Understanding Radio Frequency Identification (RFID)

Frequently Asked Questions

General RFID Information

What is RFID?
Radio frequency identification, or RFID, is a generic term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it.

Is RFID new?
RFID is a technology that's been around since World War II. Up to now, it's been too expensive and too limited to be practical for many commercial applications. But if tags can be made cheaply enough, they can solve many of the problems associated with barcodes. Radio waves travel through most non-metallic materials, so they can be embedded in packaging or encased in protective plastic for weatherproofing and greater durability. And tags have microchips that can store a unique serial number for every product manufactured around the world.

Is RFID better than using barcodes?
RFID is not necessarily "better" than barcodes. The two are different technologies and have different applications, which sometimes overlap. The big difference between the two is barcode is a line-of-sight technology. That is, a scanner has to "see" the barcode to read it, which means people usually have to orient the barcode toward a scanner for it to be read. Radio frequency identification, by contrast, doesn't require line of sight. RFID tags can be read as long as they are within range of a reader. Barcodes have other shortcomings as well. If a label is ripped or soiled or has fallen off, there is no way to scan the item. In addition, standard barcodes identify only the manufacturer and product, not the unique item. The barcode on one milk carton is the same as every other milk carton, making it impossible to identify which one might pass its expiration date first.

In what ways are companies using RFID today?
Thousands of companies around the world use RFID today to improve internal efficiencies. Club Car, a maker of golf carts uses RFID to improve efficiency on its production line. Paramount Farms - one of the world's largest suppliers of pistachios—uses RFID to manage its harvest more efficiently. NYK Logistics uses RFID to improve the throughput of containers at its busy Long Beach, Calif., distribution center. Many other companies are using RFID for a wide variety of applications. (Visit the Case Study section of our website for more examples.)

What are some of the most common applications for RFID?
RFID is used for everything from tracking cows and pets to providing secure building access to employees. The most common applications are payment systems (Mobil Speedpass and toll collection

systems, for instance), access control and asset tracking. Increasingly, retail/CPG and pharma companies are looking to use RFID to track goods within their supply chain, to simplify work in process and for other applications.

RFID Technology

How does an RFID system work?
An RFID system consists of a tag made up of a microchip with an antenna, and an interrogator or reader with an antenna. The reader sends out electromagnetic waves. The tag antenna is tuned to receive these waves. A passive RFID tag draws power from the field created by the reader and uses it to power the microchip's circuits. The chip then modulates the waves that the tag sends back to the reader, which converts the new waves into digital data. (For more information, see About RFID)

What is the difference between low-, high-, and ultra-high frequencies?
Just as your radio tunes in to different frequencies to hear different channels, RFID tags and readers have to be tuned to the same frequency to communicate. RFID systems use many different frequencies, but generally the most common are low-frequency (around 125 KHz), high-frequency (13.56 MHz) and ultra-high-frequency or UHF (860-960 MHz). Microwave (2.45 GHz) is also used in some applications. Radio waves behave differently at different frequencies, so it's important to choose the right frequency for the right application.

How do I know which frequency is right for my application?
Different frequencies have different characteristics that make them more useful for different applications. For instance, low-frequency tags use less power and are better able to penetrate non-metallic substances. They are ideal for scanning objects with high-water content, such as fruit, but their read range is limited to less than a foot (0.33 meter). High-frequency tags work better on objects made of metal and can work around goods with high water content. They have a maximum read range of about three feet (1 meter). UHF frequencies typically offer better range and can transfer data faster than low- and high-frequencies. But they use more power and are less likely to pass through materials. And because they tend to be more "directed," they require a clear path between the tag and reader. UHF tags might be better for scanning boxes of goods as they pass through a dock door into a warehouse. It is best to work with a knowledgeable consultant, integrator or vendor that can help you choose the right frequency for your application.

Do all countries use the same frequencies?
No. Different countries have allotted different parts of the radio spectrum for RFID, so no single technology optimally satisfies all the requirements of existing and potential markets. The industry has worked diligently to standardize three main RF bands: low frequency (LF), 125 to 134 kHz; high frequency (HF), 13.56 MHz; and ultrahigh frequency (UHF), 860 to 960 MHz. Most countries have assigned the 125 or 134 kHz areas of the spectrum for low-frequency systems, and 13.56 MHz is used around the world for high-frequency systems (with a few exceptions), but UHF systems have only been around since the mid-1990s, and countries have not agreed on a single area of the UHF spectrum for RFID. (For more information, visit the Frequencies section of the AIM website).

RFID Tags

How much information can an RFID tag store?
It depends on the vendor and the application, but typically a tag carries no more than 2KB of data—enough to store some basic information about the item it is on. Companies are now looking at using a simple "license plate" tag that contains only a 96-bit serial number. The simple tags are cheaper to manufacture and are more useful for applications where the tag will be disposed of with the product packaging.

What's the difference between read-only and read-write RFID tags?
Microchips in RFID tags can be read-write, read-only or "write once, read many" (WORM). With read-write chips, you can add information to the tag or write over existing information when the tag is within range of a reader. Read-write tags usually have a serial number that can't be written over. Additional blocks of data can be used to store additional information about the items the tag is attached to (these can usually be locked to prevent overwriting of data). Read-only microchips have information stored on them during the manufacturing process. The information on such chips can never be changed. WORM tags can have a serial number written to them once, and that information cannot be overwritten later.

What's the difference between passive and active tags?
Active RFID tags have a transmitter and their own power source (typically a battery). The power source is used to run the microchip's circuitry and to broadcast a signal to a reader (the way a cell phone transmits signals to a base station). Passive tags have no battery. Instead, they draw power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna. Semi-passive tags use a battery to run the chip's circuitry, but communicate by drawing power from the reader. Active and semi-passive tags are useful for tracking high-value goods that need to be scanned over long ranges, such as railway cars on a track, but they cost more than passive tags, which means they can't be used on low-cost items. (There are companies developing technology that could make active tags far less expensive than they are today.) End-users are focusing on passive UHF tags, which cost less than 40 cents today in volumes of 1 million tags or more. Their read range isn't as far—typically less than 20 feet vs. 100 feet or more for active tags—but they are far less expensive than active tags and can be disposed of with the product packaging.

What is a chipless RFID tag?
"Chipless RFID" is a generic term for systems that use RF energy to communicate data but don't store a serial number in a silicon microchip in the transponder. Some chipless tags use plastic or conductive polymers instead of silicon-based microchips. Other chipless tags use materials that reflect back a portion of the radio waves beamed at them. A computer takes a snapshot of the waves beamed back and uses it like a fingerprint to identify the object with the tag. Companies are experimenting with embedding RF reflecting fibers in paper to prevent unauthorized photocopying of certain documents. Chipless tags that use embedded fibers have one drawback for supply chain uses—only one tag can be read at a time.

I've heard that RFID doesn't work around metal and water. Does that mean I can't use it to track cans or liquid products?
Radio waves bounce off metal and are absorbed by water at ultrahigh frequencies. That makes tracking metal products, or those with high water content, difficult. However, good system design and engineering are beginning to overcome this shortcoming. Low- and high-frequency tags work better on products with water and metal. In fact, there are applications in which low-frequency RFID tags are embedded in metal auto parts to track them.

RFID Readers

What is an agile reader?
An agile reader is one that can read tags operating at different frequencies or using different methods of communication between the tags and readers.'

What is reader collision?
One problem encountered with RFID is that the signal from one reader can interfere with the signal from another where coverage overlaps. This is called reader collision. One way to avoid the problem is to use a technique called time division multiple access, or TDMA. In simple terms, the readers are instructed to read at different times, rather than both trying to read at the same time. This ensures that they don't interfere with each other. But it also means any RFID tag in an area where two readers overlap will be

read twice. So the system has to be set up so that if one reader reads a tag, another reader does not read it again.

What is "dense reader" mode?
This is a mode of operation that prevents readers from interfering with one another when many are used in close proximity to one another. Readers hop between channels within a certain frequency spectrum (in the United States, they can hop between 902 MHz and 928 MHz) and may be required to listen for a signal before using a channel. If they "hear" another reader using that channel, they go to another channel to avoid interfering with the reader on that channel.

The Cost of RFID Equipment

Can I buy a 5-cent RFID tag?
EPCglobal's goal is to drive adoption of RFID technology to the point where massive numbers of tags are made each year and the cost for silicon-based tags that can store a unique serial number drops to 5 cents per tag. Costs have fallen steadily over the past few years and will decline further as adoption ramps up.

How much does an RFID tag cost today?
Most companies that sell RFID tags do not quote prices because pricing is based on volume, the amount of memory on the tag and the packaging of the tag (whether it's encased in plastic or embedded in a label, for instance). Generally speaking, a 96-bit EPC inlay (chip and antenna mounted on a substrate) costs from 7 to 15 U.S. cents. If the tag is embedded in a thermal transfer label on which companies can print a barcode, the price rises to 15 cents and up. Low- and high-frequency tags tend to cost a little more.

How much do RFID readers cost today?
Most UHF readers cost from $500 to $2,000, depending on the features in the device. Companies may also have to buy each antenna separately, along with cables. Antennae are about $250 and up. The price of readers is expected to fall as companies purchase them in large volumes. Low- and high-frequency readers range in price, depending on different factors. A low-frequency reader model (a circuit board that can be put into another device) can be under $100, while a fully functional standalone reader can be $750. High-frequency reader modules are typically $200 to $300. A standalone reader can be about $500.

How much does a fully functional RFID system cost?
The cost depends on the application, the size of the installation, the type of system and many other factors, so it is not possible to give a ballpark figure. In addition to tag and reader costs, companies need to purchase middleware to filter RFID data. They may need to hire a systems integrator and upgrade enterprise applications, such as warehouse management systems. They may also need to upgrade networks within facilities. And they will need to pay for the installation of the readers. Not only do the readers need to be mounted, they need electrical power and to be connected to a corporate network.

Electronic Product Code (EPC)

What is EPC Gen 2?
Gen 2 is the shorthand name given to EPCglobal's second-generation EPC protocol. It was designed to work internationally and has other enhancements such as a dense reader mode of operation, which prevents readers from interfering with one another when many are used in close proximity to one another.

How does the EPC work?
The EPC (electronic product code) is a string of numbers and letters, consisting of a header and three sets of data partitions. The first partition identifies the manufacturer. The second identifies the product type (stock keeping unit or SKU) and the third is the serial number unique to the item. By separating the data into partitions, readers can search for items with a particular manufacturer's code or product code. Readers can also be programmed to search for EPCs with the same manufacturer and product code, but which have unique numbers in a certain sequence. This makes it possible, for example, to quickly find products that might be nearing their expiration date or that need to be recalled.

Why is EPC technology important?
EPC technology could dramatically improve efficiencies within the supply chain. The vision is to create near-perfect supply chain visibility—the ability to track every item anywhere in the supply chain securely and in real time. RFID can dramatically reduce human error. Instead of typing information into a database or scanning the wrong barcode, goods will communicate directly with inventory systems. Readers installed in factories, distribution centers, and storerooms and on store shelves will automatically record the movement of goods from the production line to the consumer.

How can a company track items using EPCs?
Companies have to create a network of RFID readers. In a warehouse for example, there could be readers around the doors on a loading dock and on every bay. When a pallet of goods arrives, the reader on the dock door picks up its unique license plate. Computers look up what the product is using the EPC Network. Inventory systems are alerted to its arrival. When the pallet is put in bay A, that reader sends a signal saying item 1-2345-67890 is in bay A.

Privacy and Data Collection

What information is stored on RFID tags?
The tags most companies are planning to use in the supply chain in the short term and in consumer packaging in the long term will contain only an Electronic Product Code. The EPC will be associated with data in online databases. Some information about the item might be accessible to anyone - such as what the product is - but other information, such as where it was made and when-will be accessible only to those whom the manufacturer wants to make the information available to. So Wal-Mart will not have access to data about products sold by Target and vice versa.

Are there laws governing the use of RFID?
Many existing privacy laws cover the use of data collected by RFID systems, as well as barcodes and other systems. Some U.S. states have enacted or considered enacting new laws dealing with issues particular to RFID, such as the surreptitious scanning of tags by retailers or those with criminal intent.

What kind of data do companies want to collect?
Companies are interested in using RFID in the supply chain. The main goal is to use it to make sure they have products on the shelves when consumers want to buy them. It's envisioned that "smart shelves"—shelves with RFID readers in them—will alert staff when inventory is running low. There is also hope that RFID can be used to reduce theft by alerting staff when there is unusual shelf activity—such as when someone grabs a dozen tubes of lipstick or razors.

From how far away can a typical RFID tag be read?
The distance from which a tag can be read is called its read range. Read range depends on a number of factors, including the frequency of the radio waves used for tag-reader communication, the size of the tag antenna, the power output of the reader, and whether the tags have a battery to broadcast a signal or gather energy from a reader or merely reflect a weak signal back to the reader. Battery-powered tags typically have a read range of 300 feet (100 meters). These are the kinds of tags used in toll collection systems. High-frequency tags, which are often used in smart cards, have a read range of three feet or less. UHF tags - the kind used on pallets and cases of goods in the supply chain - have a

read range of 20 to 30 feet under ideal conditions. If the tags are attached to products with water or metal, the read range can be significantly less. If the size of the UHF antenna is reduced, that will also dramatically reduce the read range. Increasing the power output could increase the range, but most governments restrict the output of readers so that they don't interfere with other RF devices, such as cordless phones.