



A review of Near Field Communication technology in several areas

Una revisión de la tecnología de Comunicación de Campo Cercano en varias áreas

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ABSTRACT:

Currently, the technology of Near Field Communication (NFC) has been popular in many sectors although NFC is still an emerging technology. NFC is a subset of radio frequency identification (RFID). NFC provides short range contactless communication for mobile phones and other devices. Therefore, many researchers are investigating this technology because of its emerging and promising technological development to provide efficiency system. In this paper, 52 journals have been reviewed and the papers have been classified into categories based on the areas of NFC implemented such as automotive, services education, public health care, indoor navigation system, payment system, public transportation, retail industries, smart posters and tourisms. Basically the focus of this literature is on either content to more understand about using and implementing NFC in different area.

Keywords: Near Field Communication, Radio Frequency Identification, Technology

RESUMEN:

Actualmente, la tecnología de comunicación de campo cercano, o NFC por sus siglas en inglés, ha sido popular en muchos sectores, aunque la NFC sigue siendo una tecnología emergente. La NFC es un subconjunto de identificación por radiofrecuencia o RFID por sus siglas en inglés. La NFC proporciona comunicación sin contacto de corto alcance para teléfonos móviles y otros dispositivos. Por lo tanto, muchos investigadores están investigando esta tecnología debido a su desarrollo tecnológico emergente y prometedor para proporcionar un sistema eficiente. En este documento, se revisaron 52 revistas y los artículos se clasificaron en categorías según las áreas de la NFC implementadas, tales como automotriz, educación de servicios, atención de salud pública, sistema de navegación interior, sistema de pago, transporte público, industrias minoristas, pósters inteligentes y turismo. Básicamente, el enfoque de esta literatura está en el contenido para comprender mejor el uso e implementación de NFC en diferentes áreas.

Palabras clave: Near Field Communication, Identificación de frecuencia de radio, Tecnología.

1. Introduction

Near Field Communication (NFC) is a technology utilized to communicate without physical contact between two devices. It is the newest technology developed from RFID that is standardized in ISO / IEC 18092 (Trottmann, 2013). NFC is a short-range wireless technology that allows connecting electronic devices between two devices in the distance up to 10 cm and transferring data between 424 Kbit/ sec. Besides, it is functioned at high frequency bands up to 13.56 MHz in 3 different modes, namely: 1. Card Emulation Mode (In this mode, smart phone devices can be used to display secure transactions such as cellular payments); 2. Peer-to-Peer Mode (In this mode, data exchange can occur between two NFC devices when the device is brought close like a business card exchange) 3. Reader-Writer Mode (In this mode, an NFC device (smartphone) can read or write data in NFC tags such as writing data into a smart poster) (Zupanovic, 2014).

The main standard of NFC was developed by a non-profit organization, the NFC Forum, starting in 2004 by Philips, Sony, and Nokia. Then the smartphone with NFC technology became popular and gained acceptance by the market very rapidly in 2010 after Samsung introduced the Samsung Nexus S Smartphone as the first Android phone to use NFC (Want, 2011) and now all cellular companies are adding NFC technology to their products such as : Huawei, Xiaomi, Oppo, Vivo, Lenovo, OnePlus, Asus, etc. NFC-related information and specifications are publicly available from the NFC Forum. The NFC Forum is a consortium of producers, application developers, financial service institutions, and other stakeholders which is established to promote NFC technology and to develop NFC standards. As standard of connectivity technology, NFC harmonizes a variety of current contactless technologies, enabling the current and future solutions in various fields such as: access control, consumer electronics, health care, cellular payments, transportation, tourism, retail, and education (Coskun, V., Ozdenizci, B., & Ok, K., 2015)

2. Research Background

Near Field Communication becomes a very promising new technology in technological developments in the industrial field. NFC is a wireless communication technology that allows the transfer of machine-to-machine data over short distances using the concept of Radio Frequency Identification (RFID). The devices equipped with NFC can be operated in three different modes. First, NFC-equipped smart phones can be operated in reading/ writing mode, with a cell phone as an active component, creating an area to interact with passive tags. The range where this area is created is short and reliable approximately up to ten centimeters (Akshay Uttama Nambi et al., 2012). Second, the devices equipped with NFC can be used as Peer-to-Peer mode (Akshay Uttama Nambi et al., 2012; E Strömmer, Hillukkala, & Ylisaukko-oja, 2007; Serfass & Yoshigoe, 2013) by allowing two users to exchange information between their devices such as music playlists, contacts, and even medical data (Morak, Hayn, Kastner, Drobits, & Schreier, 2009). And the third is the card emulation mode, in which NFC devices operate in the same way as tags rather than field generators (Akshay Uttama Nambi et al., 2012). This mode is applied to allow contactless payment, in which the payment media, in this case, use a smartphone, only brings the receiving device closer to start the transaction. This type of non-contact payment is not new in its implementation, as in 1997 Sonera wireless providers offered this type of service to buy soft drinks from vending machines (Srivastava, Chandra, & Theng, 2010).

The main NFC standard was developed by the non-profit organization NFC Forum, started in 2004 by Philips, Sony, and Nokia to provide fast and easy two-way wireless communication on mobile devices such as Personal Digital Assistants (PDAs) and cellular phones. The three companies are trying to create standards for this new technology and develop their function, such as in the retail market (Karpischek, Michahelles, Resatsch, & Fleisch, 2009) (Benyó, Vilmos, Kovacs, & Kutor, 2007).

One of the most prominent functions of NFC is enabling an efficient payment with contactless (Mainetti, L., Patrono, L., & Vergallo, 2012 and Essbach, 2012) (Leong, Ong, Tan, & Gan, 2007) (Dominikus & Aigner, 2007) (Van Damme, Wouters, Karahan, & Preneel, 2009) (Muriira & Kibua, 2012). This payment can be done by using a card emulator or reading/ writing mode. Both of these methods are the examples of payments using mobile phones

Automotive	√	√					√
Retail Industry	√	√	√	√			
Tourism	√	√				√	
Education	√	√	√	√			
Health Care	√	√	√	√	√		√
Indoor Navigation System	√	√			√		
Payment	√	√	√	√			√
Public Transport	√	√		√			

4. Result and Discussion

4.1. Implementation of Near Field Communication

4.1.1. Payment Area

In the payment area, NFC is well-known for its payment methods which use cell phones since NFC is a new technology in a safe short-range wireless connectivity that play an important role in payment issues so that it is easy to use. For example: The IDA-Pay is an application developed by IDA Lab at the University of Salento-Italy that applies NFC in a micro-payment system by using the Peer-to-Peer NFC operating mode for Android mobile phones (Mainetti, L. and Patrono, L. and Vergallo, 2012 and Shelke & Matte, 2016). Essbach (2012) in his research was established a payment system using NFC and German eID-Card through a cellular device and a decentralized payment server. Then, Leong et al. developed the NFC-Bluetooth bridge system which is implemented in mobile commerce applications (m-commerce) and operates a merchant card system and payment system (Leong et al., 2007). Moreover, Sandra Dominikus and Manfred Aigner proposed mCoupons (Dominikus & Aigner, 2007), which can be downloaded from posters or newspapers equipped with passive NFC devices to mobile devices. Through this mobile device, users can cash the mCoupon at the checkout.

In addition, Damme et al. developed an offline payment systems based on digital vouchers which uses NFC on cell phones (Van Damme et al., 2009). It is a very promising opportunity for the use of NFC in the payment system using cellular phones that can affect customers, banks and the telecommunications industries (Muriira & Kibua, 2012), such as the use of T-Cash which was developed by Telkomsel Indonesia (Khairunissa & Ph, 2017). The application of NFC in the payment method has been tested in several countries as in Brazil (Luna & Montoro-Ríos, 2017), United Arab Emirates (Halaweh & Al Qaisi, 2016), and other countries. After that, Chae and Hedman developed a framework of business model for NFC-based mobile payment solutions which consists of four interdependent components: value services, value networks, value architecture, and value financing (Chae & Hedman, 2015). Many studies developed the payment systems using NFC include: Cloud-based NFC system based on the "NFC Cloud Wallet" model (Pourghomi & Saeed, 2013), a mobile payment system using NFC that is supported by a wireless sensor network (WSN) for m-commerce that allows users to make payments, business and mobile device service transactions (Noh, Lee, & Choi, 2014).

Near Field Communication (NFC) is a modern technology for short range communication with a variety of applications ranging from physical access control to contactless payments. This technology is more often discussed as more secure, because it only requires physical proximity and does not require Wi-Fi or cellular networks. However, these systems are still vulnerable to security attacks at the time of the transaction, because they require little or no additional requirements from the end user (Giese, et al., 2019). In the development of NFC on smartphones as a means of payment, it is vulnerable to attacks such as: replay attacks, mock attacks, tracking attacks and desynchronization attacks. Therefore, to overcome this, an authentication service is needed to develop a secure payment protocol (Nashwan, 2017). One of NFC's security advantages is its close communication range, which makes it resistant to most wireless media attacks, because NFC is built on Radio Frequency Identification (RIFD), making it vulnerable to the same attacks launched on RIFD (Ali, et al., 2017)

4.1.2. Health Care Area

In the meantime, NFC technology is very helpful in the medical sector, for carrying out its activities, especially for patients, doctors, nurses, medical devices and medical records (Jiji, Abraham, John, Aswani, & George, 2018). For instance, NFC facilitates the patients identification (Shaikh, 2015)(Jiji et al., 2018), the applications of health care, namely Accelerometer Data Collection, Temperature Sensor Data Collection, Electrocardiography (ECG) Data Collection (Yi, Jia, & Saniee, 2012), home healthcare such as monitoring weight scales, blood pressure meters (Sidén et al., 2011; Iglesias, Parra, Cruces, & de Segura, 2009), heart rate monitoring (Esko Strömmer, Kaartinen, Pärkkä, Ylisaukko-Oja, & Korhonen, 2006), patient tracking and diagnosis systems using NFC-based cellular phones (Marcus et al., 2009), Electronic data capture (EDC) System using NFC and Clinical Application to easily obtain clinical data by simply touching items using NFC (Morak et al., 2009; Andreas Prinz, 2012), and a system with NFC to help nursing students to carry out patient care assignments with simple interactions, including drug administration, clinical tests, and monitoring vital signs (Fontecha, Hervás, Bravo, & Villarreal, 2011), Bluetooth pairing using NFC in treatment uses information and communication technology to diagnose diseases early and reduce medical costs through an efficient medical system called U-Health (Jung, et al., 2013).

4.1.3. Public Transportation Area

As a digital technology, NFC functions to facilitate tickets payment quickly so that the company can provide tickets according to what passengers want. The example of the application of NFC like in Germany, the standard Core Application VDV (Association of German Transportation Companies) has been successfully implemented to develop an NFC ticket system that can be operated (Widmann & Gr, 2012). Then Surya, Emir and Ida was developed the Train NFC application in railroad public transportation to facilitate the process of purchasing train tickets and electronic ticket distribution, especially electronic tickets using cell phones(Nasution, Husni, & Wuryandari, 2012). After that, Ghiron et al.(Ghiron et al., 2009) and Tamrakar et al. (Tamrakar, Ekberg, & Asokan, 2011) compiled NFC Ticketing to allow users to buy public transportation tickets with cell phones. Another example of the application of NFC is the idea of NFC applications for airplane tickets using a mobile phone that is proposed to be used at Yogyakarta International Airport (Suparta, 2012).

4.1.4. Retail Industries Area

In this area, NFC-based payments have the potential to accelerate the payment portion of the check-out process based on the results of surveys among European retailers from 2007 to 2008 (Wiechert & Schaller, 2009). Karpischek et al. conducted a research on Mobile Sales Assistant (MSA), cellular product information systems for retailers based on NFC and Electronic Product Codes (EPC) in department store clothing (Karpischek et al., 2009). Meanwhile, Benyo et al. described the implementation of NFC-based payment processes in retail environments such as loyalty applications, product authentication and product information capture, etc. (Benyó et al., 2007).

4.1.5. Tourism Area

Isaksson proposed that RFID applications might be adopted in tourism services by operating NFC on cell phones (Isaksson, 2010). In the meantime, Gopichand, Krishna and Ravi explain about adopting NFC in the tourism sector to make it easier for visitors to find their way or go exploring by using cell phones (Gopichand, Chaitanya, & Kumar, 2013; Pesonen & Horster, 2012). In addition, Pedroza et al. developed mobile-based technologies for the Meeting, Incentives, Conferences and Exhibitions, or also named MICE categories, using NFC. The result showed that the acceptance of this combination of technologies was very well received by the community (Silva-pedroza, Marin-Calero, & Ramirez-Gonzalez, 2017). Whereas in Cordoba, NFC has been applied in tourist areas by using smart posters (Borrego-jaraba, Ruiz, & Gómez-nieto, 2010 and Borrego-Jaraba, Ruiz, & Gomez-Nieto, 2011). Then, Hardy and Rukzio developed a travel guide application to enable users with NFC phones to browse nearby markers, enlarge and shift maps and finally plan trips to desired tourist attractions (Borrego-Jaraba et al., 2011).

4.1.6. Indoor Navigation System Area

Urien and Kiennert revealed a new concept to download keys securely on RFID devices, with mobile phones that support Android NFC (Urien & Kiennert, 2012). Then, Upadhyaya also proposed the implementation of RFID-based cell phones in indoor navigation applications (Upadhyaya, 2013). Likewise, Ozdenizci et al. described new, reliable, and smooth indoor navigation solutions that help create a smart and context-aware environment (Ozdenizci, Ok, Coskun, & Aydin, 2011). The use of NFC technology in indoor navigation systems has the potential to increase the usefulness of this system and it has been implemented at Multimedia University (MMU) at the Faculty of Engineering (FOE). This system is called the I2Navi system which functions to enable students, parents, and visitors who have smart phones Androids that support NFC to navigate themselves within the faculty (Choo, Cheong, Lee, & Teh, 2012).

4.1.7. Education Area

Jaraba, Ruiz et al. presents a conscious system and context for access to bibliographic sources. As a result, students use cell phones which operates NFC interactions with smart environmental universities with the aim to support compliance with European Higher Education Area(EHEA) directives (Borrego-jaraba, Ruiz, & Gómez-nieto, 2012). Besides, Ervasti, Isomursu and Kinnula developed support systems for attendance monitoring with NFC which can reduce unnecessary doubts by allowing parents to receive real-time information about absences or if students are late from school (Ervasti, Isomursu, & Kinnula, 2009). In addition, Gonzalez et al. has proposed the development of contextual learning activities on the (Learn Research Network) LRN platform for open source software to support e-learning and digital communities, which is focused on the interaction experience with physical objects using Android mobile devices that expand the concept of the learning space (Ramírez-gonzález et al., 2012). In line with that, Garrido et al. also built an application using NFC-based games on mobile devices to encourage and motivate the students in learning. The result of this research showed that students were very motivated and enthusiastic in learning activities (Garrido, Miraz, Ruiz, & Gómez-nieto, 2011). Finally, Ayu and Ahmad (2014) built the Touching system, that is the attendance system at universities using NFC technology (Ayu & Ahmad, 2014).

4.1.8. Automotive Area

Steffen et al. focused on the use of new and innovative NFC-based applications in the automotive environment such as the location of 2 NFC device installations, micro payments with NFC car keys and NFC-based Bluetooth installation in cars (Cases, Steffen, Preißinger, & Schöllermann, 2010). The NFC system is considered to be an effective method to reduce congestion and traffic congestion, to improve driver comfort and safety, and to minimize air pollution and fuel consumption for environmental protection needs. Khandekar et al. implemented NFC technology with AT89S51 Micro controller; an NFC reader, NFC cards and NFC Toll Payment system have been very helpful in reducing the heavy congestion caused in today's metropolitan cities (Khandekar, Chennal, Jatav, Baviskar, & Shaikh, 2016). Besides, Ponraj and Jakcson built the ParkZapp application to support the Smart Cities concept in the

development of the internet of things. They built this parking application based on NFC on smart phones to replace conventional tickets. By doing so, customers only need to tap NFC tag on NFC Reader to enter the parking lot and tap once again to exit parking and make a payment (Ponraj & Jackson, 2018).

5. Conclusion

Based on the reviews on 52 research papers related to near-field communication, it has suggested that there are a lot of interests and potential implementations of NFC applications in several areas, including:

- It is easier for us to make payment transactions without using a credit card or prepaid card. We only need to use a smart phone that has integrated with NFC.
- The connection with other devices is very easy, with just one touch.
- The payment transactions are performed faster.
- It is more efficient and effective because replacing the manual makes it quick and easy by just tapping.

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