

# **Trust-worthy Computing**

**Professor Mike Shaw**

**Final Project**  
**RFID Application & Issue**

**Po-Chou Chen**

**MS-Technology Management**

**May 4<sup>th</sup>, 2006**

## Table of Content

1. <u>Overview</u> .....	3
2. <u>Review</u> .....	4
- Introduction of RFID	
- Common Problems with RFID	
- Bar-code Labels vs. RFID Tags	
3. <u>Emerging Trends &amp; Application</u> .....	9
- Supply Chain Management	
Case: RFID Implementation at Wal-Mart	
- Identification	
- Transportation	
- Anti-counterfeiting	
4. <u>Issue &amp; Barriers for RFID in the market</u> .....	13
- Standardization Issue	
- Cost Issue & Other Concerns	
- Privacy Issue	
5. <u>Conclusion</u> .....	18
6. <u>Annotated References</u> .....	19

## Overview

- RFID technology has been implemented in different areas such as retailer and shipping industry and more application are going to change human being's life. However, there are also some concerns to commercialize those applications in the market.

Nowadays, people hear more about **RFID (Radio Frequency Identification)** technology than ever before since RFID is one of critical technologies that will be likely to change their life in the near future. Most of people who thought that the RFID is the brand-new technology would be surprised that RFID concept has been used for a device for aircraft identification since World War II. Recent breakthrough in RFID technology enabled element microminiaturization and cost deduction, which ultimately made it possible to commercialize this technology in different applications in the market. RFID technology has been the spot light people focus on and has been expected to initiate the next revolution in delivery and supply chain system.

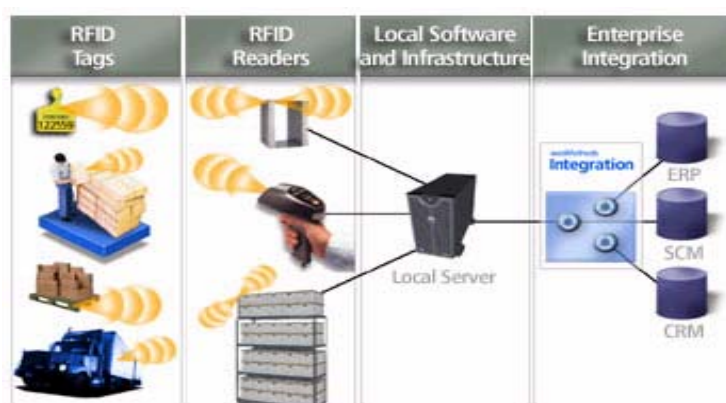
However, like many other new technologies, RFID technology also brings some concerns for people as well as benefits. The most concern is a privacy issue because using the RFID technology might have a risk of disclosing some personal information to others. So far, there are some debates about a privacy issue of RFID technology application either in legal or in morale perception.

Despite the privacy concern RFID technology has been implemented in various areas such as goods delivery and supply chain management system. As the privacy issue is solved and technology becomes more mature, RFID technology is expected to gain its momentum in the future.

## Review

### ● Introduction of RFID

*So what is RFID?* RFID is one of the identification technologies. It can identify the target automatically as well as exchange the data attached on a RFID tag by radio frequency, even for dynamic objects. Compared to the traditional bar-code technology, RFID technology can reach a target without touching it. Therefore, RFID seems like more magical technology than bar-code system, especially for delivery industry and supply chain management systems which are critical parts of nowadays globalization business.



(Elements of RFID Technology)

**Generally, the complete set of RFID includes:**

- Tag
- Reader
- Antenna

A RFID tag, a core of RFID, is used to store the information of objects on which the tag is attached. Combined with unique electronic code, the information saved in the tag can be easily identified and exchanged through communication between the reader and antenna. The tag is consisted of micro-chip and antenna, and the chip acts like the **SOC (System on chip)**, which can receive, transmit, and save the data.

Currently, there are two kinds of tags based on the way to transmit the signal; one is **Active label** and the other is **Passive label**. Generally, the Active label has the battery inside, and has capability for long range application. Active RFID tags may have the following features:

(Source: "Active RFID Tag", from

<http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=21>)

- longest range for communication
- the capability to perform independent monitoring and control
- the capability of initiating communications
- the capability of performing diagnostics
- the highest data bandwidth
- Active RFID tags may even be equipped with autonomous networking; the tags autonomously determine the best communication path.

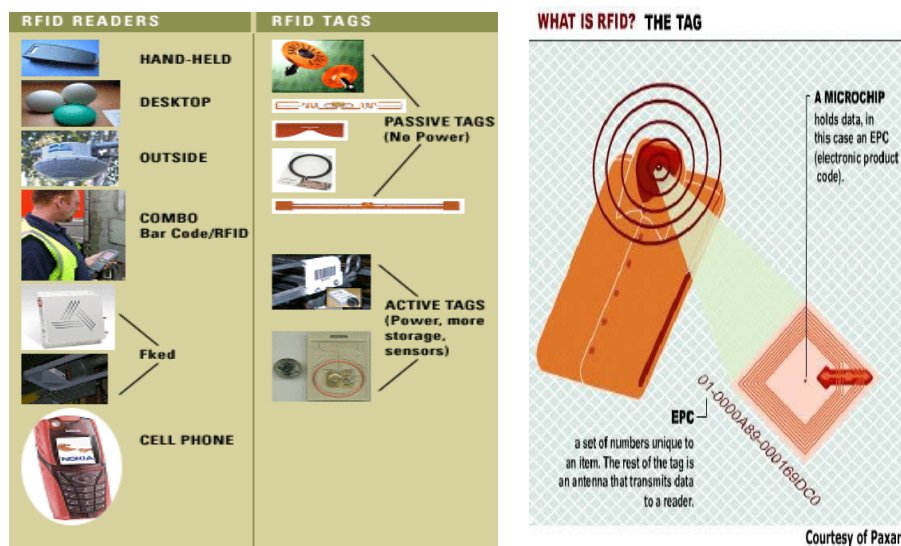
However, the Active label is heavier and more expensive than Passive label. Producing cost of Active label often costs \$ 20 or even more per unit. On the contrary, Passive label without battery inside is cheaper and the average life time is longer than Active label, around 5 years. The common advantages and disadvantages of a **Passive tag** are as followings:

#### **Advantages of a Passive tag:**

- The tag functions without a battery; these tags have a useful life of twenty years or more.
- The tag is typically much less expensive to manufacture
- The tags are much smaller, and these tags have almost unlimited applications in consumer goods and other areas.

#### **Disadvantages of a Passive tag:**

- The tag can be read only at very short distances, typically a few feet at most. This greatly limits the device for certain applications.
- It may not be possible to include sensors that can use electricity for power.
- The tag remains readable for a very long time, even after the product to which the tag is attached has been sold and is no longer being tracked.



**Reader** is the device that is designed for the label with detection, write-in, and storage functions. There are different types of readers based on the functions; for instance, the reader could have read-only function, and the cost would be lower than that of readers with write-in function.

The function of the antenna is to transmit the signal to the tag and to receive the signal from the tag. In other words, the reader will check the signal from the label attached on the object, and return the signal and information inside the label to the reader.

Currently, there are three different systems based on different frequency, 100~500K Hz, 10~15M Hz, and 850~950M Hz. 100~500K Hz is called low frequency system and costs the least. Also it can be used for short range application, especially for access control such as entrance card and metro pass. 10~15M Hz system has the capability for farther application, and can generally be described as track and trace applications. The system provides additional functionalities and benefits for product authentication. Therefore, many shipping companies pay more attention to this system which can improve their process flow and efficiency. 850~950M Hz system has the capability for long range application, but the cost is much higher than others. Therefore, this system may be used for few areas such as high speed transportation system.

- **Common Problems with RFID**

Some common problems with RFID are **reader collision** and **tag collision**. The

problems occur when the signals from two or more readers overlap because the tag is unable to respond to simultaneous queries. To avoid the problems systems must be carefully set up.

The reader collision causes two problems, **signal interference** and **multiple reads of the same tag**.

(Source: "RFID Tag Collision", from

<http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=57>)

**Signal interference:** It occurs when more than one reader exists in the vicinity. This problem can be solved by the technique called **TDMA (Time Division Multiple Access)** which is to have readers to read at fractional different times.

**Multiple reads of the same tag:** The tag is read once by different readers, and the solution is to program the RFID system to make sure a given tag is read only once in a section.

Tag collision occurs when many tags are present in a small area; however, since the read time is very short, it is easier for suppliers to develop systems that ensure that tags respond one at a time.

- **Barcode Labels vs. RFID Tags**

<b>Barcode Labels</b>	<b>RFID Tags</b>
Limited read range	Longer read range
Manually scan	Automatically detect ( Non-touch)
Limited and static data	More and changeable data
Low operational awareness & supply chain visibility	High operational awareness & supply chain visibility
For all products	Has Physical limitation (metals and liquids)
Simple to apply	Complex to implement with system
Inexpensive	Expensive

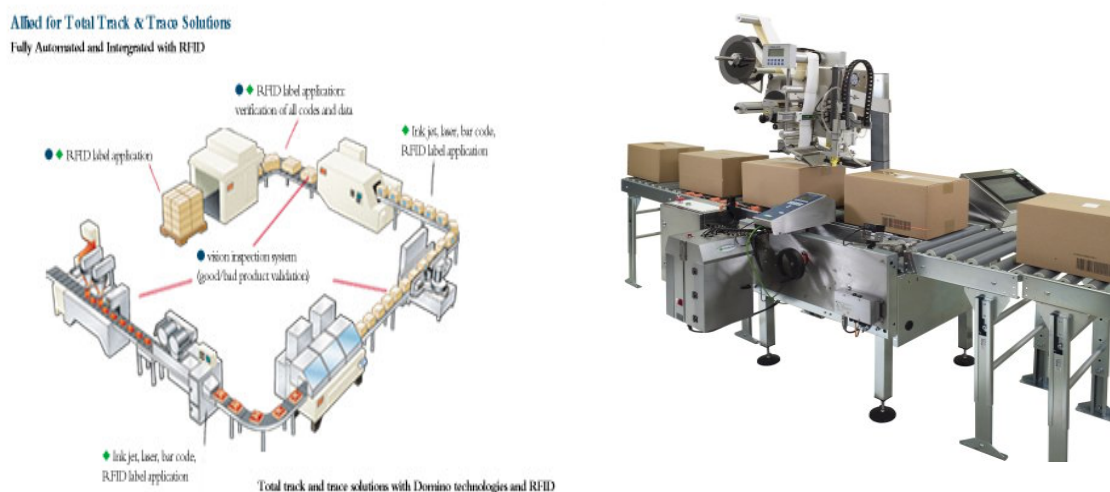
Regarding previous identification technology such as bar-code and a magnetic strip on the back of a credit card or ATM card, all of them have different advantages and disadvantages. For instance, although bar-code is cheaper, its capacity for data storage is not as high as RFID label. A magnetic strip on the back of IC card is a little bit more expensive with higher capacity of data storage, but it is fragile by abrasion while used. Compared to traditional technology, RFID has other advantages such as wireless transmission (non-touch) and capability of identifying dynamic objects as well as capability of penetration. However, the cost of implementing RFID is comparative much higher and the system is more complicated in system integration.

## Emerging Trends & Application

Typically, RFID application can be divided into four categories: 1) Supply Chain Management, 2) Identification, 3) Transportation, 4) Anti-counterfeiting

### 1) Supply Chain Management

Shipping industry is the most potential field for RFID and it has the largest market in which the RFID can be implemented. The most common applications are automation of process line, goods delivery, and inventory management.



The benefits of RFID for supply chain management are as followings:

- **Visibility**
- **Tracking**
- **Monitoring**
- **Better forecasting**
- **Labor savings**
- **Product recall easier**

Two benefits that I would like address here are the better forecasting and easier product recall. Since the RFID can monitor all the sales once the transaction completed at any time, it is easier and more convenient for companies to have the precise forecast. Companies do not need to wait for feedback from each retailer for sales. In addition, since companies can track each product by RFID, companies can

easily recall products which have a problem. Without RFID, what companies can do was to recall all products based on the lot number, production day, and so on. Companies may recall a lot of products which are not necessary, and that will increase extra costs as well as shipping cost. Both of them are important advantages that Bar-code technology can not provide.

### **Case: RFID Implementation at Wal-Mart**

Currently, Wal-Mart is the most famous retailer which implements RFID in its supply chain management system. Wal-Mart required its top 100 suppliers to use RFID technology by January 2005, and those suppliers are responsible for their own infrastructure costs. In its plan, by the end of 2005, over 600 stores and 12 distribution centers would use RFID technology. By the end of 2006, Wal-Mart wants to push another 200 suppliers and 1000 stores using RFID technology.

The **expected benefits** are as followings:

- Improve the customer service
- Improve fulfillment rates
- Reduce inventory and labor cost
- Reduce the possibility of inventory shrinkage and out-of-stock situation
- Eliminate many manual process and improve the operation efficiency

The detail cost saving from RFID implementation is estimated in the following table:

Estimated Annual Cost Saving	Detail Benefits
\$6.7 Billion	Labor cost saving by 15%
\$600 Million	Smart shelves to monitor on-shelf availability
\$575 Million	Automatically Reduces administrative error and vendor fraud
\$300 Million	Better tracking of over 1 billion pallets and cases that move through its distribution centers
\$180 Million	Improved visibility of product location to reduce inventory carrying cost
\$8.35 Billion	Total pre-tax savings

(Source: Analysis: Ziff Davis Media Inc. RFID - Wal-Mart's Network Effect By Mark Roberti, eWeek)

From the table, the estimated cost saving is around \$8.35 billion for Wal-Mart, and that is a huge cost saving benefit for Wal-Mart to compete with competitors. Therefore, other retailers such as Target, Best Buy, and Tesco are going to do the same thing, and more retailers are expected to invest in RFID once they can afford RFID system.

## 2) Identification

This application includes goods safety management and environment identification. For instance, RFID can be used to monitor the behavior of animals and fruit growing, and to track objects. As the bird flu becomes a big problem, some scientists consider adopting RFID for preventing the bird flu outbreak. One of the advantages to use RFID technology is the capability of RFID to track the movement of livestock or human beings without interrupting normal activities. The data can be immediately transmitted to database system for further analysis. This kind of advantage could be widely used for research purpose.

## 3) Transportation field

Using RFID in transportation management can increase its economic benefit and decrease statistic cost. For example, RFID can be used in highway toll system, intelligent parking system, transportation statistic system, and package management.



Similar to the advantage for supply chain management, RFID can save the labor cost and provide the advantage of tracking goods or transportation.

#### 4) Anti-counterfeiting



Because the tag has capability of identification and of data storage, the RFID technology can be used for detecting a counterfeit.

The common application is like authentic check, electronic ticket, special goods, and drug. For example, Pfizer adopts RFID in Viagra package to preventing counterfeit.

### Issue & Barriers for RFID in the market

- 1) Standardization issue
- 2) Cost & Other Concerns
- 3) Privacy issue

Despite its obvious advantage, RFID has some disadvantages also; cost is higher than traditional identification technology and the performance of reader is not stable so far. Besides, the range that RFID can work relates to a) the efficiency of reader and label, and b) the angle of the antenna. Sometimes, the performance of RFID would be affected by environment condition. Therefore, in early stage a government would be a pioneer to implement RFID technology because companies are likely to be reluctant to adapt the technology in their existing system due to the cost concern and immaturity of technology. However, companies, such as FUJITSU, HP, IBM, NEC, PHILIPS, SIMENS, SAP and TI which are RFID providers, already invest in this market either for manufacturing or service, and they want to take good position in the market in early stage as this market is expected to have a huge business opportunity in the near future.

### The table is the list of current RFID providers

<b>Companies that supply..</b>	<b>that Include..</b>
Chips	IBM, Hitachi, Phillips, AMI, TagSys, RFSaw, and Charterate
Inserts	International Paper, MeadWestvaco, TI, Avery Dennison, SmartTag, Rafsec, Power Paper, and LabID
Printers	Zebra, Printronix, Alien, Intermec, and Toshiba
Tags	Alien, Matrics, Intermec, Phillips, TI, SAMSys, MeadWestvaco, Flint Ink, Hitachi, Siemens, Power Paper, Avery Dennison, TagSys, RFSaw, Savi, Rafsec, FlexChip, Omron, iPico, Identec, Amatech, Tyco, Wavetrend, and LabID
Antennae	Flint Ink, Avery Dennison, Moore, EMS, and Omron
Readers	Alien, Intermec, Matrics, Symbol, TI, SAMSys, Hitachi, Checkpoint, Savi, TagSys, Rafsec, Wavetrend, Feig, Omron, Tyco, Moba, Siemens, InKode, Amatech, Identec, and iPico
Data Aggregation,	IBM, OATSystems, and ConnectTerra

Filtering Systems	
Middleware	IBM, Accenture, OATSystems, Microsoft, SAP, Oracle, Sun, Savi, Wherenet, Checkpoint, Matrix, Sensormatic, and Genesta
Directory Services	Verisign and Embe

(Source: Professor Suman Mallik (2006), Supply Chain Management Course slide, University of Illinois at Urbana-Champaign, IL)

RFID has a potential in supply chain management, identification, shipping and anti-counterfeiting compared to traditional technology. However, the current RFID technology still can not be implemented in the market for large scale demand. Here is the brief discussion about difficulties for RFID in the market.

### 1) Standardization issue

The first is the standardization of RFID technology. A global standard is needed to ensure interoperability and cost reduction. Several groups are now actively developing technical RFID standards. Due to lack of standard, many companies tend to wait and see until there is a standard that they can follow to avoid the risk. Different companies that already have proprietary technology naturally do not want to invest a lot on system modification. Therefore, even shipping companies which can take the most advantages of RFID are also waiting for RFID standard to come out.

There are ongoing projects among organizations to develop RFID standards. EPCglobal, a nonprofit international consortium, has developed specifications for RFID tag placement, coding structure, data and interface systems. The International Organization for Standardization and the International Electrotechnical Committee has formed a joint committee to develop RFID standards. In the near future, such organizations can produce the RFID standards without giving too much trouble to RFID manufacturers. Right now, the approach is to favor the development of standards that are market-oriented with industry input. So setting standards will become more important as RFID market grows- according to analysts, the value of RFID market will reach \$4 billion in next three years.

So far, three main developed standards are in the market; EPC, UID (Ubiquitous ID), and ISO 18000. While UID standard is defined by Japanese organizations, EPC standard is developed by Auto ID sponsored by MIT and EPCglobal. EPC standard has better compatibility, and is also more recognized in Europe. In 2003, EPCglobal merged the Auto-ID center, and announced the standard of first generation. There are

three categories- Class 0, Class 1, and Class 2- based on read-only and re-write-in capability of the label. However, the market does not really support this application so the global RFID standardization progress delays. The delay of the standardization progress resulted in slowing the progress of main application in inventory management in shipping industry. Therefore, the RFID standardization becomes a main barrier for RFID to take off on large-scale.

## **2) Cost Issue & Other Concerns**

Another problem for RFID is the cost issue. RFID system development cost and current tag price do not meet an industry expectation level. As long as cost stays this level, there will not be enough demands in the market. Besides, the companies developing RFID hesitate to pour more capital and resource in RFID development so it makes the RFID application more difficult to be marketed in large scale. In addition, the software which connects the RFID system to whole system even has much higher cost than hardware. As mentioned, the whole integration system is the most difficult and complicated part, and software plays an important role in success of integration.

In addition, for enterprises, the most important concern is cost regardless of benefit that they can get from RFID; enterprises would not be interested until cost issue resolves.

Followings are other concerns regarding RFID;

### **a) Bar-code is more practical than RFID tag**

Compare to the cost of bar-code, the label of RFID is extremely expensive. It will make enterprises still prefer the bar-code in current business situation, especially for those companies which can use bar-code system without any problems. RFID would be the luxury technology, but not necessary for those companies.

### **b) The EPC infrastructure is more important in supply chain improvement**

Although the RFID provides the advantage of non-touch operation, the complete net infrastructure and management, and complete system mechanism are the keys to make wireless networking work successfully. Nowadays, many enterprises exchange the data through the EDI so RFID is not the only solution for enterprises to pursue the efficiency in data exchange and to share the information in supply chain management.

From this point of view, the RFID is not much different from Bar-code, and the EPC networking still can work with Bar-code technology.

**c) Initial investment in RFID technology is higher than the saving in labor cost**

Although the RFID can decrease the labor cost, the investment in implementing this technology may be much higher than the cost saving in labor cost. Given the fact that even the bar-code is not that common, jumping into RFID implementation would be unlikely. For that matter, it would take more time than expected to have RFID application implemented widely in the market with the reasonable price.

**3) Privacy Issue**

So far, retailers seem to use RFID only in inventory monitoring, security, and anti-counterfeiting areas because of privacy issue for their customers. For example, lately Benetton announced that they would use a RFID tag in their products only in the evaluation stage since some privacy- protection group protested against this application. Also, Wal-Mart just announced that it will use this technology in its inventory system testing project but shortly after the project was cancelled because of the privacy issue. The privacy issue comes first even though RFID can speed up the check-out process, prevent shoplifting, and decrease the labor cost. As long as RFID bring a privacy concern, consumers would not easily accept the RFID application. It will remain a problem for companies that try to adopt the technology.

**a) What is the privacy?**

In 1965, the Federal Supreme Court put the privacy liberty in the constitution; however, the concept of privacy is very wide because the meaning of privacy liberty would be different in different situation. Here, the privacy liberty includes personal information, body, property, and the right to act one's own. In other words, the privacy liberty is the right to act on one's own for one's personal information.

**b) Will RFID violate the consumer privacy?**

The reason people have privacy concern about RFID technology is that the reader of RFID can check the information from the tags in the vicinity, which depends on how far the tag can transmit the signal. Therefore, people can use the RFID reader to check and collect the information about what kind of products consumers buy. Even

more, RFID may disclose other privacy information like place and itinerary; for instance, people could track your moving by tracking the signal from the tag attached on your clothes. Therefore, the more areas RFID technology is implemented, the more chance the private information would be disclosed if people do not handle this application properly. The report from GOA (Government Accountability Office) pointed out that some government organizations already use RFID in different functions; however, those organizations do not concern the privacy issue cautiously.

### **c) Legal actions for privacy protection**

So far, some states' senate either already passed measure or have planed to draft bills or to conduct studies to address the impact of RFID technology on consumer privacy. For instance, California's state senate passed a bill on Apr. 30, 2004 to set limits on the use of RFID technology by libraries, retailers and other private entities. The bill would prohibit businesses and libraries in California from using RFID tags attached on consumer products or using an RFID reader that could be used to identify an individual, unless they follow with certain conditions:

- The information collected from RFID can only be in regard to items customers actually are buying, renting or borrowing.
- Information can't be collected on what customers may have picked up but put back prior to a transaction, on what they're wearing or on items they are carrying in a wallet or purse.

A previous version of the bill also requested businesses to detach or destroy any RFID tags that are attached to a product purchased by a customer before that customer leaves the store, and also required that businesses obtain approval from an individual before their personally identifiable information is attached to data collected via RFID. But those requirements were deleted from the amended version of the bill that passed the senate. Some states would like to require stores to notify the customers that the RFID is used on those items they buy, and give the consumers chance to choose to disable the RFID tag prior to the purchasing.

Since the privacy issue becomes the biggest concern for consumers, especially in the United States, the government already tries to make the law to prevent any privacy issue caused by RFID implementation. On the other hand, unless the privacy issue is not solved, it is still difficult for consumers to accept this technology in the market no matter how good the technology is.

## Conclusion

According to IDTechEx, the global output value of RFID is \$1.85 billion, and the expected output value of 2006 is 2.71 billion. Therefore, we can see the potential of RFID and related markets. However, whether the RFID can perform some functionalities relating to personal privacy would depend on whether the government and RFID vendors can come out the solutions to protect the personal privacy. Of course, there are some other issues such as cost and reliability that would be the barriers for RFID to get into the market for large scale; however, compared to the privacy issue, the cost and reliability issue would be more easily solved by technology improvement. As I learned from one of the guest speaker in Trust-Worthy Computing course, **the problem is not the technology, but how people use the technology.** We may be able to control the technology, but it is difficult to control people to use the technology in the right way, even by making the strict law. Therefore, hopefully, RFID technology would bring us advantages without other problems.

## Annotated References

Katherine Albrecht & Liz McIntyre (2005), *Spy chips: How Major Corporations and Government Plan to Track Your Every Move with RFID*. Nashville. Tennessee

Claire Swedberg, "States Move on RFID Privacy Issue", *RFID Journal*, Apr. 30, 2004, from <http://www.rfidjournal.com/article/view/924>

Dibya Sarkar, "U.S. officials favor global RFID standard International groups tackle the issue", Jun. 20, 2005, from <http://www.fcw.com/article89310-06-20-05-Print>

"What is RFID?", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=1>

"How RFID Works", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=2>

"How is RFID used inside a living body?", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=3>

"What can RFID be used for?", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=4>

"Is RFID Technology Secure and Private?", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=5>

"Are There Concerns About How RFID Will Be Used?", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=6>

"Problems With RFID", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=20>

"RFID Information Technology Articles", Technology.com website, from <http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=8>

“RFID Versus Barcodes”, Technology.com website, from  
<http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=60>

“大廠競相投入RFID”, Taiwan CNET.Com, August 20, 2004, from  
<http://taiwan.cnet.com/news/software/0,2000064574,20091874,00.htm>