POLICYMAKERS' GUIDE
to Radio Frequency IDentification Technology

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An Introduction to RFID

You have probably heard of Radio Frequency Identification (RFID) technology in many different contexts. RFIDdescribes a broad range of technologies that allow the identification and tracking of physical items using radio waves, and have far-reaching implications for processes as wide-ranging as factories, hospitals, airports, battlefields and retail stores.

An Introduction to RFID

The term RFID encompasses a broad range of capabilities in tags and readers, and RFID systems are designed for many different purposes. We won't be able to describe them all here. But it should be kept in mind that RFID doesn't just represent the next generation of barcodes.

It helps create an environment in which objects can communicate with one another. By combining RFID with sensors and wireless communication, everyday objects will be able to sense, communicate, and even take action based on those interactions.

Like the Internet, RFID is an infrastructural technology which can be used by people with imagination and skill in countless different ways. But as with any revolutionary technology, RFID raises a range of public policy questions.

The potential benefits of RFID are enormous, and the technology is improving on a daily basis, but there are still obstacles to its widespread adoption. The following piece attempts to illustrate some of the applications, some of the benefits, and some of the issues that are raised by various implementations of RFID.

An Introduction to RFID

RFID technology makes real-time information about objects and their history available to people who can use that information. Among many other benefits, the availability of such information facilitates delivery of important goods to the frontlines of combat zones; it streamlines factory and shipping processes, and decreases losses due to inefficiency and cargo "shrinkage;" and it benefits consumers by facilitating product recalls and warrantees.

How Radio Frequency IDentification Works

New uses of RFID systems are now emerging due to the convergence of a number of technological trends. The trends that led to the development of ever more capable computer chips at lower prices have led to smaller and cheaper RFID chips; RFID readers are becoming less expensive and more convenient to use. Recent innovations in radio technology have encouraged entrepreneurs to find new radio-based applications. The revolution in data processing allows businesses to collect more data and to use it to become more efficient. And the growth of the Internet provides a means for data to be moved quickly and inexpensively.

How Radio FrequencyIDentification Works

1TAGS

RFID tag

- The tag, also referred to as a "chip," or transponder, contains an antenna allowing the tag to receive and send signals via radio waves, and a microchip to store information.
- The tags are often incorporated into a larger sticker and stuck on an item. These, and tags in an item's external packaging, are readily removable. In other cases, tags may be more integral to the packaging or even to the item itself.

Glass capsule tags

- Small and cheap tags will include a unique identification number for each object; more expensive tags will be able to store and process more data. Some tags are "read only," meaning that the information on the tag is fixed; more complex tags are classified as "read/write," meaning that the information stored on them can be changed and updated. Some tags are capable of using encryption or password protection to control access to the data that is stored on the chip.

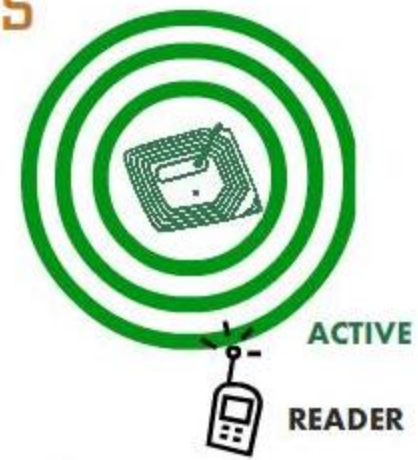
Adhesive label tag

- Tags can be combined with sensors, including those that can detect and record temperature, pressure, humidity, and other environmental factors. This allows users to monitor the condition of an item while in transit. Further, when used in conjunction with sensors and wireless communication, RFID tags will enable everyday objects to sense, communicate, and even respond to these external stimuli to great benefit.

How Radio FrequencyIDentification Works

1TAGS

ACTIVE vs. PASSIVE TAGS



Tags can be either **passive** or **active**. More common and less expensive are passive tags, which do not have any independeMore common are passive tags, which do not have any independent power source and are inactive when not in range of the reader. When within range, they respond to an electromagnetic field generated by the reader and, using energy generated by this field, emit a signal containing the information they have stored. Active tags, by contrast, have their own power source that transmits the signal. Active tags generally offer longer read ranges, and have a finite battery life.

How Radio Frequency IDentification Works

2 READERS

Symbol T

Mobile computer with RFID reader

Fixed reader in a warehouse setting

TI RFID

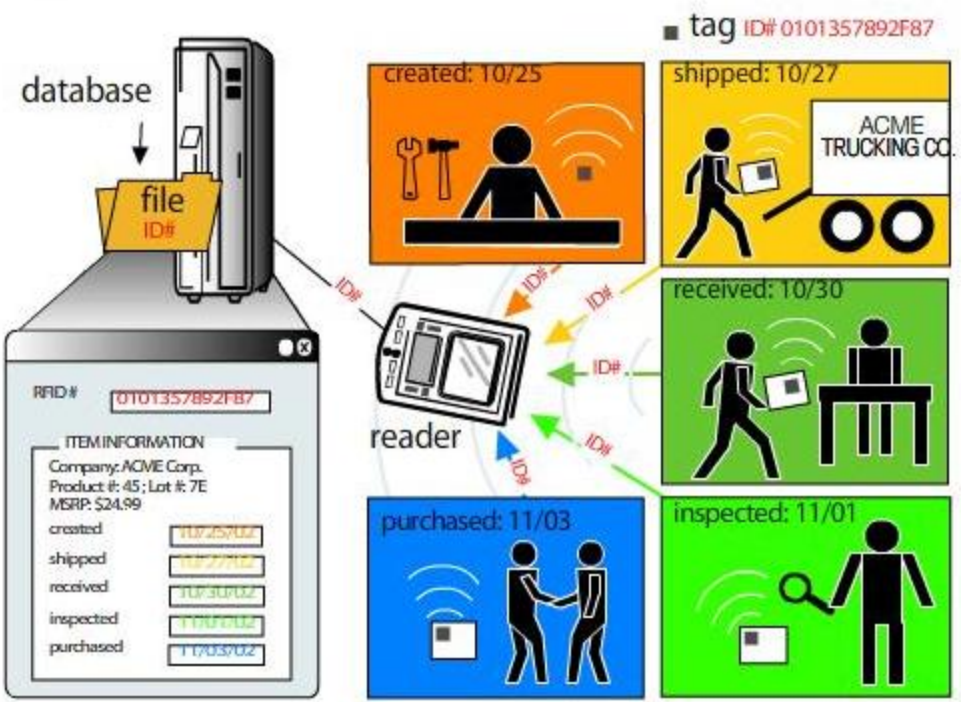
RFID reader

- A reader or "scanner" is used to collect information from the tag. The reader captures the information and displays it, or forwards it via a local network or via the Internet to other devices or remote databases.
- Because the tags and the reader communicate using radio waves, readers can "scan" items without making direct contact or even without a direct line of sight to the item. Readers can also communicate with many tags virtually simultaneously making them much more efficient than today's laser scanners. Readers can be hand-held like wands or fixed, such as a readers attached to the entryway of a warehouse used to scan items that are arriving or leaving.
- While the goal is for readers to accurately read 100% of the tags, today's readers do not always accomplish this. Reader accuracy is affected by the strength of the signals from the tags and even by the materials that make up the tagged item; metals and liquids make accurate reads much more difficult.
- Prices for readers, as those for chips, are falling. But readers are still relatively expensive with prices ranging from hundreds to thousands of dollars. These costs presently limit the proliferation of RFID readers.

How Radio FrequencyIDentification Works

3 DATABASES & NETWORKS

- While most tags emit only an identifying number that remains unchanged, a file in a database can be constantly updated to hold a wealth of information about the tagged item.



How Radio Frequency IDentification Works

RFID highlight

Databases and networks – and issues of privacy and security – are not unique to RFID systems. Most RFID tags are analogous to a license plate, which uniquely identifies a vehicle and is publicly visible, but itself doesn't offer any meaningful information about a car or its driver. The sensitive, detailed information that corresponds to that identifier is held in a separate database.

In most cases, even though the radio signal from the tag itself is potentially subject to intercept, the most important element with regard to maintaining privacy and security of a tagged item is **the security of the databases and the networks** with which the tag is associated. More sophisticated (and expensive) tags can encrypt the information or provide access control in cases where the information emitted from that the tag is itself sensitive – such as with tags on e-passports.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

LOW FREQUENCY PASSIVE TAGS

125-134 kHz

100 kHz

applications

RFID tags have been used to **track animals**, by attaching tags to their ears or implanting tags under the skin. The RFID systems can include information about the animal's pedigree, medical history, even diet, which can help prevent and isolate outbreaks of disease in livestock. Foodstuffs can be tagged from farm to table to assure quality.

In hospitals, RFID systems are being used to **track devices**, particularly high cost/high value equipment that might be needed in emergencies, so that doctors can find essential equipment more efficiently. Use of tags on patients can offer critical information about a person's medical history even when the patient is unable to do so.

One form of RFID system that is becoming more widespread is sometimes referred to as a **"contactless" identification system.** These systems – found in building security systems, mass transit fare cards, and credit cards – operate on the same principles as other RFID systems but have very limited read ranges requiring that the card containing the chip come very close to the reader.

Beginning in October 2006, the State Department will equip new and renewed **passports** with RFID tags that will speed up entry processing and which will be harder to forge. The initial proposal drew considerable protest from privacy advocates because of concerns that the unencrypted radio signals would be intercepted, allowing unauthorized reading and surreptitious identification of Americans.

RFID Applications*

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LOW FREQUENCY PASSIVE TAGS

125-134 kHz

100 kHz

cost

RELATIVELY CHEAP Simple, low-frequency passive tags generally cost 25 cents or less. However, some chips can hold and manipulate more information, or encrypt the data in the radio signal, raising the price.

read range

LOW READ RANGE Low frequency chips use "inductive coupling," which means the read range is low, but the reliability is high - because they are less susceptible to interference from other metals.

read rate

LOW READ RATE

other

In the U.S., RFID-enabled devices allow us to pay at the gas pump. RFID enabled wireless phones, which are proliferating in Europe and Asia, allow users to swipe their phone past a reader to pay for all types of goods and services.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

HIGH FREQUENCY PASSIVE TAGS

13.56 MHz

10 MHz — 100 MHz

applications

Shoppers should see increased choices in the goods available with better **supply chain management**. As more and more retail items are tagged, it will be easier for stores to ensure that the right goods are on the right shelves where customers can find them. Libraries are using the same tagging technology to track their resources more efficiently.

Many RFID applications are **transportation**-related. The FAA has recently authorized airlines to use RFID tags on spare parts used for repairs on the ground. The airlines estimated that they could save $700 million dollars per year through better tracking of parts. Tire manufacturers are utilizing RFID systems to monitor the performance of tires and to automatically detect and communicate problems such as tire under inflation or excessive wear.

The FDA has authorized tagging to improve the handling of certain **dangerous drugs**. And in an effort to combat the counterfeiting and diversion of drugs, the FDA and the pharmaceutical industry are developing RFID systems that will allow drugs to be tracked from factory to pharmacy. Such systems might help prevent errors in dispensing drugs; they might even be extended, past the final sale of the item, to facilitate in-home monitoring of patients with special needs, to ensure that they take their medications.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

HIGH FREQUENCY PASSIVE TAGS

13.56 MHz

10 MHz — 100 MHz

cost	 **LESS EXPENSIVE**
read range	 **LOW READ RANGE** Up to 3 ft/0.9 m
read rate	 **MEDIUM READ RATE** 10-100 tags/second
other	 Because of the present cost of tags, most inventory applications now place tags only on the pallets and cases used to transport multiple items. But where the individual item comes in its own case, such as a computer printer, item-level tagging by some manufacturers and retailers has already begun.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

ULTRAHIGH FREQUENCY ACTIVE TAGS

433-900 MHz

500 MHz

applications

Cargo tracking is one of the most important applications of RFID. Not only can it save shippers billions in cargo losses and "shrinkage," the identification of goods can have national security implications, by giving the Department of Homeland Security and other first responders access to information on shipments entering ports and on highways. **The Department of Defense**, like Wal-Mart,mandated in 2003 that its principal suppliers use passive RFID technology, including manufacturers of everything from tanks to paper towels. In combat situations, though, it is hard to track shipments and confirm delivery, so DOD often employs robust high frequency active RFID to help automate the processes.

Widely used in the U.S. are systems like **E-Z Pass** which uses RFID to allow motorists to pay tolls by passing through collection gates and having their accounts automatically debited. The benefits in time and effort can be substantial. At the same time, these systems gather information about the movement of the car, which might be used later for different purposes.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

ULTRAHIGH FREQUENCY ACTIVE TAGS

433-900 MHz

%00 MHz

cost

MOST EXPENSIVE Active tags are generally more robust than other tags, sometimes allowing users to save money on other components of the RFID system (readers, etc) because the tags are so powerful.

read range

LONG READ RANGE Some active devices can work at distances up to 250 feet/75 meters, and the reader and tag can communicate even at relative speeds greater than 150 miles/hour (240 km/hr).

read rate

HIGH READ RATE As well as having a high read rate, active tags are often "read/write," meaning that the information in them can be changed and updated when they are scanned.

other

RFID systems are not the same thing as Global Positioning Systems (GPS), which are used to determine the location of objects using satellite technology. RFID systems can also be used to track goods but read ranges are much more limited, measured in feet, not miles.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

ULTRAHIGH FREQUENCY PASSIVE TAGS

900 MHz - 2.5 GHz

900 MHz — 2.5 GHz

applications

Wal-Mart's decision to mandate the use of RFID by its largest suppliers has focused a great deal of attention on RFID use in the **retail inventory and shipping** environment. On pallets and packages – and more often on store shelves, too – Ultra-High Frequency RFID is taking hold. Other major retailers, including Albertsons, Best Buy, Target, Britain's Tesco and Marks & Spencers, and Germany's Metro have also launched major RFID initiatives projects.

RFID's retail and shipping applications make use of **electronic product codes** (EPCs). While bar codes describe a particular type of product, the EPC identifies the individual item itself. In factories, warehouses, and on the shelves of retail stores, RFID systems are streamlining shipment, delivery, and shelving procedures, improving inventory control, and facilitating the reordering of goods to prevent out-of-stock occurrences. RFID tagging can help prevent counterfeiting and unauthorized diversions of goods.

The Department of Homeland Security (DHS) is using RFID in order to improve border management. As part of the US-VISIT program for those visiting the U.S. from abroad, DHS has begun a program involving radio frequency identification chips at land crossings. RFID systems are also part of newDHS programs aimed at improving the screening of containers arriving from abroad.

RFID Applications*

Frequencies and categories on this page are illustrative, not definitive. For example, some applications fit under more than one frequency.

ULTRAHIGH FREQUENCY PASSIVE TAGS

900 MHz - 2.5 GHz

900 MHz — 2.5 GHz

cost	 **LESS EXPENSIVE**
read range	 **MEDIUM READ RANGE** Usually around 15 ft / 4.5 m
read rate	 **HIGH READ RATE** 100-1000 tags / second
other	 Passive RFID systems in the 900 MHz band to 2.5 GHz range are well suited to the automotive, trucking and container shipping industries because they can read distances in excess of 15 feet and can communicate large amounts of information at very high speeds.

RFID Policy Issues and Outlook

An awareness of potential policy issues has marked the most successful implementations of new technologies. Dialogue about the issues and development of appropriate responses increases the likelihood of public acceptance. In some cases the introduction of a new technology has led to a legislative response. With infrastructural technologies like RFID or the Internet, though, legislation in the early stages of a technology's adoption can be premature and prevent not only the aim of the legislation but other, socially desirable, outcomes.

1. Security
2. Privacy
3. Health
4. Environment
5. Labor

1 Security

The security and integrity of any sensitive data that is collected – whatever the collection system – is very important. Because RFID readers and tags communicate using radio waves, unauthorized parties can potentially intercept the signals and misuse any sensitive information. However, the read range for most passive chips varies from a few inches to several feet, making "skimming" (unauthorized reading) difficult; and in most cases even unencrypted data from the tags may not provide much useful data to the unauthorized reader in the absence of access to the database itself. When sensitive information is at stake, more sophisticated tags can encrypt the information within the radio signal or provide some form of access control.

Nonetheless, it is always possible to find a way to intercept a radio signal, and criminals will always seek to crack, counterfeit, and defraud. The security of any RFID system should not be taken lightly. At the same time, though, we must acknowledge that there will always be a balancing among privacy, security, and efficiency. While simpler tags may reveal less personal information to an eavesdropper, they might also be easier for a counterfeiter to copy. As well, sometimes security and privacy come at the expense of efficiency. For example, there is concern about the possibility of a tag being read by an unauthorized reader after a tagged item has been purchased. If all tags were "killed" at the point of purchase, however, post-sales uses of the tags would be precluded, including using the tags to facilitate product recalls, returns, or warranties. Another solution might enable consumers to switch tags "on" and "off."

2 Privacy

The privacy concerns surrounding the gathering of sensitive information and the conditions of its use are not limited to RFID systems. The use of credit and loyalty cards have led to the accumulation of information about individual purchase behavior; developments in information technology have allowed vast quantities of data to be brought together and analyzed.

But whereas loyalty cards and credit cards are read with the customer's active participation, RFID systems can collect information without any obvious indication that such collection is taking place. This potential "invisibility" has raised fears about RFID's being used to surreptitiously track movements or monitor behavior. These scenarios – whether imminent or unlikely – mean that RFID implementers (especially in government applications) should be particularly cognizant of various best practices in data collection and use.

Since the passage of the Privacy Act of 1974 a set of commonly accepted practices has developed. Central to these practices are letting people know when information is being collected, setting out how the information will be used, and allowing for choice. Use of the information is limited to the specified purposes and the amount of data collected is to be minimized; data is not to be retained after the various uses are completed. In addition, the data should be protected by reasonable security safeguards from unauthorized access or use and should be available for correction.

3 Health

If, over the years, RFID systems proliferate, there will be a substantial increase in the use of radio based systems and exposure to radio waves.

4 Environment

While it is possible that the tags may make some materials more difficult to recycle, RFID systems can facilitate recycling by allowing for cost effective automation of sorting processes. By providing the history and content of an object RFID systems may also allow for better tracking and treatment of toxic materials.

5 Labor

Many of the efficiency gains from the use of RFID involve the automation of processes which could have implications for the workforce.

OUTLOOK

RFID is definitely on its way, but there are still some obstacles. A major obstacle is cost. The prices of the components of an RFID system are still expensive, particularly for consumer-oriented applications like item-level tagging which will involve enormous numbers of tags. Many companies involved in retail, shipping and logistics, too, already have considerable investment in bar codes, which makes them more reluctant to switch their systems to RFID, requiring a substantial investment.

The promised return on the investment for many applications is still theoretical and it will take some time for the value of these applications to be accepted. In addition to the investment in the hardware and software, companies using RFID will have to developthe ability and expertise to put the new, real-time data to good use.

Wide-scale adoption of the technology will require that systems be interoperable and follow internationally recognized standards. Cost decreases in tags and readers depend on economies of scale. Both of these depend on agreement on standards for RFID that are now still being developed. While substantial progress has been made, the inherent adaptability of the technology requires that the standards process continue so as to be able to incorporate the new capabilities of the systems.

These standards are international so that systems can interoperate globally, but there is a technical barrier in that different regions of the world have assigned RFID systems to different radio frequencies. The radio frequency regulators and standards bodies have already begun to address this issue.

HIGHLIGHT

When the general public buys into the benefits of the technology, RFID's broader adoption seems likely to be a question of when, not if. It is hard today to imagine commerce before bar codes, but they took time to catch on. Bar codes were patented in 1952, but approval of a standard took twenty years. Even after that, broad adoption of the technology didn't take off until the mid-1980s.

End

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