

Near Field Communication (NFC): Issues, Capabilities And Applications In Vehicle Anti-Theft Security Systems

Fidelis Chukwujekwu Obodoze

Department of Computer Engineering Technology
Akanu Ibiam Federal Polytechnic Unwana, Nigeria
fcobodoze@akanuibiampoly.edu.ng

James Ifeanyi Odegwo

Department of Computer Science
Renaissance University Enugu, Nigeria
write2degwo@gmail.com

Ndubuisi John Ngene

Department of Computer Science
Enugu State University of Science and
Technology (ESUT), Enugu, Nigeria
john.ngene@esut.edu.ng

Abstract— with the rapid advancement in Near Field Communications (NFC) technology, very soon in Nigeria, mobile phones using NFC will replace car keys. It will then be possible for drivers and car owners to lock and unlock their vehicles using their mobile phones via NFC technology. This technology has promising and enormous potential applications for vehicle owners in Nigeria, especially with regards to its advantages of convenience and security. In this paper, we present the features of NFC, its potentialities and latest applications in automotive industry and finally, we proposed a vehicle's security and control system to protect the vehicle's NFC system from hackers' attack.

Keywords— RFID, NFC, GPS, car theft, Nigeria, Bluetooth, Near Field Communication, Automobile, Automotive, Vehicle, security, hackers

I. INTRODUCTION

The snatching and theft of vehicles in Nigeria is on the increase. Virtually every day, there is one report or the other on snatching and theft of vehicles from car owners or commercial drivers while in transit or where the vehicles are parked. The ugly trend in the car thefts in Nigeria can be addressed with use of technology such as Global Positioning System (GPS), Radio Frequency Identification (RFID) and Near Field Communication (NFC). The former is already with us and had been in use over the past decade in Nigeria and all over the world. The later is the future technology for vehicle lock system and security in Nigeria and all over the world. These two technologies GPS and RFID/NFC can be effectively combined to checkmate the excesses of car thieves or highway robbers in Nigeria and all over the world.

Near-field communication (NFC) is a set of communication protocols that enable two electronic devices, one of which is usually a portable device such as a smartphone, to establish communication by bringing them within about 5 cm (2 in) of each other. NFC-equipped smartphones can be paired with NFC

tags or stickers that can be programmed by NFC apps. These programs can allow a change of phone settings, texting, app launching, or command execution. NFC is an application of Radio Frequency Identification (RFID).

Near Field Communication (NFC) utilizes wireless communication technology with a very short range – typically just a few centimeters – hence the “Near” in its name. It has been developed to enable phones to communicate with each other and with other devices or passive ‘tags’ simply by bringing the two close together. Fig.1 depicts typical NFC RFID chips or IC in the market.

Near Field Communication is the future of technological enhancements and security in automobile applications. GPS security has been used and is still used today to secure automobiles in form of vehicle tracking but NFC ,together with GPS, is the future because NFC encompasses more than security to a motor vehicle but equally opens up a lot of possibilities and applications.

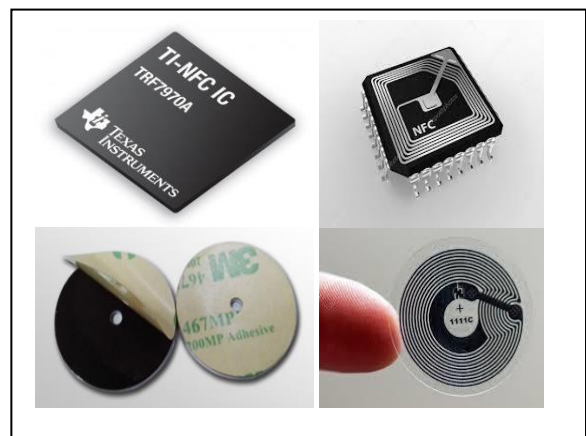


Fig.1. Typical NFC Chips in the market

NFC operates in three communication modes as follow:

1. Read/ write mode,
2. peer-to-peer mode and

3. Card emulation mode.

In Read/write Mode, NFC reader reads data from NFC enabled smart device usually a mobile device contactless and act upon the information. NFC enabled mobile phone can connect to the internet wirelessly through a retrieved source and can send text messages by tapping on the device.

Peer-to-peer NFC enabled device that has read/write capability can communicate by the exchange of relevant data in read/write mode, in peer to peer one of the read/write device can function as a tag thereby creating a communication link between another devices. For example, two mobile phones that have read/write features can communicate with each other.

Card Emulation mode can replace a contactless smartcard, enabling the use of NFC-enabled devices within the existing contactless card infrastructure for operations such as ticketing, access control, transit, tollgates, and contactless payments. This mode can also be used to create authentication and authorization schemes in identity cards.

A. Application of NFC in Automotive Industry

According to [1], the NFC Forum states that it expects to see NFC adoption for multiple automotive uses poised for a breakout of new products and services in 2016-17. It believes that combining the automobiles' electronic platform with powerful NFC-enabled mobile devices are the catalysts leading to multiple innovations.

NFC services and implementations continue to be prototyped and tested. NFC can connect vehicles and car keys to portable devices and infrastructure, opening up the possibility for a broad range of innovations in the field of connected car solutions. The following list of the NFC-enabled applications is most likely to make it to the market over the next few years, according to the NFC Forum:

- Car access: use NFC-enabled phones or wearables as a car key to unlock doors
- Engine start
- Create personalized settings: Climate control settings; Automatic seat and mirror adjustments
- Pair and connect hands-free interface or entertainment systems with Bluetooth
- Set up Wi-Fi or WLAN connections
- Acquire vehicle information
- Make in-car payment for videos, tolls, drive-through, etc.
- Vehicle management:
- Vehicle diagnostics can be handed over to Wi-Fi for transmission to dealerships
- Alert the owner of pending service requirements

B. NFC and Embedded Device

Embedded device technology integrates microchips on small electronic device and can be deployed on any electronic device; hence its application on Internet of Things (IoT) increases day by day. For NFC to be integrated in an embedded device it must exist in one of the operational mode; that is read/write mode for it link. An NFC mobile phone device will operate in active read mode while embedded device will exist as a tag. The tag will be integrated in an embedded system for the mobile phone to read it. This operational mode makes it easy for NFC mobile phones or enabled devices to be linked with any electronic device such as cars, wearable's, television, bill boards and saleable items on transit. Fig. 2 depicts the NFC mobile phone in active reader mode while establishing a communication link with a car embedded device with tag.

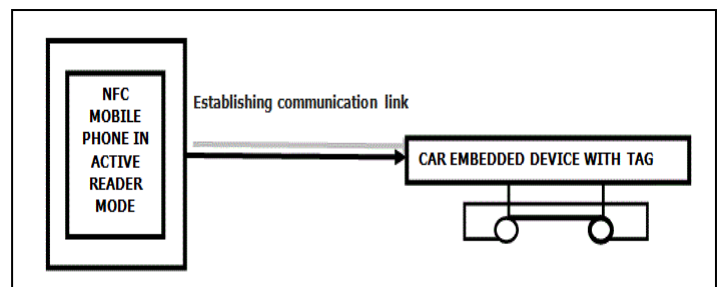


Fig.2. NFC Device and Embedded device in Car

The use of NFC enable mobile phone device to communicate with cars is a welcome development since the cost of acquiring device is relatively cheap; NFC device is cheap and embedded device is cheap, it only require proper integration into electronic device control system, its low power consumption gain it wide use in the industries and companies. When out of battery or power, one can still read the tags of an item or product on transit. It requires less power and does not cost much to implement.

Another feature of an NFC connected tags is that they are passive, meaning that it can be read from or written to by an external source even when the embedded device is turned off. This connected tags functions using dual memories port which facilitates exchange of data between an embedded system and external system with NFC reader/writer.

II. MILESTONES IN NFC TECHNOLOGY IN AUTOMOTIVE INDUSTRY

A lot of progress has been made already in the application of NFC technology in the automotive industry. The following section describes the progress made by the two biggest automakers Mercedes, BMW and Hyundai in the use of NFC in motor vehicles' application. This section also describes the progress made in the manufacture of ST25R3914 NFC reader development board by STMicroelectronics

A. **Wireless Charging in Cars**

Mercedes Benz:

During this year's CES, Mercedes-Benz announced that its new E-Class is enabled with capacitive aerial coupling. By simply placing the device on the charging area on the front part of the center console, the Smartphone connects to the multimedia system via NFC. Moreover, while using NFC, the customer's Smartphone becomes the digital vehicle key with which the car can be locked and unlocked as well as started.

Mercedes adopted ST25R reader in their E-Class models. Now, decision makers want a reader because keyless entry and Smartphone pairing are all the range. In fact, the real differentiating factor is the ability of a design to be future-proof. An ST25R3914 NFC reader and an STM8 MCU are so efficient that teams know they can use them for multiple years, which will enable them to focus on other aspects of the vehicle as they put out a new model each year.

Fig. 3 depicts a typical ST25R3914 NFC reader by STMicroelectronics Inc. The ST25R3914/5 are highly integrated NFC Initiators / HF Reader ICs for automotive applications. They are positioned perfectly for the infrastructure side of the NFC system, where users need optimal RF performance and flexibility combined with low power. The ST25R3914/5 are designed to operate from a wide (2.4 V to 5.5 V) power supply range; peripheral interface IO pins support power supply range from 1.65 V to 5.5 V.



Fig. 3: ST25R3914 NFC reader by STMicroelectronics [2]

According to [3], ST's Ecosystem has created a development board for NFC incorporation in cars known as X-NUCLEO-NFC05A1 as depicted in Fig.4.



Fig. 4: The NFC development board (X-NUCLEO-NFC05A1 on top of an STM8 Nucleo board) based on ST25R3914 NFC reader [3]

The X-NUCLEO board is modeled after the popular ST25R3914 NFC reader adopted by automaker Mercedes. It has the capability to enable developers can take advantage of the automatic antenna tuning and the ultra-low power wake-up sequence. Engineers can then decide to use the same components in their final design, porting the code they used on the development boards.

B. **Wi-Fi Hotspot in cars**

BMW:

Luxury Original Equipment Manufacturers (OEMs) are pioneers in integrating NFC technology into their cars. BMW is the first OEM to bring the NFC functionality inside the car. The BMW Car Hotspot LTE was first introduced in 2012 with NFC to facilitate mobile device pairing [1]. The Wi-Fi connection of the BMW Car Hotspot LTE can be automatically established simply by briefly placing a NFC-capable device on top of the Hotspot.

In addition to Bluetooth and Wi-Fi pairing, BMW shared with IHS that it is now mainly focusing on using NFC for Smart Access. Smart Access allows users to use smart devices to open the vehicle and to start the engine. The OEM just presented NFC Smartphone access for its DriveNow car sharing service at the Mobile World Congress 2016 in Barcelona. At present, after a one-time registration and ID check via a smartphone application or an ID card, the user can drive away and be billed automatically for usage of the car. Fig.5 depicts the pairing mobile phone using NFC in BMW 7 series car.



Fig.5: Pairing mobile phone using NFC in BMW 7 series car

Security can be built into a car or vehicle using NFC and RFID. This will provide authentication and authorization for the real owner of the car or vehicle to lock, unlock and make use of the car any how he or she feels.

In Fig.6, Car user1 and user2 are registered with the car manufacturing company and access privileges are given to them. Car user1 can also delegate access to a friend or family member. Car user1 will establish connection to the NFC enabled car using radio frequency identification (RFID) technology. The same authentication process follows for car user2. The use of NFC mobile phones in automotive cars will grant user access to lock and unlock the car, to run self

check on the electronic system and entire car control system, the NFC tag installed in the car will enable an NFC reader installed in the mobile phone to read information from the embedded device in the car and write to the device when necessary. Also car users will be able to share files, watch movies and play any music of their choice.

C. Locking and Unlocking of cars using cellphones

Hyundai Mobis

Indonesia's largest auto parts maker, Hyundai, has built an integrated system that supports the NFC technology, allowing drivers to use their cell phone to lock and unlock the car, as well as start and stop the engine by simply downloading the application on their gadget.

Hyundai Mobis said it plans to start producing the system in 2019 to be widely equipped in the vehicles.

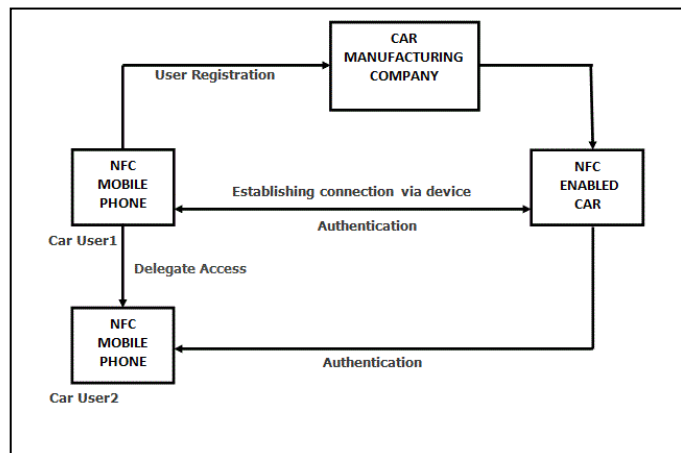


Fig.6: Car's inbuilt security using user's registration and authentication scheme with NFC embedded device by the manufacturer

III. NFC COMPARED TO BLUETOOTH

NFC is better than Bluetooth technology is several ways as can be seen in Table 1.

Table 1: NFC versus Bluetooth

S/N	Feature	NFC	Bluetooth
1.	Wireless transmission over radio waves	Faster sending speed using electrical currents	Slower sending speed using electrical currents
2.	Distance covered	Shorter walking distance up to 10cm	Further walking distance up to several meters
3.	Connections setup	Automatically within seconds	Manually setup within minutes
4.	Power Consumption	Consumes less power	Consumes more power

The following section summarizes the advantages of NFC over similar technologies such as Bluetooth and Wi-Fi.

IV. ADVANTAGES OF NFC OVER BLUETOOTH AND WI-FI

The major benefit of NFC technology over Bluetooth and Wi-Fi, two typical wireless communication technologies already adopted by automotive Original Equipment Manufacturers (OEMs), comes in its ease of use. Bluetooth and Wi-Fi require users to manually set up connections between smartphones and takes several seconds. NFC connects automatically in a fraction of a second, so fast it seems instantaneous. Its contactless "tap-and-go" function is simple and intuitive. Another benefit of NFC technology over Bluetooth is regarding power consumption. NFC typically consumes much less compared to Bluetooth and Wi-Fi.

While NFC works at close range and only when the user initiates action using its simple tap interface, Bluetooth and Wi-Fi work over greater distances, enabling different functionalities, such as a location generator, or communication via peer-to-peer connections.

In summary, table 2 depicts the differences in features between NFC, Bluetooth/Wi-Fi.

Table 2: Differences between NFC and Bluetooth Wi-Fi

S/N	Feature	NFC	Bluetooth/Wi-Fi
1.	Connection Speed	Connects in a fraction of seconds	Connects in several seconds
2.	Power Consumption	Consumes less power	Consumes more power
3.	Connection Range	Works at a very close range	Works at a greater distance

V. RELATED SYSTEM

Near Field Communication (NFC) enabled cards or smartphones provide a convenient and secure way to access vehicles. Car keys have long been a weak link in vehicle security and will progressively be replaced by this technology as it filters down from premium vehicles to the mainstream vehicles. The NFC based solutions will not only add a more flexible and cost effective access mechanism, they will also provide new possibilities such as enabling rental car companies to send to a renters' smartphone the ability to unlock and start their rental car using NFC. ST's NFC transceivers and SPC58 microcontrollers with embedded Hardware Security Modules (HSM as depicted in Fig.7, cover the most important requirements for such access control applications: security, reliability, usability and cost efficiency

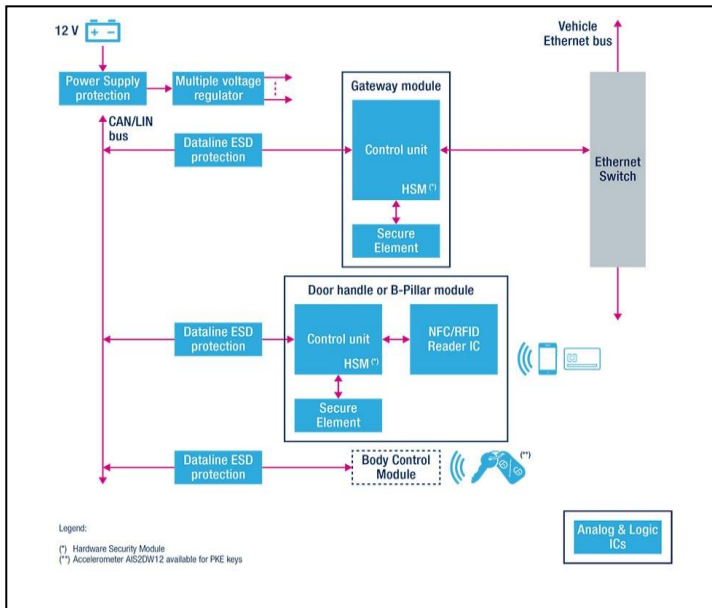


Fig. 7. NFC Keyless Entry [4]

VI. OUR PROPOSED SYSTEM

In our proposed system depicted in Fig.8, a user will login using his/her email address and password to access his/her mobile phone or device, the mobile phone or device will be used to establish connection with the car control system where the NFC tag is installed, the system triggers alarm when an authorized user or hacker tries to access the car. The car security system will then use SMS technology to alert the user that there is an attempt on his car.

To ensure security, NFC often establishes a secure channel and uses encryption when sending sensitive data such as credit card information. Users can further protect their private data by keeping anti-virus software on their smart phones and adding a password to the phone so an intruder cannot use it in the event that the mobile phone is lost or stolen.

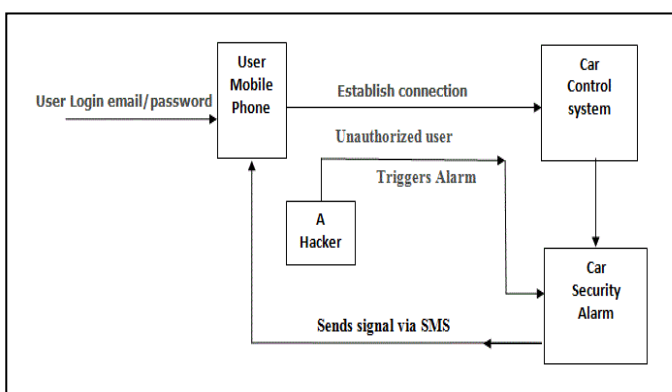


Fig. 8: Car's inbuilt security using user's registration and authentication scheme with NFC embedded device by the manufacturer

NFC technology has emerged as a strong contender for replacement of the current transaction and mobile payment techniques owing to its improved security and connectivity features. Similarly, the hardware architecture with considerable security promised by NFC is also very attractive to the

automotive industry. The car industry has very high security requirements, whether it is to unlock the car door or start the car. In a recent interview with IHS, BMW noted that the security element is the main reason that it favors NFC technology over the other options. Other German OEMs including Daimler, Volkswagen and Audi also follow the same NFC strategy.

VII. CONCLUSION

In this paper, it has been shown that cars with Bluetooth is fast phasing out due to weak and poor connection. Bluetooth are usually manual setup before it can be linked to another Bluetooth device. NFC enabled car connects automatically, it is tap-on-go, once a device that is linked together is in a close range, it connects automatically. The cost of obtaining a NFC embedded device is relatively cheap, it only requires the phone manufacturer to accept NFC technology and work in hand with car manufacturers to boast a digital experience by it users and make cars with a smart key which will allow users use their mobile phone devices to lock and unlock the car, start the car, carry out engine maintenance test and diagnose the car at certain test level. The security features in NFC technology will make frustrate the effort of car snatchers here in Nigeria and car thefts will be no longer be business as usual. Whether there is battery or not in the car, due to tags installed in the car an NFC enabled mobile can be used to track location and read data and the car recovered.

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