Erickson	Not quite prime time but dawdle at your own risk.
Ohkubo et al.	RFID in China: Opportunities and Challenges.
Stajano et al.	RFID in biopharmaceutical supply chain
Phillips et al.	Standard regulation for 950 MHZ band RFID device
Borriello	Integrating supply chain with RFID
Weinsein	Value of RFID under imperfect inventory information
Goth	Active RFID powers productivity and protection in the enterprise.
Lai et al.	Health care sees safety in RFID.
Ahlund	DoD RFID updates
ARIB	RFID field guide – Deploying RFID
Asif	RFID: tagging the world
Atali	Analog and digital technologies are maturing.
Axcess, Inc.	Making the most out of RFID technology.
Collins	Remotely powered addressable UHF RFID integrated system.
Barlas	Management tools survey.
Bhuptani, et al.	How many RFID tag are sold in 2005.
Borriello	Case analysis for the department of defense on passive RFID.
Browne	Securing industry wide EPC global network.
Curtin, et al.	What does RFID do for the consumer?
Curty	Libraries and the digital identification frontier.
Rigby, D.	An in-Depth user's guide to selecting and deploying Gen2 Tags, readers.
Das, R.	The value of RFID.

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	Fabbi	Temple of the computer – the electronic library.
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	Freed, T.	Branch libraries and technologies.
	Guilford, et al.	Experimentation with RFID usage in supply chains.
	Heinrich	Supply chain logistics initiatives.
	Heinrich	The history of RFID.
	Falk, H.	Unlocking the value of RFID.
	Jaques	Efficient authentication for low cost RFID systems.
	Jeanne	Buddy finding in the mobile environment.
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	Landt, J.	Help wanted.
	Ozer, L.	Future impacts of RFID on e-supply chain in groceries.
	Lee and Hwang, et al.	The road to ROI.
	Li, X.	Real time data capture and job-tracking technology in the field.
	Mennecke, et al.	Security industry wide EPC global network with WS-security.
	Mietschin, et al.	Wal-Mart assesses new uses for RFID technology.
	Morrison	Leveraging the internet of things.
	Prater, et al.	RFID in the industry.
	Roberti, M.	Developing consumer friendly pervasive retail system
	Sean, T. et al.	Automating the task of tracking the delivery and receipt of fabricated pipe spools in industrial projects.
	Shih, D-H., et al.	
	Sullivan, L., et al.	Suppliers meet mandate frequently
	Violino, B.	About Symbol technology
	WERC	RFID in Pharmaceutical supply chain
	Kourouthanassis, P.	Seven considerations for your RFID projects
	Song, J., et al.	Pharmaceutical companies seek benefits of RFID
		The Pharmaceutical industry turns to RFID as one cure for many Prob.
	Anonymous, 2005	RFID: Opportunities and challenges
	Anonymous, 2005	Bar code history
	Anonymous, 2005	EPCglobal Network
	Anonymous, 2005	EPCglobal Network
	Anonymous, 2005	EPCglobal Network
	Anonymous, 2005	EPCglobal Network
	Anonymous, 2005	Understanding the EPC Gen2 protocol
	Anonymous, 2005	EPC reduces out-of-stock at Wal-Mart
	Anonymous, 2005	The pros and Cons of RFID – data analysis, strategic directions
	Anonymous, 2005	The global data synchronization network (GDSN)
	Anonymous, 2005	RFID enhances visitors' museum experience
	Anonymous, 2005	
	Anonymous, 2005	
	Anonymous, 2005	
	Anonymous, 2005	
	Anonymous, 2005	
	HIS and HOLLY FAIT's search	
2006	Ranky, 2006	RFID Concepts. Reviews the current state of the arts and future opportunities
		A hybrid approach to the valuation of RFID/MEMS inventory control
	Doerr et al.	Tracking and locating components in a storage yard
	Esin et al.	RFID in the built environment buried asset location systems
	Dziadak	Dynamic mobile RFID based supply chain control and management system
	Wang	construction
		RFID frequency standards, adoptions and innovations
	Ward	Beyond retail: thinking outside the box
	Murphy	Boeing selects chipmaker for parts tags
	O'Conner	RFID attractiveness in the US and Spanish grocery chains
	Reyes et al.	Crown saves manufacturing cost via RFID
	Swedberg	Wireless sensors in agricultures and food industries
	Wang et al.	Provides a comprehensive overview of RFID.
	Spekman, R.	Describes the implementation of RFID in 35 libraries in Essex, UK.
	Palmer, M.	An empirical study of RFID implementation in warehouse industry.
	Vijayaraman, B.S., et al.	Discusses the basic points on RFID.
	Wyld, D.C.	How RFID can impacts the e-supply chains in grocery retailing.
	Prater E.	The purpose of article is to introduce RFID in Middlesex university.
	Hopkinson, A. Et al.	Performance evaluation of RFID applications in printing industry.
	Hou, J-L, and huang, C-H.	RFID technology and its applications, strategies and challenges.
	Li, S., Visich, J.K., et al.	An overview of EPC technology.

	Thiesse, F.	Read rate improvement in RFID-based network-centric environments.
	Cha, K., et al.	A tested architecture for auto-ID technologies.
	Soylemezoglu, A. et al.	RFID and corporate responsibility.
	Barut	A story of extremes.
	Das, R.	Traceability data management for food chains.
	Dimitris, et al.	RFID in the built environment - buried asset location system.
	Dziadak, K.	Quantitative performance evaluation of RFID applications in SCM.
	Jiang-Liang,H., et al.	RFID security and privacy.
	Jules, A.	Interference migration and read rate improvements in RFID.
	Kainan, Cha, et al.	RFID technology: applications, technical challenges, and strategies.
	Li, Suhong, et al	RFID technology is revolutionary.
	Taghaboni-Dutta, F. et al.	RFID technology and the EPC network as enablers of mobile business.
	Wamba, S.F., et al.	Dynamic mobile RFID based SC control and management system.
	Wang, L.C., et al.	RFID applications in healthcare.
	Wicks, A.M., et al.	IdentechSolution.com
	Anonymous, 2006	Cisco system
	Anonymous, 2006	IDtechEX
	Anonymous, 2006	IDtechEX: RFID retail case studies
	Anonymous, 2006	Cisco systems-delivering an intelligent foundation for RFID
	Anonymous, 2006	Cryptography and Authentication on RFID Passive Tags for Apparel Products
	Wong, et al.	Applying Autonomous Sensor systems in Logistics-Combining Sensor networks, RFID and Software agents
	Jedermann, et al.	Development of a Smart wireless soil monitoring sensor prototype using RFID Technology
	Hamrita, et al.	
2007	Chao et al.	RFID. Determining technology trends and forecasts of RFID
	Chapin	RFID. Putting RFID to work on asset tracking
	Fourdraine et al	RFID. It is used in the state of Wisconsin to encourage cattle growers
	Dade	RFID. Washington hospital center to quadruple its RFID expansions
	Bacheldor	RFID. It is used by oil refinery to test sensors tags
	Zare Mehrjerdi	Profitability Enhancement in Excellent Supply Chain Management through RFID Utilization.
	Ngai	Mobile commerce integrated with RFID technology in a container depot.
		At Infosys, a Live lab RFID APP eases parking
	O'Conner	RFID enabled billboard to mini motorists.
	O'Conner	RFID applications that provide beta access, strong mass data and programming are
	Shien-Chiang Yu	better than barcode.
		Increasing number of libraries are implementing RFID solutions
	Muir Scott	To help managers determine whether RFID is appropriate for their particular
	Reyes, P., and Jaska, P.	organizations.
		Cutting supply chain costs has made RFID technology one of the today's most
	Attaran, M.	discussed retail technology.
		RFID systems, standards, and privacy within libraries.
	Butters, A.	How to integrate web and RFID technologies for visualizing logistics operations.
	Chow, H.K.H., et al.	A primer on radio frequency identification for libraries.
		Supplier attitude to implementation of RFID in grocery stores.
	Curran, K., Porter, M.,et al.	Information quality attributes associated with RFID-driven benefits in
	Hingley, M., et al.	Retail supply chain businesses.
	Sellitto, C., et al.	How to build competitive advantages using RFID tags
		RFID and ubiquity for humanity.
	Erickson, S.G., et al.	RFID-enabled traceability in the food supply chain
	Srivastava, L.	Sensor trends in processing and packaging of foods and pharma.
	Kelepouris, T.	Making the MOST out of RFID technology.
	Connolly, C.	Management tools and trends survey.
	Curtin, et al.	Ensuring supply chain safety.
	Rigby, D.	Integration of web-based and RFID technology.
	Sahin, E.	Knowledge management approach in build-to-order supply chain.
	Harry, K.H., et al.	RFID enabled inventory routing problems.
	Harry, K.H., et al.	The future of mobile computing.
	Jarugumilli, et al.	Going beyond the auto-ID.
	Herzong, Otthein, et al.	Collaborative SC practices using new technologies.
	Spieb, P., et al.	RFID technology in retail outlets: Indian scenario.
	Paramatari, et al.	Space management analyzes data with data-tracking device
	Srivastava, S.K.	Wireless technologies for logistic distribution process.
	Varpu Uotila, et al.	RFID applications in CVS distribution center in Taiwan.
	Win-Bin See	RFID is no fake: the adoption of RFID in the pharmaceutical SC.
	Wu, Y.C., et al.	Economical assessment of the impact of RFID technology
	Wyld, D.C., et al.	Break-even analysis of RFID technology for inventory analysis
	Bottani, E.	Gas Sensors integration in RFID flexible tags for food logistics
	De Kok	A brief introduction on RFID applications
	Estefania, A.	Sushi restaurant management using RFID enabled system
	Konstantatinos, D.	Mobile commerce integrated with RFID technology
	Ngai, E.W.T., et al.	RFID-enabled automation in support of factory integration

	Ngai, E.E.T.,et al.	Analysis of the impact of the RFID on reducing product misplacement
	Qiu, R.G.	In retail stores
	Rekik, Y.	Strategic value of RFID in supply chain management
		Evaluating the Business value of RFID evidence from five case studies
	Tajima, M.	A real time wireless smart sensor array for scheduling irrigation
	TZeng, S-F, et al.	Exploring the impact of RFID technology and the EPC network on mobile B2B
	Vellidis, G	ecommerce
	Wamba, S.F., et al.	Enhancing Construction Quality Inspection and Management Using RFID Technology
		Challenges to Global adoption
	Wang, L-C.	Pharmaceutical manufacturing: RFID – reducing errors and effort
		Implementation of RFID Technology in Parking Lot
	Wu, N.C., et al.	Success factors of the introduction of the RFID in Maintenance
	Adams, A.	RFID for better supply chain
	Ostojić, G., et al.	RFIR tagging: Supplier attitudes regarding grocery retail sector
	Chiang, K.-H.	Barriers to RFID adoption in the supply chain
	Delen, D., et al.	RFID Business Case for Baggage Tagging
	Hingley, M., S. et al.	An exploratory study of RFID adoption in the healthcare
	Huber. N, et al.	Development of an RFID-based traceability system
	IATA	Strategic and institutional perspectives in the adoption RFID
	Lee, C.P. et al.	*Internal Antenna Design of 900 MHZ- Band Mobile RFID System*
	Ngai, E. W. T., et al.	*A comparable market study of RFID for manual item-level*
	Sharma, A., et al.	Roadmap to solving security and privacy concerns in RFID systems
	Kim,Y., et al.	RFID: An exploratory study adoption in the South African retail sector
	Courtney, V. V.	RFID Technologies
	Ayoade J.	Adoption and Diffusion of RFID Technology in the Auto. Industry
	Brown I, Russell J.	
	Lieshout M, et al.	
	Schmitt P, et al.	
	Yahia Zare Mehrjerdi	RFID-enabled systems: a brief review
	Chen, C.,C., Jiinpo Wu, et al.	Key drivers for the continued use of RFID technology
2008	Corchado, J., Bajo, J., et al.	Intelligent environment for monitoring Alzheimer patients
	Fisher, J.A., et al.	Tracking the social dimensions of RFID systems in hospitals
	Huang, C-L., et al.	Reliability improvement for an RFID-based Psychiatric Patient system
	Katz, J.E., et al.	A US national survey of consumer sentiments for RFID healthcare
	Cannon, A.L., et al.	RFID in the contemporary Sc and its benefits and risks
	De Kok, A.G., et al.	A break-even analysis of RFID
	Bottani. E et al.	Economical assessment of the impact of RFID
	Cheong, Cheng Pak	Factors Affecting Customers Intention to Use RFID fresh Seafood.
	Chiani Giuseppe, et al.	RFID and mobile museum guides
	Coltman, T., et al.	RFID and supply chain management
	DeVries, Peter D.	the State of RFID for Effective Baggage Tracking
	Fosso-Wamba. S, L. et al.	Impacts of RFID and EPC network on mobile B2B
	Iwan Vanany, et al.	Barriers and Critical Success Factors towards RFID Technology
	Ngai, E. W. T., et al.	Development of an RFID-based sushi management system
	SeBW, E-business Watch	RFID Adoption and Implications
	Singh, S., et al.	RFID Research and Testing for Packages of
	Zhang, Jianyu. et al.	Exploratory case studies of RFID adoption
	Boeck, H., et al.	Technological requirements and derived benefits from RFID
	Bornhovd, C., et al.	*RFID in Manufacturing*
	Ng, M. L., et al.	RFID tags for metallic object identification.
	Kye H, et al.	Developing an Adoption/Diffusion Model of RFID
	Szmerekovsky, J.G., et al.	Coordination and adoption of item-level RFID
	Tzeng, S.F., et al.	Evaluating the business value of RFID:
2009	Yahia Zare Mehrjerdi	Review of RFID and its applications in Iran and other countries
	Yahia Zare Mehrjerdi	RFID and Supply Chain incorporation: Productivity enhancement
	Yahia Zare Mehrjerdi	RFID-enabled Supply Chain Systems Using Computer Simulation
	Kumar, S., et al.	RFID in the healthcare supply chain: usage and application
	Aluri, A., et al.	A comparative study of consumer attitudes for RFID use
	Carrender, C.	Focus on RFID's value, not tag cost. RFID
	Hellstro¨m, D. B.	The cost and process of implementing RFID technology
	Lee Mi Sook	An Empirical Study about RFID Acceptance-Focus on the Employees
	Chieh-Yu Lin, et al.	An Empirical Study on the Adoption of RFID Technology
	Lin, C.Y. et al.	An empirical study on the adoption of RFID technology
	Oztaysi, B., et al.	Radio frequency identification (RFID) in hospitality.
	Swedberg Claire	NYC's Metropolitan Museum of Art adopts RFID
	Tsai, Wei-Chen et al.	RFID Adoption Model for Taiwan's Logistics Service Providers
	Chen, S-L	*Miniature RFID Tag Antenna Design for Metallic Objects Application*
	Chen, X., et al.	*Authentication Approach to Enhance Security in RFID System*
	Jung, B. M., et al.	*Estimating the ROI on implementation of RFID*
	Jeurissen W.	*RFID adoption*
	FassoWamba, et al.	RFID adoption issues
	Ustundag, A., et al.	The impacts of RFID technology on supply chain costs
	Zhou, W.	RFID and item-level information visibility

	Yahia Zare Mehrjerdi	Coupling RFID with supply chain to enhance productivity
	Ustundag, A., et al.	Fuzzy rule-based system and RFID investment
2010	Kamarulazizi, K. et al	Electronic toll collection system using passive RFID
	Bayraktar, A., et al.	Implementation of RFID technology
	Chieng We, Ng.,	Improved back-of-the-house processes with RFID
	Huang Yo-Ping, et al.	Experiences with RFID-based Interactive Learning in Museums
	Johnson, G.G. and E. Yip	Exploratory Research To Apply Leadership Theory to RFID
	Keating, Byron W. et al.	Unpacking the RFID Investment Decision
	Mishra Deepti, et al.	Improving baggage Tracking Security and Services with RFID
	Nemoto. M. C. M.O, et al.	The Adoption of New Technology
	Tan-Hsu Tan, et al.	Development and evaluation of an RFID-based e-restaurant
	Upfold, C, et al.	Radio Frequency Identification (RFID) Adoption in the South African
	Wang, Y.M., et al.	Understanding the determinants of RFID Adoption
	Wen, T.C., et al.	Cost-Benefit Analysis of RFID Application
	Aysegul Sarac, Ã., et al.	A Literature Review on the Impact of RFID
	Bendavid, Y	*Replenishment Process of Medical Supplies in Hospitals with RFID*
	McKerricher, G.I., et al	*Quadrifilar Helix Antenna for UHF RFID*
	Gambon, J.	An RFID roadmap for small and midsize contract manufacturers
	Hozak, K., et al.	Material handling trade-off when lot splitting with RFID in a Job Shop
	Ozdemir, A., et al.	*Assessment of RFID investment in the military logistics*
	Kim S, Garrison G.	the adoption and implementation of RFID technology in South Korea
	Tsai M-C, et al.	Determinants of RFID adoption intention
	Wang Y-M, et al.	Understanding the determinants of RFID adoption
	Yen DC, et al.	Determinants of users' intention to adopt wireless technology
	Honarzadeh, M., Karimzadegan , and Yahia Zare Mehrjerdi	RFID applications in Hotel industry, the first conference on intelligent computer systems and applications
2011	Honarzadeh, M. Yahia Zare M.	Increment of Service Quality in Hotels using RFID technology
	Yahia Zare Mehrjerdi	RFID: The big Player in the Health Care Management
	Yahia Zare Mehrjerdi	RFID: The Big Player in the Libraries of the Future
	Yahia Zare Mehrjerdi	RFID and its benefits: a multiple case analysis
	Yahia Zare Mehrjerdi	RFID-enabled Healthcare Systems: Risks and Benefits Analysis
	Ting SL, et al.	RFID-enabled healthcare management system in a medical Org.
	Lee, C.K. et al.	Demand management with RFID Expert systems with applications
	Szmerekovsky, J.G., et al.	Analytical model of adoption of item level RFID
	KO, J.M., et al.	Adaptive product tracking in RFID
	Merilampi, S., et al.	Embedded wireless strain sensors based on printed RFID tag
	Vukelic, Dj. et al.	Machining fixture assembly/disassembly in RFID
	Yu, M., et al.	An RFID electronic tag based
	Chiu, Yuh-Wen., et al.	Analysis For the Adoption of RFID technology
	Chi-Hsuan, Mai.	Museum guide system with existing wireless technologies
	Fakhr Ali	Barriers and Critical Success Factors in Adoption RFID
	Hsiang-Yung Feng	Development of an RFID-Based Tourist Management System
	Stephen Waters, et al.	RFID Technology Adoption Status
	Qu, X., et al.	Quantifying the Value of RFID-Enabled Equipment Tracking
	Ilie-Zudor, E., et al.	A Survey of Applications and Requirements of RFID Techniques
	Lai, M.Y., and Li, R.L.	*Broadband UHF RFID Tag Antenna with Parasitic Patches*
	Bunduchi R, et al.	Mapping the benefits and costs associated with process innovation:
	Moslehpour, et al.	Smart RFID Based Design for Inventory Management in Health Care
	Mehmet Erkan Y-KSEL, Asım Sinan Y-KSEL	RFID Technology in Business Systems and Supply Chain management
	Zare Mehrjerdi, Yahia	A Framework for Six-Sigma Driven RFID-Enabled Supply Chain Systems
	Zare Mehrjerdi, Yahia	Library Expense Control: A System Dynamics Approach
2012	Zare Mehrjerdi, Yahia	A System Dynamics Approach to Healthcare Cost Control
	Zare Mehrjerdi, Yahia	Multi-Criteria Risk Benefit Analysis of Healthcare Management
	Zare Mehrjerdi, Yahia	Hierarchical Multi-Criteria Risk-Benefit Analysis in Fuzzy Environment
	Southard PB, et al.	RFID in healthcare: a Six Sigma DMAIC and simulation case study
	Censi F, et al.	Radiofrequency identification and medical devices
	Rieche M, et al.	Radio Frequency Identification (RFID) in medical environment
	Unluturk MS, et al.	Integration of RFID and web service for assisted living
	Massawe LV, et al.	Reducing false negative reads in RFID data streams
	Yen YC, et al.	Two RFID-Based Solutions for Secure Inpatient Medication
	Schneider CW, et al.	RFID tracking of sublethal effects of two neonicotinoid
	Chen CL, Wu CY.	Using RFID Yoking Proof Protocol to Enhance Inpatient Medication
	Valero E, et al.	Automatic construction of 3D basic-semantic models and RFID Sensor
	Wu, Chao-Yen, et al.	Using Delphi Method in Constructing Business Adopting RFID
	Anand A.	Indian Schools All Set TO Implement RFID And GPS based Track
	Carter D.	Study-probes-rfid-use-in-schools. Assistant Editor, eSchool News
	Wessel R.	UAE Universities Adopt RFID to Thwart Diploma Forgery
	Farzin Yazdi, M.	Investigation of effective factors of RFID on adoption – in library
	Yahia Zare Mehrjerdi	System selection using Fuzzy TOPSIS group decision making

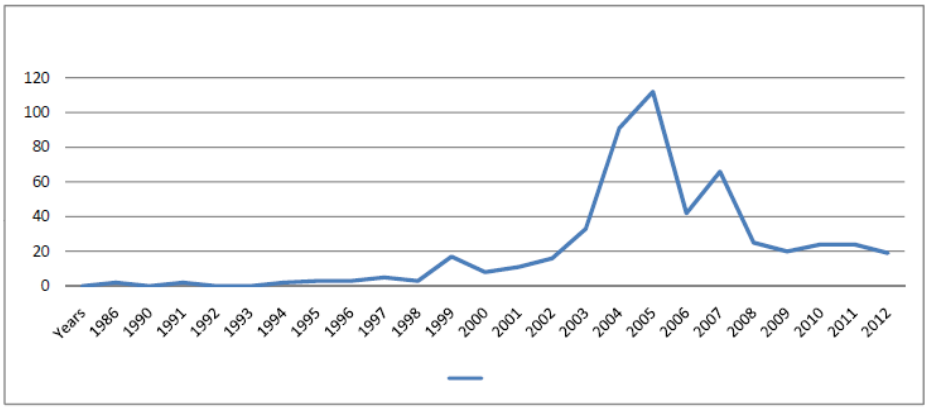

Fig. 1. RFID Articles by the Years of Publications

3-2. Distribution of Articles by the Years of Publications

Table 6 shows the list of articles published in various journals from 1985 through 2012 by the years of the publication. This table is developed based upon 550 articles about RFID listed in the reference section. Excluding fifteen articles not related to the RFID topic from the list author came up with 535 articles on RFID as table 6 shows. Figure 1 and table 7 together indicate that research on RFID has started to pick up on year 2002 with 16 publications and then reached to its pick at year 2005 (112 publications) and then trend went down to 42 and up to 66 publications for years 2006 and 2007, respectively.

3-3. Distribution of Articles by Top 25 Journals

Table 7 list top 35 journals published 1 or more articles on RFID technology from 1985 to 2012. Using the results of our finding as shown by table 7 Microwave and Radio Frequency journal has published 18 articles and all IEEE journals combined published 20 articles. In the third, fourth, and fifth places are RFID Journal, International journal of production economics, Assembly Automation, Library High Tech, and communications of ACM with 16, 16, 13, 12 and 12 articles, respectively. The international journal of supply chain management is tied with Technovation with 7 articles as well.

Tab. 6. Published articles by year

Years	Articles
1986	2
1990	0
1991	2
1992	0
1993	0
1994	2
1995	3
1996	3
1997	5
1998	3
1999	17
2000	8
2001	11
2002	16
2003	33
2004	91
2005	112
2006	42
2007	66
2008	25
2009	20
2010	24
2011	24
2012	19

4. Classification of RFID Application Areas

4-1. Airline Industry

Hong Kong Airport is one of the largest and busiest in the Asia. It handles about 35 million passengers each year. To have satisfied customers with languages on time with them airport is in need of a reliable tracking system. The head of Hong Kong's Technical Services and Procurement believes that selected technology is right for the Airport and it is wise to invest on that (Das, 2006). Many other Airlines such as British Airways, United, Japanese, and Southwest have experiences with the RFID tracking systems. Delta is leader in using this technology. Delta's experience shows that only about 85% of the time scanners were successful in correct reading of bar codes. However, some Airports have reported some 70% accuracy for wet luggage. A pilot program tested by Delta using 40,000 bags with RFID technology reached a correct answer between 96.7% and 98%.

4-2. Railways

Canadian National Railways implemented RFID technology in its 195 acre inter-modal yard to improve asset tracking, reducing asset cycle time from six days to three days (Chapin [101]).

4-3. Manufacturing Industries

Procter & Gamble and Gillette Companies are the big users of the RFID technology. Gillette announced that its estimations indicate that sales would be about 15% higher if stores have always products in the shelves. International Paper Company that is located in the state

of Connecticut uses passive EPC tags in its several internal programs. It also uses at its 300,000-square-foot warehouse where it stores very large amount of its products [4]. Genco uses EPC-compliant tags and readers from Intermec. Provia in Michigan, USA, a provider of warehouse management software, also is working on ways to use RFID to improve the accuracy and efficiency of picking. Combining RFID with voice recognition technology would speed this process even more, says Don Lazzari, director of marketing at Vocollect, Pittsburgh. Van Donselaar, and Van Woensel [125] have discussed 'A Break-Even Analysis of RFID Technology for Inventory Sensitive to Shrinkage' through adapting inventory policy by including both the shrinkage fraction and the impact of RFID technology. By comparing the situation with and without RFID in terms of costs, an exact analytical expression is derived for the break-even price of an RFID tag.

The authors reveal that these break-even prices are highly related to the value of the items that are lost, the shrinkage fraction, and the remaining shrinkage after the implementation of RFID. A simple rough-cut approximation to determine the maximum amount of money a manager should be willing to invest in RFID technology is presented and evaluated.

Tzeng et al. [360] have presented an in-depth analysis of the business value components that an organization can gain from the adoption of RFID. They proposed a framework to determine the business value of RFID technology emphasizing the delivery of value through the refinement of business processes and the expansion of the business model. They have illustrated these concepts by drawing on the experience of five early RFID adopters from the Taiwan healthcare industry, and formulate this framework as a set of propositions based on the relevant literature, cases from pioneers in the field, and intuition.

4-4. Agriculture

Although, the "Wisconsin Department of Agriculture, Trade and Consumer Protection" in USA has no intention of mandating animal identification, it has looked to its neighbor, Michigan—and that state's incentive program of a 50 percent payment for tags—for a way to help modernize the cost to farmers while still ensuring that the majority of livestock are tagged. Approximately 1.2 million head of dairy cattle and a slightly smaller number of beef cattle live on 14,000 Wisconsin farms (Fourdraine, 2007).

4-5. Health Industry

Washington Hospital Center is planning to quadruple its RFID expansion soon. The MedStar hospital is using 700 active RFID tags; by spring, it will have more than 2,500 in operation across its entire campus (Dade, 2007[121]). El Camino hospital in Mountain View, California has established a state of the art healthcare system using RFID. A 1988 study of the developed system for the hospital had shown that the system helped to reduce medication error rates by 55%. Due to automation of the pharmacy system of their hospital it takes less than 15 minutes to verify. According to the EL Camino Hospital CIO, Reducing medical errors not only improves patient safety but also provides a huge benefit to the hospital. The average cost of an error can range from $4,000 to $12,000 per instance.

4-6. Blood and Plasma Applications

Usually, RFID system is used for blood and plasma applications including tracking and tracing blood transfusions with a donor [365].

4-7. Dietetic Applications

Applications of RFID for dietetics professionals will be innumerable. Dietetics professionals can anticipate personal digital assistants and other handheld devices to be equipped with RFID transceivers. Research opportunities will emerge as future applications, advantages, and pitfalls of these new technologies surface. Like all health professionals, dietetics professionals will quickly incorporate RFID into daily practice as new uses arise and radio devices appear in places never before seen or imagined [170].

4-8. Material Management

A 2004 survey of vehicle manufacturers by AMR found that more than 35 percent use RFID technology for material management and more than 22 percent use it for tracking racks or totes. Automotive plants including BMW use a real-time locating system from WhereNet for tracking and managing the location of vehicles during and after production.

4-9. Livestock

RFID tagging of livestock is also a big issue and huge business. For instance, the European Community and New Zealand will join together in years 2008 through 2010 to create a market for tagging sheep, goats, pigs and cows. It is estimated that the total demand for these two regions is about 150 millions tags yearly at about $2 each. Another area to be considered is the largest book seller in the Netherlands BGN that is ordering for several million tags yearly (Das, 2005 [23]).

4-10. Pharmaceutical Industry

A critical tool for fighting with drug counterfeiting and making any improvement for the public, in general, can be achieved today through the RFID technology. The question that this industry is facing with is where they should start and how they should employ RFID technology for complex supply chains. It is estimated that between 5%-8% of the trade in drug industry is counterfeit. Given that the pharmaceutical market is over $500 billion across the world, counterfeiting becomes a very large amount and hence a huge problem. In February 2004 report, the U.S. Food and

Drug Administration (FDA) stated that RFID represents one of the most important tools to help improve the safety of the drug supply chain. Then, FDA has asked the industry players to pilot the track-and-trace solutions based on the RFID and related technologies by the end of 2007. Key industry players are already invested considerable amount of money on the related technologies [1, 3, 25, 26, 30, 33, 111,and 399].

In fact, because many of large pharmaceuticals are working on multiple RFID projects, Sun Microsystems is helping them in developing a global RFID approach and architecture instead of implementing separate solutions for each RFID project (Anonymous, 2005 [24, 25]): "FDA estimates that counterfeit and substandard product represents $32bn of the global pharmaceutical business," says Kara Romanow, research director at AMR Research, Boston. "So RFID for Pharmacy represents a unique opportunity to address the counterfeit problem" [67]. Drug makers Pfizer and GlaxoSmithKline have announced that they also are preparing to launch RFID pilots (O'Connor, January 2007[271]).

Today, the safety of working locations, products, transportations and customers are the main things to managers. In Pharmaceutical industry that is even more important. This is because the safety of the people and nations also must be taken into consideration. Refreshable goods often require strict control of storage/transportation environments such as high and low temperature.

The expiration date must be taken into consideration as well. Tracking and tracing processes offer the documentation needed to ensure these safety requirements. Tracking and tracing are ineffective most often. This is because they are reactive instead of proactive. If we use EPC technology, products can be tracked and traced very easily. Any person who has access to information along the supply chain can find out the historical background on a particular drug, as well as its current location. EPC technology verifies information at every point along the supply chain helping to ensure product integrity (Anonymous, 2005 [3, 25]).

EPC technology [44, 45, 46, 47, 48, 49, 50, 51, 52, 61, 62, 89, 132, 156, 172, 187, 215, 328, 356, 376, and 377] employs RFID tags, which are physically placed on bottles, boxes, cases and pallets at the beginning of the supply chain. RFID tags are read by RFID readers. In EPC verification, goods are scanned and status is checked. Status can come back as okay, expired or recalled. As products move through the supply chain, the RFID tags enable them to be tracked. Information is gathered about the current location of the shipment and other vital statistics (Anonymous, 2005 [25, 26]).

4.11 Parking Cars

To help employees find parking spaces once they entered the garage, InfoSys Company has installed a combination of ultrahigh-frequency RFID tags and magnetic sensors. Now, interrogators detect RFID tags embedded in windshield stickers attached to employee cars from as far as 3 meters in front of the gate. The readers send each tag's unique ID number to a middleware layer, which verifies that the employee associated with that ID has access to the garage. The middleware then sends a trigger for the gate to lift (O'Connor, February 2007[272]).

Each time a car drives onto one of the parking levels, a magnetic sensor embedded under the entrance sends a signal to middleware that is part of a device-management and decision-making engine designed by Infosys for the application, just as an identical sensor embedded under the pavement leading off the parking level does. The middleware keeps track of the number of cars driving onto and off each level. When a given floor reached to its capacity, the middleware triggers a message saying that "level is full" to let people know (O'Connor, February 2007[271]). As part of a pilot program recently launched by the automaker's USA division, selected Mini drivers in New York, Chicago, San Francisco and Miami can utilize RFID to initiate personalized messages on billboards containing LED displays (O'Conner, January 2005[272]).

4-12. e-Passports

The value of chips used in the United States e-Passports is 3 Dollars per US passport. This is needed to make each passport safe and physically robust. This by itself will bring revenue of 120 million Dollars in year 2010.

4-13. Supply Chain Coupled with RFID

Supply chain management is a link between planning and control of the supply process and corporate competitiveness. Supply chain management is an effort to win economic advantage by expert deployment of supply chain resources. In simplest terms, an integrated supply chain is a connected series of organizations, resources and activities involved in the creation and delivery of value in the form of finished products and services to end customers. Management of a supply chain involves the integration of all decisions that affect the design and flow of purchased items/materials/services into and through a corporate entity to finished products.

In the application of supply chain management, internal and external materials decisions become part of a focused sourcing strategy aimed at winning customers and increasing competitiveness [3, 6, 18, 22, 25, 26, 31, 32, 75, 77, 84, 89, 90, 99, 137, 164, 174, 175, 186, 201, 203, 218, 219, 220, 234, 240, 269, 281, 286, 287, 301, 309, 310, 324, 331, 345, 347. 353, 357, 359, 364, 377, 378, 380, 382, 399, 407, and 408].

A research conducted by AMR indicates that early adopters of RFID can cut supply chain costs by about 3-5% (Anonymous, 2005 [407]). The same study points out that these users of RFID can reduce costs by about 2-7%. Generally speaking, RFID can have a

huge impact on the entire supply chain processes. Hence, it is important for the big supply chain players to learn about this technology and to take its effectiveness into consideration. Companies considered to be the best in the class for their supply chain performance must be able to operate their network efficiently at 4 to 7 percent of revenue less than the average company in their industry.

Bottani and Rizzi [89] have described 'Economical Assessment of the Impact of RFID Technology and EPC System on the Fast-Moving Consumer Goods Supply Chain'. They described a research that aims to quantitatively assess the impact of RFID technology and electronic product code (EPC) systems on the main processes of the fast-moving consumer goods (FMCG) supply chain.

A three-tier supply chain that is composed of manufacturers, distributors, and retailers is examined, and the results of the feasibility study show that RFID and EPC implementation is still not profitable for all of the tiers in the chain. Wang et al. [382] simulated the impact of an RFID system on the inventory replenishment of the thin film transistor liquid crystal display (TFT-LCD) supply chain in Taiwan, and examined global operations and logistics through a case study of a well-known LCD monitor manufacturer. The results of the experiment show that an RFID-enabled pull-based supply chain can be effectively achieved with a 6.19% decrease in the total inventory cost and a 7.60% increase in the inventory turnover rate.

4-14. Food Industry

Estefania et al. [140] have discussed the enabling of technologies for developing a flexible tag microlab for food monitoring during the logistic chain. The realization of the system includes the integration of physical and chemical sensors with Radio Frequency Identification communication capabilities. The first ISO 15693 compliant semi-active tag prototype, including low power control electronics, RFID antenna, commercial sensors, memory and a thin film battery, is shown together with the development of novel ultra-low power hotplates required for this application and the process, based on the use of anisotropic conductive adhesive (ACA) flip chip technology, for gas sensors integration onto flexible substrates. As the demand for food quality, health benefits, and safety increases harsh scrutiny on the inspection of agricultural-food products would become mandatory. One think that also being increasingly demanded is "traceability", which requires not only careful inspections, but also systematic detection, labeling and recording of quality and safety parameters while archiving the entire agricultural-food production chain, from farms to consumers' tables. RFID has been considered the most important identification tool to establish an effective "traceability system" (Sahin et al. 2002 [310]).

Wentworth (2003) conducted a study aimed at inexpensive, disposable RFID biosensor tags used on food products for history checking and contamination and inventory control [76, 125, 131, 197, and 382]. Connolly [111] and Jansen et al. [195] discussed the potential of RFID tags for "smart packaging", automatic checkout, "smart appliances", "smart recycling" and marketing/promotional opportunities. He has pointed that this type of technology could improve security, productivity, inventory control, traceability and result in capital and operational savings.

4-15. Pets Identification

RFID technology has been used for identifying pets for years. Veterinarians frequently implant puppies and kittens with rice-sized capsules containing unique microchips. A radio signal that is sent from a reading device can then energize the tag to transmit its unique number. An animal recovered at a shelter is often scanned upon arrival, alerting caretakers of the rightful owner [68, 194, 217, and 394]. RFID has been accepted as a new technology for a well-structured traceability system on data collecting, and human, animal and product tracking (Sahin et al. 2002 [310]). It has been projected that the applications of RFID will grow rapidly in the next 10 years with a compound annual revenue growth rate (2003–2010) of 32.2% (Sangani, 2004 [312]). To support these great application potentials of RFID, much research has been conducted.

4-16. RFID as a Speed Passes Tool

Drivers in some states use RFID in the form of "speed passes" to pay for gasoline with a wave of a chip in front of the pump. Others have chips in devices that are attached to the inside of their vehicles' windshield, allowing them to drive through tollbooths to have a charge automatically added to an account. One company has patented a washing machine that can interpret RFID devices sewn into clothing for the purpose of adjusting wash settings based on instructions provided by the microchip.

4-17. Retail Industry

Once RFID tags infiltrate the market, the retail industry will be revolutionized. Transceivers will be equipped to read multiple products simultaneously, allowing for shopping carts to be pushed through a device that seamlessly recognizes all items being purchased. Self-checkout will be commonplace, and cashless transactions will become regular practice. Product-specific promotions and coupons will be targeted and offered to consumers based on individual purchasing habits, similar to current systems that utilize customer loyalty cards [54, 56, 69, 90, 113, 137, 159, 182, 192, 206, 207, 208, 209, 210, 211, 218, 233, 238, 263, 287, 295, 324, 340, 376, and 377].

4-18. Equipment Tracking

Song et al [337] presented a method extending the application areas of RFID in the construction sites intending to determine the precise location of tagged materials. For this purpose, the performance experienced with a commercially available RFID system is compared with the theoretical performance derived from an analytical discrete framework. Using this methodology useful parametric relationships between RF power, the number of reads and tag density and finally, performance trade-offs are characterized in order to propose guidelines for potential field deployments.

The problem of managing and tracking equipment has always been considered as a serious problem in both hospitals and construction sites. In hospitals, the serious problems are ranging from bed facilities, IV pumps, surgical equipments, and wheel chairs to mention a few.

By analyzing the operations and economics related to the problem of equipment tracking we can conclude that there exist (1) labor costs to find equipment, (2) the staff time lost for searching the equipment, (3) increasing purchasing or renting costs for not having equipment as needed, (4) patient and experts times lost due to finding equipment late, and (5) increasing inventory costs for purchasing extra equipment due to mismanagement of equipment.

RFID tags have been employed in the construction sites to track assets. These tags are capable of gathering data related to the location of targets items [18, 101, 130, 139, 204, 323, 337, 367, and 270]. Using RFID tags, it is possible to identify the location of the equipment on the construction site and to provide security at the level necessary to the management. Current methods for identifying the exact location of water, sewage and gas pipes under the ground are a major issue for utility companies. Using RFID on the pipelines can help utility workers to identify the exact location of the pipes under the ground.

4-19. Animal Radiofrequency Identification

Animal radio frequency identification has grown rapidly during last few years to the points of acceptance that all kinds of animals (pets and zoo animals) are encompasses. There exists an ISO standardization that helps to identify all kind of animals from any country in the world to any place. ISO 11785 is an international standard on Radio Frequency Identification of Animals (RFID) transponders [Jansen and Eradus [194].

4-20. Other Application Areas

There are many other areas that researchers and practitioners have tried to implement the RFID technology. Some of these industries are oil industry [42, 80, 134], army [130], automobile industry [38, 154], libraries [94, 103, 114, 115, 117, 141, 142, 143, 144, 200, 222, 223, 279, 327], construction quality inspection [264, 379], mining industries [100], service sector [146, 176, 242, 400, 401], Inventory Control [76, 125, 131, 197, 382], increasing profit and productivity [15, 79], and water irrigation [371].

5. RFID Effectiveness

Hewlett-Packard (HP) is an early adopter of the RFID technology and now with 28 sites located around the world all are RFID capable. HP has employed RFID technology mainly to improve its supply chain efficiency. The tags that HP uses are passive EPC-compliant tags. These tags have additional memory that can be used for collecting information needed as printer go through several Quality Assurance stations. One of the managers at the HP site claims that "in the past, an operator would have to scan the printer to capture its identity, conduct the tests and then key in quite a lot of information about the test results. Today, we don't have to do all that.

The printer is identified automatically and the key results of the test are written back to the tag. HP sees RFID as a key to the concept that calls it "The Uninterrupted Supply Chain".

The world biggest retailer, Wal-Mart, expects to receive about four billion cartons in year 2004 and five billion in 2005 (Nogee, 2004 [270]). A decrease of 10 Pennies in cost per carton for year 2005 is about \$0.1*5 000,000,000 = \$500,000,000 saving for Wal-Mart. The saving for year 2008 with the same usage incremental rate is about \$800,000,000. Management at Wal-Mart believes that RFID system can help them to do the following:

1. Reducing labor costs
2. Reducing inventory costs
3. Reducing human errors
4. Increasing revenues by limiting the shortages
5. Increasing the overall efficiency and productivity of the their Supply chain

RFID has been identified as one of the ten greatest contributory technologies of the 21st century. This technology has found a rapidly growing market, with global sales expected to top \$7 billion by year 2008 (Chao et al, 2007 [100]). Companies lined up to use RFID and employing experts to improve the efficiency of their operations in order to gain competitive advantages over time.

Manufacturers can use RFID solutions to reduce operating costs through decreasing the labor costs, claims and returns. This will help them to increase the operating income. They also can reduce the working capital by enabling reductions in inventory and lowering the inventory write-off from the return goods and those items that are un-saleable at the end. Main benefits of RFID can be categorized as follow [237]:

1. Improving the speed and accuracy for tracking pallets, cartons and containers

2. Helping to reduce stock levels
3. Helping to reduce operating costs
4. Improving the management of inventory
5. Improving efficiencies in WIP reporting
6. Improving inventory visibility to feed JIT systems

The introduction of RFID technologies has brought much debate and speculation about its potential impacts. This research shows that investments in RFID infrastructure will yield significant economic benefits for manufacturers and consumers alike. A study conducted by the University of Texas at Austin and sponsored by NXP shows the financial impacts of RFID in the US healthcare and retail stores. The key finding of this study can be summarized as listed below [237]:

1. Companies in the retail and healthcare sectors have experienced, to date, a 900 percent rate of return (ROI) of their RFID investments
2. Current adoption levels of RFID at the pallet and item levels in retail currently derive $12.05 billion in benefits from existing RFID applications
3. Retail consumers see a $2.63 billion annual cost savings benefit
4. Total benefits accruing to healthcare industry manufacturers, distributors, and hospitals is equal to $45.9 billion
5. Improved patient care from RFID deployment is valued at $30.72 billion
6. Benefits to the healthcare consumer, through enhanced patient care, is estimated at $165.12 billion.

Table 8 shows RFID contributions by dollar amounts on various types of industries. Due to the fact that RFID is a very young technology in making impacts and generating revenues for industries the extent of this contribution is very low.

Tab. 8. Industries classification

Rows	Industries	Organization	Type of Contribution by RFID	Amounts	Durations of Impacts
1	Health care industry manufacturers, distributors, and hospitals			$45.9B [6]	To date
2	Patient Care Industry			$30.72 B [6]	To date
3	Retailing industry	Wal-Mart	Reducing labor costs, inventory costs, human errors, increasing revenues and overall efficiency and productivity of the Supply chain	$12.05 B benefits, and $2.63 B cost savings to consumers (900% ROT of RFID investments) [6]	To date
4	RFID integrated Supply Chain systems			Adopters: 3%-5% and Users: %2-%7 in cost reduction	To-date
5	Automobile industry	Ford company	RFID tags improved tracking and quality of the produced cars		To-date

6. Future Research Directions

As this is a rapidly developing technology, it is not possible to say what capabilities may be available in one, two, or five years, much less further out. There has been significant advancements of this technology in just a few years, with no sign that limits of its potential have been reached. [Karen Coyle Sept. 2005]. RFID technology and its application have attracted much attention from academics and practitioners in recent years.

This author was able to locate over 400 academic and non-academic articles in RFID from 1985-2007 where about 35% of them are the academia work related research.

There are many topics related to the RFID technology that can be taken into consideration as future research areas:

1. Cost – benefit analysis for organizations using some sort of benefit estimation from the use of RFID. This may include the cost of designing, developing, maintaining and controlling, and updating the system as it becomes necessary over a specific length of time
2. How RFID can impact one industry and not the other. And, the overall impacts of that on all industries
3. RFID impact on cost of the final product as well as the return on that per each piece of product or service
4. Privacy and security issues for the users in general and the public in particular
5. Basic considerations relating to organization and RFID such as strategies and design considerations
6. Recognizing separate and distinguishable researches for service and non-service organizations. This is due to the fact that for service organizations the human being factor needs to be considered as well
7. How recognize various types and brands of RFID that might work effectively, efficiently together in an RFID network
8. Productivity, efficiency, and effectiveness study of a reinforced RFID supply chain versus a fragile one
9. RFID and information system integration into a supply chain dynamic system
10. RFID, information system and ERP integration into a supply chain dynamic system
11. RFID armored quality control systems versus regular quality control systems

12. Standardization, a topic that needs much of researcher attention
13. Employees behavior with respect to RFID armored systems and their satisfaction
14. Managements satisfaction of systems' quality and productivity
15. Design of a smart emergency care unit, public library, customer service, and automobile of the future
16. Designing classrooms of the future with students willing to participate with better learning methodologies
17. Redesign retail, service, and food/cuisine/fast food industries to make checking and bill producing processes more operational and easy to use.

In relation to system readiness for RFID implementations the following research questions can be taken into consideration:

1. Is it necessary for an under-developed country to take the RFID path instead of using barcode technology?
2. Is my company ready to employ the RFID technology?
3. What are the critical success factors for an RFID-based system?
4. What is the performance of RFID technology in organization?
5. What are the RFID related strategies for organization?
6. What is the RFID impact on flow management of products in supply chain systems?
7. What is the RFID impact on serviceability and customer satisfaction?
8. What is the RFID impact on companies' bottom line?
9. What rules and guidelines a company should follow to get ready to implement RFID and to be a permanent user of that?
10. What are the concrete results for the ROI of RFID?

In relation to RFID integration with other systems

1. Barcode vs. RFID studies for various industrial sectors for determining whether that sector is apt to use RFID
2. RFID implementation in Robotic systems.
3. Quality Function Deployment in an RFID-based system
4. RFID-based systems and expert systems integration for better decision making purposes

In relation to RFID privacy issues and security

1. Privacy and security issues on RFID - regarding critical and sensitive issues (minority issues, gender type issues, age, and sex discrimination cases)
2. Psychological impacts of RFID utilization on employees and customers
3. The RFID true impacts on people health
4. Data collection on employees' performance.

RFID technology is still becoming mature and the industry still young. Its full impact is not yet foreseeable and there is still much promise for the future. It will simply take some time to realize its full potential. However, the potential benefits of RFID system may only be observed when the whole system is fully involved. Currently, most applications are confined within a single department or an isolated company.

7. RFID Main Challenges

The global challenges that RFID is facing with [Challenges to Global RFID adoption] are human expert challenges, privacy issues, technology challenges, standard challenges, pattern challenges, cost challenges, infrastructure challenges, ROI challenges, barcode to RFID migration challenges, management commitment challenges, and technical support challenges. There are not many skilled RFID professionals that can help to set up appropriate systems to construct suitable applications.

In a survey conducted by the Computing Technology Industry Association revealed that 80 percent of the responding companies said that there were not sufficient numbers of skilled RFID workers. About two-third of respondents pointed that training their employees to become proficient in RFID is the biggest challenges they faced in order to succeed in the RFID market (Morrison, 2005) [259]. RFID can generate at least ten times the amount of data generated by barcodes.

It is crucial to build a secure and reliable network ecosystem to process the data collected by readers and move it across partner companies in an integrated supply chain (Chopra and Meindl, 2006).

To implement RFID, gaining management commitment is another big challenge. Here, management looks into the ROI to assess RFID investment before commits to its implementation. Another challenge that companies face with is the high cost of implementation.

To justify the adoption of RFID technology into business, cost-benefit analysis is a must. At the present, the costs of RFID adoption comprise the major investment in hardware, application software, middleware, and tags, and the cost of integrating the RFID based system with the legacy systems, of consultancy fees, and of employees [266]. Main obstacles of RFID can be classified as:

1. Standardization for RFID is not yet completed.
2. Early adopters of RFID are still managing consciously
3. Many potential adopters are waiting on the sidelines for proofs of successful and safe adoptions
4. Compatibility with legacy systems is not addressed seriously

5. Security issues need to be resolved.
6. Complexity and high cost for coverage in large plants prevent fast adoption.
7. Power supply is always a great concern for wireless systems.
8. The reliability of wireless system remains unproven and it is considered too risky for process control.
9. Lack of experienced staff for troubleshooting.
10. Future trends

In relation to RFID wider abilities following research questions can be taken into consideration:

1. What are the effectiveness, efficiency, and productivity of an RFID-based system?
2. What is the RFID-based system ability?
3. What can an RFID-based system offer that a Barcode-based system can not?
4. What can an RFID-based system offer to better implement the voice of customer?
5. What is the RFID role for improving the system Reliability?

8. Implications

Through this research, we notice that RFID is being applied in various businesses to enhance productivity, and improve the quality of the data, goods, and decision making. RFID technology is applied to various processes for monitoring the manufacturing process and tracking goods and services as they are distributed.

It can be used to detect the human error and then correct it on-time and online. For instance, in the assembly line once a newly training employee is working the trainer can monitor the process, detect the mistake, and guide the employee by sending a mobile short message warning the to pay attention and to correct the error right away. The same can be done in the surgery room once the professor/team leader is watching the surgical student to do the surgery and when an error is in progress a message can be sent to warn the student of the wrong doing and taking immediate action to correct that.

9. Discussion and Conclusion

Greenberg (1991) stated that "an important part of any new research venture is the building and maintenance of a reference collection of relevant publications". To the best of this researcher knowledge this is the first literature review on RFID technology that looks into RFID from 1985 through 2007. With 401 references listed in the reference section of the article it covers various types of articles from academic published articles in conference proceedings, magazines, doctoral dissertations to white papers and case studies. With this research, author created a database of the RFID literature technology and its applications from 1985 to 2007 by classification and statistical analysis.

Although the number of academic researches has started to grow we anticipate researchers and academics get more interest on the topic by the passage of time as more companies and large organizations get ready to invest on the technology. Now that we are at the verge of RFID conceptual and descriptive studies, the trend of such studies is upward and we anticipate its reduction once more of real research type studies to appear.

With this study completed here we can highlight some important implications of that:

1. RFID is a hot research topic today and it has been hot since 2003.
2. Past publication rates direct us to predicting substantial development in this area in the near future, with a significant increase in research and published literature.
3. Although, this research tracks RFID history from 1985 but the reality is that RFID has taken off in the past few years
4. The application review of articles indicates that there are now many and varied applications areas for RFID technology and soon it will expand to other areas as well.
5. Due to the fact that after a large investment on RFID implementation then tag prices is a real issue, a large number of researches that have appeared in the literature are related to tags, its various types, prices, and frequencies.
6. There are some articles that pointed to the RFID policy and security issues but the number of articles on RFID standardization is limited, however.
7. It seems there is a need for such a move, that is, to bring some of RFID standardization to the "global intention". However, this depends on more research and new thinking.
8. Organizations should take this technology serious before they want to think about what sort of impact it will have on the organization and the bottom line. This means that companies must look at the key issues of price, implementation, maintenance, and then its real impacts.
9. There are little research pointing to the after sale and services that producers actually offer.
10. There are few researches that point to the adoption of RFID and the impacts that it will have on the entire system.

RFID is an emerging technology with full benefits to be emerged in several years to all industries worldwide. It will bring a good opportunity for improving supply chain efficiency and hence the safety of the public in return. With the presence of Sun Micro-systems in the development stage of the RFID products, a series of RFID industry solution architectures will be developed and provided soon.

EPC technology employs RFID tags, which are physically placed on bottles, boxes, and cases at the beginning of the supply chain. RFID tags are read by RFID readers.

Large US companies and many large worldwide companies will be the big beneficiaries of such technologies soon.

This means that many companies will take the advantage of this technology to increase their profitability and enhance productivity. This is an indication that larger companies will get larger and richer companies will get richer. I am sure competitors will not sit to watch. For instance, Sears the big Wal-Mart competitor will get into the technology and use it seriously to make big profits from that.

If RFID is to achieve the level of adoption that has been forecasted, it is important to understand the capabilities and limitations of the technology as it evolves, the different types of applications where it can be used, and how business value is realized resulting in impact to the organization and the value chain. We believe the articles in this special issue provide a solid foundation upon which to build a valuable stream of academic literature with contributions to the research community and practitioners.

We sincerely thank all the authors for their contributions to this special issue and the reviewers for their valuable time and energy in reading and commenting on the articles. In this article we reviewed some of the most prominent applications of RFID in industries and provided a comprehensive review of the work done from 1985 through 2007 and the research trend on that. The effectiveness of RFID and the challenges that it is facing with are also discussed. RFID implementation trend is upward and predicted to be one of the hottest technologies up to 2010.

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