



RFID and the Internet of Things

The computing industry is in a relentless trend towards any-time, anywhere availability of information that reflects as close to a real-time picture of business conditions as possible. The ability to deliver on this promise, however, is limited by the timeliness of the raw data about where things are, and what is happening to them. RFID is a technology for identifying people and assets without human intervention, enabling computer systems to not only identify objects, but also understand their status. Like smart cards, RFID has created some controversy in its early application, but its value proposition makes it clear that RFID will be a growing part of the web of identity that is emerging.

In many applications, RFID is simply the logical extension of bar code technology, removing the need for active scanning and thus increasing productivity in basic supply chain processes. The MIT AutoID initiative to create extremely low cost RFID “tags” and a universal Electronic Product Code (EPC) to parallel the UPC bar code system is focused on creating a standardized RFID product tag at a cost that is competitive with a printed bar code label. A recent decision by Wal-Mart to require its suppliers to RFID tag pallets of product within a year has generated a lot of buzz around the EPC technology.

There have been many false starts with the EPC version of RFID, however, and it remains to be seen how rapidly this technology will deploy. The excitement of Kevin Ashton, a former brand manager at Procter & Gamble and the driving force



behind the AutoID center is infectious. Ashton says, "This is bigger than the Internet. Creating a way for companies to use sensors to identify goods anywhere in the world is a very big deal. It's going to revolutionize the way we track goods from manufacturing to the consumer and even through recycling. We are, in effect, creating an Internet of things."

Paul Saffo, director of the Institute for the Future, says of RFID, "Once all of these machines start talking to one another, they're going to make commerce - and the world - move much faster, more efficiently and at speeds that humans alone couldn't match."

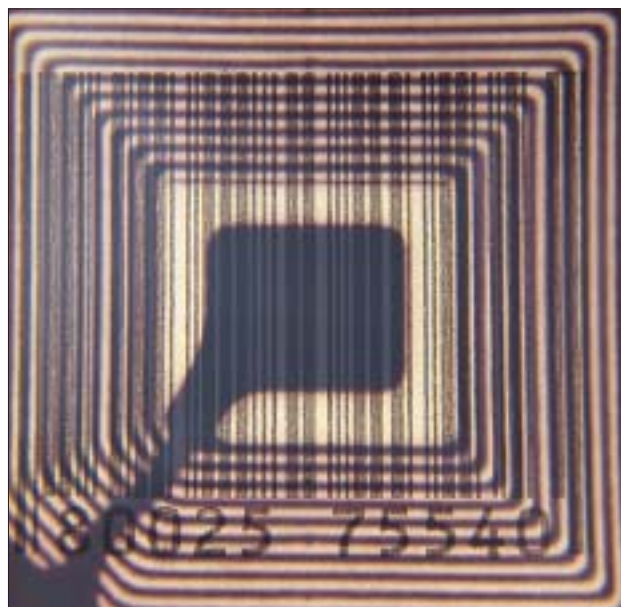
All the Ships at Sea

RFID is more than just "the next bar code" technology, however. It creates a variety of interfaces to connect computers directly to physical items. One of the larger RFID networks in the world is the Joint Total Asset Visibility (JTAV) network built by the military over the last decade. It uses active RFID tags and GPS locators to globally track military supplies and has dramatically improved military logistics. The impetus for this system was an analysis of the logistics problems encountered during the first Gulf War in

1991. During that war, the US lost track of many supply shipments, leading to redundant deliveries and wasted resources. Even when supplies arrived in the right place, 75% of the containers had to be opened just to learn what was inside them. In the most recent conflict, the value of JTAV was demonstrated as the US shipped far fewer supplies and simultaneously had dramatically fewer instances of lost or misallocated materials and munitions.

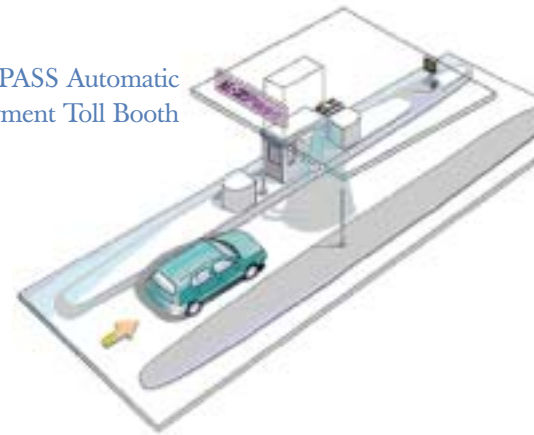
According to the DoD and Savi Technologies, who played a key role in the creation of the JTAV network, JTAV is the largest RFID network in the world in terms of geographic scope. It can read RFID information in 400 places in 40 countries including seaports, military bases, and rail yards world wide. JTAV tracks over 270,000 cargo containers and can even locate them on ocean going vessels via satellite in real time. RFID tags on trucks in convoys report in every hour and JTAV tracks them as well.

The success of JTAV is reflected in the statement by Gen. Paul J. Kern, head of the Army Materiel Command, "No other existing system provides the necessary visibility or level of detail. RFID is the only tool that allows CFLCC (the Coalition Forces Land Component Command) to identify critical cargo, locate it and anticipate its arrival. The technology is proven, widespread and is positively required for CFLCC operations." In one example the British



Combination Bar Code and RFID Tag (rear lighted to show RFID components)

RFID E-Z PASS Automatic Payment Toll Booth



were trying to locate a \$3 million item they needed to effect repairs and couldn't find it anywhere. A check with the JTAV system showed it was sitting 300 feet away from where they were.

Not a New Technology

The first patent for RFID technology was issued in 1973, and Mario Cardullo who received it indicates that things haven't changed as much as you might imagine in the decades since. One of his first RFID application ideas was an automated toll collection system, but when he presented it to the Port Authority of New York the reaction was familiar - "no one will ever mount those transponders on their windows." There was also concern about invasion of privacy and worries that the system could even be unconstitutional as a result. Needless to say the RFID express toll systems in place today indicate that those problems were solved.

Wireless Payment Systems

Wireless toll payment systems, such as EZ-Pass are an area where RFID is making significant inroads. In fact, in this arena RFID and contactless smart card technologies are converging, as is evidenced by pilot projects by Visa, MasterCard and American express to do wireless payment card programs.

In May of this year, the European Commission considered embedding RFID chips in Euro notes to determine the authenticity of the money as a counterfeiting protection (a classic digital identity of things application.) They noted at



the time that in addition to acting as a digital watermark, the use of RFID chips could speed up routine bank processes such as counting. With such tags, a stack of notes can be passed through a reader and the sum added quickly.

The “RFID Euro” effort has raised privacy concerns however. It was reported that the authorities were considering using the RFID notes to record information such as details of the transactions a paper note is involved in to prevent money-laundering and make it possible to track illegal transactions. Doing this is probably not feasible due to the number of reader stations it would require, but talking about it certainly generated adverse publicity.

Trains Keep A Rollin’

Another area where RFID technology has seen success is in tracking rail cars. In this application, a larger RFID tag is used that has a range of nearly 100ft, allowing readers more freedom in positioning along the tracks.

The railroad experience also shows the value of standards. About 10 years ago, all the major rail lines in North America agreed on a standard for RFID tags and readers, and have deployed to that standard to tag over 1.5 million rail cars. By standardizing, common readers can be used on common tracks by multiple companies.

What about ROI? Burlington Northern provides an example. Prior to the RFID system, they employed clerks to walk up and down the tracks at depots and switching stations, and read numbers painted on the sides of their railway cars. That data was then keyed into the company’s mainframe system to track

cars. Today all of Burlington’s cars are tagged and it has completely eliminated manual tracking clerks. The system has paid for itself, plus Burlington is able to more accurately tell customers where their shipments are. The system also has dramatically reduced track delays. Shannon McGovern, Burlington’s director of network support, said “In the old days, when a car was out of place, people had to spend hours trying to figure out where it should be, and that would cause delays throughout the system. Today, that almost never happens.”

Combining Other Sensors with RFID

Combining sensors that measure such things as temperature, G forces, etc. with RFID also creates opportunity. Not only can you monitor things, but you can know what has happened to them. For example, the expiration date on food could be automatically invalidated if temperature ranges were exceeded during transport. Similar applications for impact to boxes in shipment are possible as well.

Not all RFID/sensor projects are immediately practical. One of the more Sci-Fi sensor/RFID combinations is one being championed by Gary Fedder of Carnegie Mellon University - “smart dust.” Smart dust is comprised of RFID particles that are distributed over an area and which then self organize into a mesh-style peer-to-peer network for some purpose. DARPA (Defense Advanced Research Projects Agency) began funding smart dust research in 1998. The military is experimenting with smart dust net-

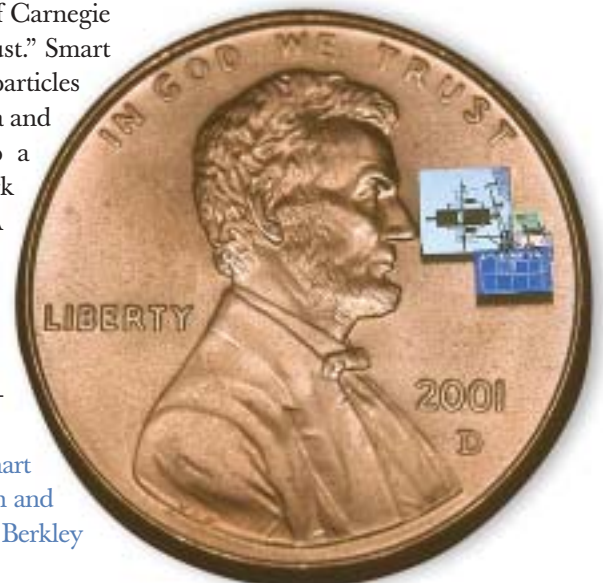
works to detect enemy soldiers and equipment on the battlefield, and also to sniff out deadly toxins in an area.

Ultimately smart dust could lead to practical applications such as temperature and humidity sensing in large areas, out of limits vibration detection in equipment, traffic sensors in urban areas, etc. Smart dust is still likely at least a decade away, but it gives some idea of what may become possible when a true “Internet of Things” appears.

Privacy Issues

Like many digital identity technologies, RFID raises privacy issues. In many cases these could have been avoided if technologists had thought things through a bit, but it is now too late for that. In August, 2003 California State Senator Debra Bowen had her subcommittee on New Technology begin hearings on whether RFID could invade citizens’ privacy. It is fair to say that whenever technology starts to automatically identify things, privacy advocates get spooked. Even though it would be very difficult to use RFID to track people in any practically significant way, the fact that the possibility exists is enough to open the discussion.

Solar Powered Prototype Smart Dust Node with acceleration and light sensors. – UC Berkley



Will Euro notes one day
contain RFID tags?



This is an area that the RFID industry needs to become proactive in, and with the pulling of several high profile RFID retail projects (from Benneton to Wal-Mart) this year in response to privacy advocate's concerns, it appears that at last the developers of RFID have heard the message.

State of RFID Technology

Like many digital identity technologies, RFID is plagued by lack of interoperable standards (or maybe too many standards which creates the same result.) Progress has been made over the past year, but there are significant differences in cost and capability between the various methodologies in use, so convergence is not likely for some time. RFID "tag" technology is

quite advanced today, and costs have come down dramatically. The major area where technology still needs improvement to fully commercialize is in readers and antennas.

RFID has been dogged by many failed experiments in the commercial arena. Many projects launched with high hopes only proved that a specific technology wasn't as ready to use as had been indicated. This initial overselling of the technology has led to a reputation for RFID as an arena primarily populated by "science experiments" and not by real technology. This is not a fair characterization, but many of the technologies are not yet fully mature, and you should not skimp on research if you are looking into RFID.

RFID holds the promise of networking the physical world and tightly integrating it with computing systems. The rewards for successfully doing so are tremendous, as several early projects have proved. But RFID is a technology that must be carefully considered and presented, with the implications for privacy and customer acceptance fully thought through. Otherwise, what should be a highly rewarding deployment can turn into a failed project. ■