

Genesis of the Versatile RFID Tag

Mario Cardullo received the first patent for a passive, read-write RFID tag. He tells how he came up with the idea in 1969.

The media often likes to portray new technologies as the result of a flash of brilliance in the night, or the work of some solitary genius. In fact, if you look at the development of the telephone, the light bulb or the first airplane, each of these inventions was based on the convergence of basic concepts that were fairly well known in the scientific community. The inventors built upon prior knowledge to create something that was practical and versatile.

Similarly, radio frequency identification (RFID) devices are based on basic concepts that have a long history (see [Shrouds of Time: The History of RFID](#)). The concepts initially resulted in the development of "friend or foe" transponder systems for military aircraft. In the 1960's this technology served as the basis of electronic article surveillance (EAS) devices to counter theft. These early devices usually employed a one-bit system, which only indicated the presence or absence of the tag.

In 1969, I was the corporate planning officer to chairman of the Communications Satellite Corporation (Comsat). In the spring of 1969, I was seated next to an IBM engineer on a flight to Washington, from St. Paul. The engineer was implementing the CARTRAK optical system for the railroad industry. This system consisted of a reflective color bar code placed on the side of each railroad car. As the railroad car passes an optical base station, the station would transmit a beam of light. The optical bar code would reflect back a signal associated with the individual car so it could be identified.

There were a number of problems with the CARTRAK system. One was that the reflectors were easily damaged or vandalized. Dirt and mud would obscure the reflected surface, and there was no way to easily change the data the reflected bar code contained, which limited the usefulness of the system.

Birth of an Invention

I was well aware of the friend or foe systems and EAS security devices and believed that these concepts could be expanded upon to offer an alternative to the optical reflector systems being deployed. After the IBM engineer finished talking, I started to sketch in my notebook the idea for the RFID tag with a changeable memory. The original sketch showed a device with a transmitter, receiver, internal memory, and a power source. I signed and dated the sketch and went back to reading a book I had started.

In 1969, I was becoming very dissatisfied with the management of COMSAT and their reluctance to implement the maritime and mobile communication satellite concept, later known as IMARSAT that I had proposed. I began looking to start my own company. I investigated various concepts, and in mid-1969, I decided to launch a startup that would provide analysis of EKG's using a mainframe computer program developed by the National Institutes of Health (NIH).

This analytical program required that the data be in a digital format. So the company would have to design and build a digital medical acquisition terminal initially for EKGs and provide a service. During this period I was also lecturing every few months for the Industrial Management Center of Harvard University. At a lecture series given at Lake Placid, New York I met Daniel Webster, a "cashed out" computer executive. Mr. Webster

was excited about the concept I had for a new company, Communications Services Corporation (ComServ). He asked me to put together a management team and prepare a business plan.

On returning to the Washington, I met with several individuals I knew whom had various competencies, marketing, finance and electronic development. One of those individuals was Bill Parks, a brilliant electronics engineer. Putting my management team together we started work on a business plan. The principal product and service chosen was the EKG terminal and processing service. We also chose a series of electronic products that we thought would be follow-on products, since we did not want to be what the venture capital industry refers to as a "one-trick pony."

One of the products was the initial RFID tag I had sketched earlier that year. After much discussion, we decided to present to Mr. Webster an RFID tag based on a passive transponder with a changeable memory instead of an active battery operated device. The illustration is a page from the original business plan that showed the basic concept that we entitled the "Encoder".

We estimated that the new company would require a capitalization of \$500,000 to start followed by additional capital of several million once the initial product and service was developed. When we presented the business plan to Mr. Webster he was extremely pleased. However, when we outlined the plan to develop a passive transponder with a changeable memory for use as a toll system he literally was ecstatic. Within a week of our meeting with Mr. Webster checks averaging \$50,000 from various investors' he had met with started to arrive at my mailbox. Once the funds were available my management team and I left our positions and started ComServ.

Developing the Initial RFID Tag

ComServ was the first company I had started. At that time, the Washington, DC, area was not known for technology. Many of the companies in the area were dedicated to serving the US Government. From one of those companies I chose, Bill Parks to be our vice president of engineering. He hired a small group of development engineers and technicians, which immediately started developing our two basic products and services, the EKG terminal and the RFID tag.

We contracted with Jacobi, Davidson, Lilling and Siegel, of Washington as our patent attorneys. On May 21, 1970, they filed on our behalf the patent application for the RFID tag. The U.S. Patent Office issued the patent on January 23, 1973 (See Figure 2 for diagram of the initial RFID Tag). The claims that the Patent Office approved included:

1. A transponder comprising:
 - a. Memory means for storing data.
 - b. Means responsive to transmitted code signal for selective writing data into or reading data out from the memory, and for transmitting as an answerback signal data read-out from the memory.
 - c. Means for internally generating operating power for the transponder from the transmitted code signal.
2. A transponder where the transmitted code signal comprises a modulated carrier wave, this being the means for generating operating power comprising detecting means detecting the carrier wave and producing an operating power output signal and means responsive to the operating power output signal for powering the transponder, and the modulations of the carrier wave containing data and command information.
3. A transponder as defined in the patent where the carrier wave is of radio frequency.
4. A transponder as defined in the patent where the carrier wave is of light frequency.
5. A transponder as defined in the patent where the carrier wave is of acoustic frequency.
6. An interrogation system

The patent also presented various uses for the invention including:

1. Detailed description of an automated automotive vehicle highway toll system similar to now used in most of the toll systems today.

2. Provide a transponder which would be "physically small in size such that the device is highly portable, can be easily hidden, if desired, and can be carried and placed in or upon many different objects."

During this period the technical staff started on the process of building the first RFID Tag. In 1970, the only non-volatile memory was ferrite cores that were used in mainframe computers. We needed a small number, sufficient for 16 bits. To achieve this, we purchased small ferrite donuts which served as memory cells that we then hand wound to obtain the non-volatile memory. We built a breadboard unit that we could demonstrate the system.

In 1971, we went to New York to meet with New York Port Authority representatives. We showed them the concept and how it could be used in an automated toll collection system. At that meeting the representative of the Port Authority told us "no one will ever mount those transponders on their car windows". He also thought that the system would lead to invasion of privacy and could be "unconstitutional".

Within two years, the New York Port Authority had contracted to test a system similar to the issued patent (January 1973) but supplied by GE, Glenayre, Philips, and Westinghouse Air Brake. We can now question the propriety of what happened between our meeting with the Port Authority in 1971 and their tests in 1973.

We met similarly with the San Francisco Port Authority who participated in the test with the New York Port Authority. The concept was also presented to the Southern (now Norfolk Southern) Railroad that several months prior had chosen the CARTRAK optical system. I also made a presentation to the Director of the Public Works Committee of the U.S. House of Representatives. At that meeting, I presented the concept as a means of foiling car thieves and as a means of charging people for the use of the Interstate Highway system based on mileage.

While ComServ was building the RFID Tag with a changeable memory, others were also engaged in developing similar concepts including Los Alamos Scientific Laboratory, Northwestern University, and the Microwave Institute Foundation in Sweden. However, ComServ was the first to receive a very generic patent.

By the end of 1973, I had left the ComServ after a disagreement with my original investors. Within a year the company had closed. The development of the RFID concepts continued. Raytheon, RCA and Fairchild had systems by 1973-1975 time period. The developments continued into the 1980's. On January 23, 1990, the original patent expired without further patents by ComServ. The 1990's was a period of significant growth of the RFID tag concept by the wide scale deployment of electronic toll collection systems. Today, the RFID Tag in its various configurations is becoming ubiquitous. While I never benefited financially from my RFID invention, I do look with pride on its use today. Many of the applications I envisioned for it in the early 1970s are now being widely adopted.

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