Near-Field Communication: It Pays

Mobile payment systems explained and explored.

By William Lumpkins and Martin Joyce

THE EXCHANGING OF GOODS FOR A RECOGNIZED SYMBOL OF VALUE CALLED *CURRENCY* HAS OCCURRED ON our planet for tens of thousands of years. The concept has stayed the same: an object represents a set value that is exchanged for goods and services. The object is then reused for other goods and services, with the object's value set by the local or international level of a group of individuals, which sets the value through a complex set of value or trust factors. At one time, precious metals were used, like gold and silver, and then we progressed, first to paper money, specialized paper notes issued by a regulatory body; then checks, paper notes that reference a local bank; and credit cards, plastic cards with identifiers that represent banks or credit-issuing institutions as well as the individual borrower of the credit. The inherent problem still existed that if the paper money, checks, or credit card were lost, stolen, or copied, the individual would lose the value, or "net worth," of his

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BACKGROUND IMAGE LICENSED BY GRAPHIC STOCK. PAYMENT IMAGE COURTESY OF ZYTRONIA.

or her economic buying power. Multiple ideas have been pursued to strengthen the security of exchanging these trust-based tokens of material wealth. An idea that has been explored since the late 1960s (roughly 1968) is the use of radio-frequency identification (RFID) technology.

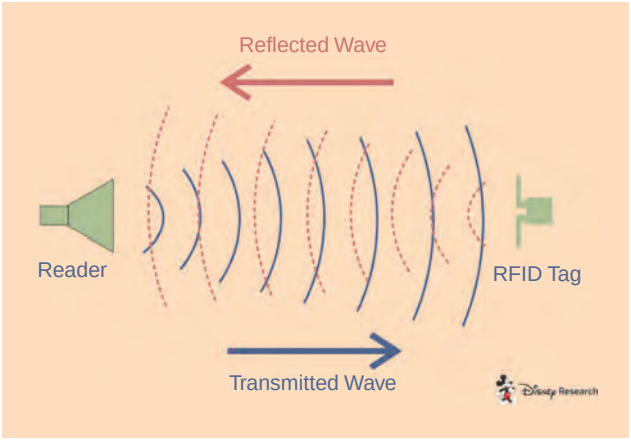

FIGURE 1. A basic RFID system. (Figure courtesy of Disney Research)

FIGURE 2. An RFID tag being injected into a hand. (Photo courtesy of Nick Morrison.)

FIGURE 3. Pet tagging can be used to trace lost animals. (Photo courtesy of the Denver Animal Shelter.)

RFID is simple in its use at a high level, but, as with all things, it becomes more complex in the details of its implementation. Figure 1 shows a simple block diagram of an RFID system in operation. As can be seen in Figure 1, a magnetic field is produced from a field generator. As the RFID tag enters the field, the RFID tag's corresponding antenna, which reacts to the field from the field generator, develops an electrical charge that ostensibly powers a small microprocessor (which may pass a key from the transponder, or just an identifier, back and forth). The RFID tag then sends information to the RFID transponder, which can be used for location-based services or as a value token, i.e., mobile currency. RFID has been used for many years for real-time location-based services as well as for mobile payment in many forms. One early implementation of this was the ill-fated Fairchild e-commerce project of the mid-1980s. Fairchild Semiconductor, as well as Motorola, Texas Instruments, IBM, and the now-defunct DEC, were experimenting with RFID-based monetary systems. Fairchild issued press releases stating that paper money, checks, and credit cards could become mere mementos of the past, proposing the injection of RFID sensors into the hand, which would be tied to the individual's bank or credit institution. Figure 2 shows an example of this procedure.

Great idea, poor market research—Fairchild did not consider the fact that in the United States at the time, there had been a resurgence of "end-of-the-world" fears. Some fanatical religious groups touted the new technology as a sure indication of the end of times, as indicated in the Bible (Revelations 13:16–18): "…a mark on his right hand or forehead, so that no one could buy or sell unless he had the mark…of the beast." These groups very vocally squashed the idea, and Fairchild decided against releasing a product at that time. Interestingly enough, the patents were purchased by various companies and have been very successful as "pet tagging," inserting or embedding RFID tags into pets for enhanced security in the event that pets are lost. Figure 3 shows an example of the marketing advertisements commonly found to promote such activities. Veterinarians and animal shelters now have scanners that can read the identification chip so that they can contact the owner. If you create an environment or the impression that the product is needed, consumers will buy it. Love is a great motivator, as any sociologist or psychologist will tell you.

RFID has many names, and one is *near-field communication* (*NFC*); one could argue that RFID is the physical embodiment of NFC, and NFC is just the communication protocol. Either way, RFID and NFC tend to be used interchangeably among technologists. Arguably, RFID/NFC was developed in the United States as an eavesdropping device for the dark recesses of the U.S. government and then quickly morphed into e-commerce applications. But it did not take off for predominant use in North America. The Japanese/Hong Kong marketplace widely deployed RFID/NFC with Sony Corporation's FeliCa communication standard. FeliCa is rumored to be a reconfiguration of the Felicity Card, which was first used in Hong Kong by Sony Corporation for Hong Kong's mass transit system. FeliCa used the underlying

antenna/field generator (reader/writer) of RFID and incorporated a proprietary communication protocol including encryption for use as a mobile payment system. This early version of FeliCa used 13.56 MHz as the field frequency, with a communication rate of 212 or 424 kb/s. Figures 4 and 5 show some of the common uses of FeliCa card systems.

NFC is derived from communication technology specified by the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) Standard 18092 (NFCIP-1). After the establishment of NFCIP-1, NXP Semiconductors N.V. (formerly Philips Semiconductors), Nokia Corporation, and Sony founded an industry standardization group, the NFC Forum, in March 2004. The NFC Forum has developed a set of specifications that, in addition to NFCIP-1, consider the compatibility with existing contactless integrated circuit (IC) cards. The NFC Forum has also set up a certification program allowing device manufacturers to certify that their products conform to the NFC Forum specifications. In the NFC Forum specifications, the type-A and type-B communication technologies specified in the contactless IC card international standard ISO/IEC 14443 are called *NFC-A* and *NFC-B*, respectively. The FeliCa communication technology, based on the Japanese industrial Standard JIS X 6319.4, is called *NFC-F*. The NFC Forum develops specifications to realize global compatibility and equally handling these technologies. Related to NFC, there is also the international standard ISO/IEC 21481 (NFCIP-2). It covers NFCIP-1, ISO/IEC 14443, and ISO/IEC 15693. Although ISO/IEC 15693 uses the same frequency as the other standards, it is mainly applied to RFID tags used for products and logistics management. ISO/IEC 15693 is not currently included in the specifications defined by the NFC Forum.

An interesting social concern at the moment is the issue of low minimum wages for fast-food workers around the world. There is a general consensus that the wage that fast-food workers make at restaurants such as McDonald's is too low for them to support a family. Thus, fast-food companies are finding ways to automate many of the less-needed functions that require human intervention (e.g., order-takers), including payment systems, with human intervention needed only for the creation of the food product. Self-serve kiosks, such as those shown in Figure 6, are becoming a more common sight around the world. Not only does this help to alleviate the worker issue, it tends to reduce lines and wait times for the consumer, and it speeds up the entire process, so consumers can "consume" faster. As companies are able to outsource more work to automation and reduce the redundant employee base, they are able to increase the wages of the human workers and create both a socially viable economic structure and a profitable bottom line. Hopefully, robotic systems will not advance enough to replace volunteer writers; otherwise, the authors of this article might find themselves out of a job.

GOING BEYOND TRADITIONAL WALLETS

Google Wallet is a free digital wallet that securely stores your credit-, debit-, gift-, and loyalty-card information as well as offers and other data. With Google Wallet, you can shop in stores, buy online, and send money. In stores, you can shop and save by storing all of your gift cards, loyalty cards, and offers on the Google Wallet app. You can also make purchases in stores using the Google Wallet Card or NFC tap-and-pay

FIGURE 4. A student uses FeliCa at a soda machine. (Photo courtesy of Zytronic Inc.)

FIGURE 5. FeliCa being used to purchase sodas with an NFC-enabled phone. (Photo courtesy of *Japan Times*.)

FIGURE 6. NFC enables kiosks for a Spanish fast-food company. (Photo courtesy of O&S Services LLC.)

FIGURE 7. Paying with an NFC-enabled phone. (Photo courtesy of VendingMarketwatch.com.)

FIGURE 8. The Google Wallet Card and app. (Photo courtesy of Google Inc.)

FIGURE 9. Google Wallet in action. (Photo courtesy of Extreme-Action.com.)

system if you have an NFC-enabled Android device. Online, you can use Google Wallet to make purchases in the Google Play store, with other Google products, and on select Android apps and sites, wherever you see the "buy with Google" button. You can send money to or request it from anyone in the United States who has either an e-mail account through Gmail or the Google Wallet app. If he or she does not have a Google Wallet already, he or she can create one. In addition, you can track your online purchases, get shipping notifications, and view a detailed order history using the Google Wallet app.

Google Wallet exists either on the user's NFC-enabled Android device (Figure 7) or as a separate NFC-encapsulated plastic card that looks like a credit card (Figure 8). Author William Lumpkins ordered a Google Wallet Card, as he does not have an NFC-enabled Android phone, just an Apple-based NFC phone, which Google does not presently support. Figure 9 shows the Google Wallet in action. In theory, like all NFC solutions, it is supposed to replace credit cards, although the authors are not sure that they are willing to cut up their credit cards anytime soon. There is still the issue of trust that always exists with new technology and payment systems.

Another payment system that has come out is the Apple Pay mobile payment system (Figure 10). Apple Pay is designed to protect the user's personal information. It doesn't collect any transaction information that can be tied back to the user, and payment transactions are between the user, the merchant, and the user's bank. Apple doesn't collect your purchase history, so when you are shopping in a store or dining at a restaurant, they don't know what you bought, where you bought it, or how much you paid for it. Actual card numbers are not stored on the device; instead, a unique device account number is created, encrypted, and stored in the secure element of the device. The device account number in the secure element is walled-off from iOS and not backed up to iCloud.

Apple Pay supports credit and debit cards from the three major payment networks, American Express, MasterCard, and Visa. In addition to American Express, Bank of America, Capital One Bank, Chase, Citi, Wells Fargo, and others who announced their support in September, more than 500 other banks in the United States have signed on to Apple Pay. Users can make purchases in stores and within apps with credit cards issued by many of the leading banks nationwide, which make up 83% of the credit-card purchase volume in the United States. In stores, Apple Pay is fast and easy to use. Simply hold the iPhone near the contactless reader while keeping a finger on the Touch ID button [1].

Both Apple Pay and Google have the very real restriction that they are currently both U.S.-centric; this is mostly because the level of security that the rest of the world requires for banking and credit-card transactions has oddly never been implemented in U.S. systems. Both Apple and Google will need to beef up their encryption and security protocols to be able to operate in the worldwide arena, just as Japan and China have with FeliCa and the European Union has with the Smart Card ICs. One possible bridging mobile solution is an "outside-the-box" financial e-payment system, Bitcoin.

Bitcoin was first created in 2009 by a person or group of people that go by the pseudonym Satoshi Nakamoto. He/they continued working on it until mid-2010. The main development of the Bitcoin core was then handed over to Gavin Andresen, who continues his work on it as the chief scientist of The Bitcoin Foundation. Bitcoin is a decentralized, peer-to-peer, digital form of transacting value. There will only ever be a finite amount of Bitcoin, which makes it deflationary as a currency. It can be sent over the Internet and, more recently, through SMS. There are no banks involved in the protocol. The network is run by people called *miners* who act as banks or notaries, recording every transaction, and the data are then stored publicly on the Blockchain securely, using complex cryptographic algorithms. The miners also take a small fee for processing the transaction. To store Bitcoin, one needs a digital wallet, several of which can be downloaded as an app to your mobile device.

To send a transaction, you enter the recipient's address, the amount you want to send, and simply click "send." The end-user experience is quite simple. Bitcoin also has no borders. It can be sent from anywhere in the world to anyone who has a wallet. The transaction fee for sending Bitcoin is usually only a few cents and sometimes free. Transactions are sent instantly but take several minutes to be confirmed by the miners.

When using Bitcoin, your mobile phone is your wallet. You can pay for things by simply flashing your phone off another device. You would never need to visit an ATM. You would never have to worry about having exact change or breaking a note because your money is digital. There would be no more piles of small coins building up in your house because you will never receive change. The conventional wallet would become extinct.

Possibly where it may have its biggest impact will be in third-world countries. Worldwide, about 3 billion individuals are unbanked and undocumented. But most people own phones, which would allow them to be financially independent through Bitcoin. It would significantly reduce the cost of remittances, saving people in developing countries billions of dollars. There is a company in Kenya, bitPesa, that is creating such services.

There are not many places where you can use Bitcoin today, but the number of merchants accepting it is growing every day. A problem with using it as a currency is the volatility. There are wild price swings that occur often, which deters people from using the network. Many merchants who accept Bitcoin exchange it to their local currency instantly.

Another interesting technology, which is directly linked to Bitcoin, is the Blockchain. This is where all the records of every transaction ever made are kept. These transactions are tamper-resistant. A Bitcoin doesn't have to just be a currency. It can be a representation of ownership. People can use Bitcoin to sign a contract, e.g., if you buy a car from someone. They give you the key, and within that key is a Bitcoin, which represents ownership of the car. The car will not start unless the Bitcoin, which will be in the key, is in the ignition.

It also allows for micropayments. Bitcoin can be divided into millionths of pieces. With this, you could pay ten cents to read a news article instead of paying for whole monthly subscriptions. It also allows for peer-to-peer lending of money. A group of people could lend fractions of a loan to someone instead of relying on one central entity.

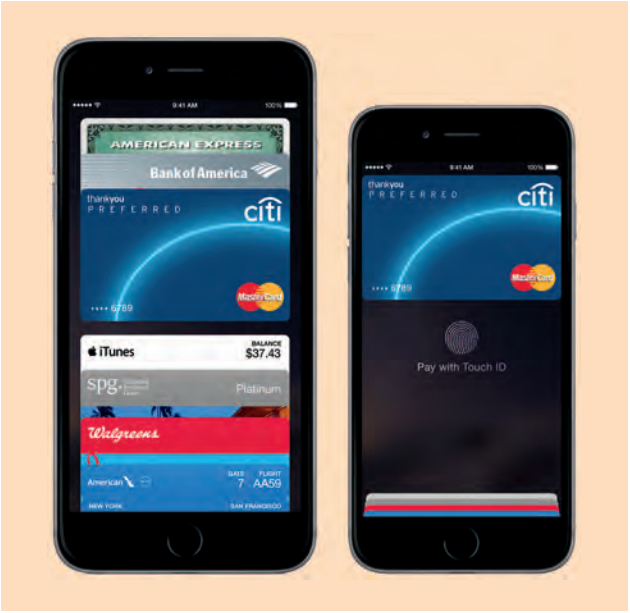

FIGURE 10. The Apple Pay interface. (Photo courtesy of Apple Inc.)

Hopefully, Bitcoin (through NFC-enabled devices), Google Wallet/Apple Pay, or FeliCa will standardize each other or one will win out sooner rather than later. NFC is the way forward to eliminate paper currency and plastic credit cards, probably with the addition of tightened biometric security protocols like the P2410 Biometric Open Protocol Standard [2].

We can foresee a future where, with smart contact lenses, we no longer need to worry about being robbed or losing mobile payment systems and can just enjoy life without the added stress that money can create. Perhaps this is a dream, but dreams are good.

As always, the views expressed in this article are those of the authors and are not representative of the IEEE or *IEEE Consumer Electronics Magazine*. All comments are welcome.

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