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Recent Developments in Near Field Communication: A Study

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Abstract

Near field communication, development in radio frequency detection has put its foot in today's life of individuals through sophisticated mobile phones. NFC technology has become very popular due to its transparent and simple integration with a number of applications such as health care, consumer electronics, public transport payment methods, etc. A few new approaches have been attempted to make NFC progressively competent in routine day-to-day applications. This paper discusses the latest development in the use of NFC's in a few implementations and the potential outcomes of the hustle-free implementation of these applications. A systematic analysis of recent research deployment in different areas of use has been clarified and explored.

Keywords Near field communication (NFC) · Health care · Consumer electronics · Public transportation (PT) · Internet of things (IoT) · Contactless payments

1 Introduction

Field communication (NFC) technology has become increasingly important in different real-life settings, beginning with the credit/debit card with embedded NFC to Bluetooth paring. Some common uses include product/asset validation and monitoring, payment methodologies, organizational attendance systems, wireless device pairing, transportation. Other than this, some of the noted applications where NFC technology can be used include networking, tourism, hotels and restaurants, customer support, etc. NFC is an extension of the radio frequency identification (RFID) that can function as an RFID via tap and connect (Fig. 1). Consumer communication of NFC devices is predominantly through taping or touching NFC device/tag. But more than reading or writing unique ID as in RFID, it can share and transmit unique content to/from programmable apps. Exchange of data through NFC are formatted using NFC data exchange format (NDEF). NDEF is the data format which used across all NFC devices [14, 23]. NFC protocol stack has been shown in Fig. 2.

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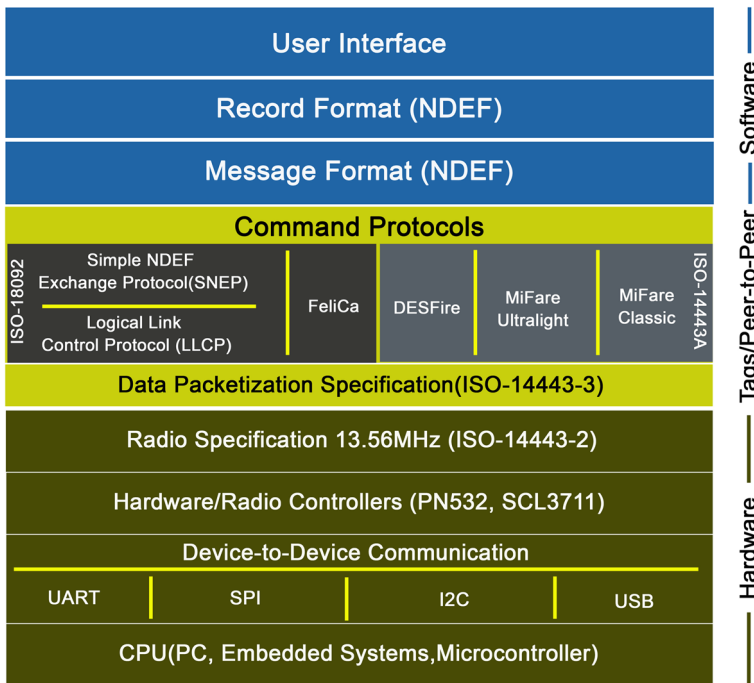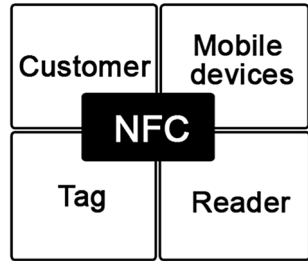
Fig. 1 NFC consumer commu-
nication

Fig. 2 NFC protocol stack [23]

1.1 NFC Tags

NFC systems can operate in the following modes of operation. Card emulation, reader/
writer and peer-to-peer modes. In card emulation: NFC cards/tags/devices function as
smart cards used for payment purchases, next reader/writer mode apps are used to read
or write data to/from other NFC devices or tags, and thirdly NFC devices used to con-
nect with each other through an ad-hoc networks [62]. Passive NFC tags will be used to
communicate with other active NFC devices. NFC tags are created with an antenna and
an NFC IC that includes memory used to store the required data [1, 10]. Types of NFC
tags and their working specifications are given in the Table 1 [31].

Table 1 Types of NFC tags and their working specifications [31]

NFC tag	Type 1	Type 2	Type 3	Type 4
Standard	14443 A	14443 A	ISO-18092 and JIS-X- 6319-4	14443 A/B
Data rate	106 kb/s	106 kb/s	212, 424 kb/s	106/212/424 kb/s
Memory	96 bytes-2 kbyte	48 bytes-2 kbyte	Upto 1Mbyte	Upto 32 kbyte
Anti-collision	✗	✓	✓	✓
Read	✓	✓	✓	✓
R/W	✓	✓	✓	✓
Product	Innovision Topaz, Broadcom BCM20203	NXP Mifare Ultralight	Sony FeliCa	NXP DESFire, SmartMX- JCOP.

✓- Yes/available, ✗- No/not available

1.2 Mobile Phones as NFC Devices

New generation mobile phones or tablets are equipped with NFC technology built-in like other wireless technologies such as Bluetooth and Wi-Fi. This makes the NFC-based application more and more publicly available. The result of short-range communication also leads to consumer-based interactive devices being simplified, helping to share data or information about the product, area, network, etc. easily and securely [2]. For example, if a user needs to connect to another smart device just to bring the smart phone close to the device and tap, the connection between the device and the data transfer will be made. Nokia made the first popular application of combining NFC technology and mobile phones with its 3320 and 5140i series 40 range phones. As a result, the Japanese telecommunications company DTT DoCoMo has supplied almost 5 million telephones for the deployment of national rail networks and an option to written fares [16]. Some of the early and recent NFC mobile phones are listed in the Table 2 [25, 61].

1.3 Reviewing a Wide Range of Innovations

Throughout the years [48], different techniques have been used to capture the understanding of each packet through its supply network, as it is transported from its storage area to its conveyance target. With the advent of RFID and NFC advancements, the correct solution has been implemented to meet the requirement for a site row. Barcodes have grown from one-dimensional to two-dimensional and recently to common QR codes that could enable the processing of a large data series to recognize a particular object. The main shortcomings for barcode and QR codes were time and labor-intensive and failure to provide real-time position. Perusing an RFID tag does not involve a viewable route close to the scanner tag case, but read-separation is determined by whether the RFID tag is active or passive. Downsides to Passive RFID Inability to protect the distribution center, Complexity in setting up and Inability to provide a consistent field. Active RFID innovation has discovered its application when it comes to the observation of high-quality bundles or equipment in distribution centers, yards and railroads. A comparison of barcode, Bluetooth and NFC technology is given in Table 3

Table 2 NFC mobile phones [25, 61]

Brand	Name	Platform	NFC controller	Tag compatibility		
				MIFARE classic	MIFARE ultralight	NTAG
Nokia	3220	Series 40	Not mentioned	✗	✗	✗
	5140/5140i			✗	✗	✗
	6131			✓	✓	✓
	6212 classic			✓	✓	✓
	6216 classic			✓	✓	✓
Samsung	SGH-D500	–	–	✗	✗	✗
	SGH-X700	–	–	✗	✗	✗
Apple	iPhone 7 Plus	iOS	NXP PN67V04	F	✓	✓
	iPhone 8		NXP PN80V	F	✓	✓
	iPhone 8 Plus		NXP PN80V	F	✓	✓
	iPhone X		NXP PN80V	F	✓	✓
	iPhone XR		–	F	✓	✓
	iPhone XS		NXP 100VB27	F	✓	✓
	iPhone XS Max		NXP 100VB27	F	✓	✓
	Phone 11		–	F	✓	✓
	iPhone 11 Pro		–	F	✓	✓
	iPhone 11 Max		–	F	✓	✓
	iPhone SE		–	F	✓	✓
Google	Nexus 4	Android	BCM20793	✗	✓	✓
	Nexus 5		BCM20793M	✗	✓	✓
	Nexus 6		BCM20795	✗	✓	✓
	Nexus 5X		NXP PN548	✓	✓	✓
	Nexus 6P		NXP PN548	✓	✓	✓
	Pixel		NXP 55102	✓	✓	✓
	Pixel XL		NXP 55102	✗	✓	✓
	Pixel 2		–	✓	✓	✓
	Pixel 2 XL		–	✗	✓	✓
	Pixel 3		–	✗	✓	✓
	Pixel 3 XL		–	✗	✓	✓
	Pixel 3a		–	✗	✓	✓
	Pixel 3a XL		–	✗	✓	✓
	Pixel 4		–	✗	✓	✓
	Pixel 4 XL		–	✗	✓	✓

✓- Read/write available, ✗- read/write not available, F - only formating available

2 Related Works

This paper offers a comprehensive analysis of day-to-day NFC technologies that have been introduced as consumer electronics. We have presented literature on the introduction of various articles and their use of NFC technologies for real-world applications. The following segment includes a short report on numerous NFC research survey articles. In [13, 15,

Table 3 Comparison table of barcode, Bluetooth and NFC with technical specifications

	Barcode	Bluetooth	NFC
Types/versions	Linear and 2D	1, 1.5, 2, 3,4	Tags 1–4
Power requirement	Less	Low energy (LE)	Less
Managed by	GS1	Bluetooth SIG	ISO/IEC
Network standards	ISO/IEC 15416, ISO/IEC 15415	IEEE 802.15.1	ISO/IEC 14443, FeliCa
Range	50 cm	Nearly 100 m	< 10 cm
Frequency	Depends on reader or scanner	2.4 GHz to 2.485 GHz	13.56 MHz
Bit rate	Depends on reader or scanner	2.1 Mbits/s	424 kbits/s
Data length/capacity	256 bits of each byte	251 bytes	96 bytes to 32 kbytes
Encryption/encoding	Data Matrix, Code 128, Code 39, UPC , etc	AES 128, ECDHE	ECDH, AES

39] article's offers a good analysis on NFC technology including requirements for connectivity, security-based problems. This also offers a broad perception on the usage of technology for payment systems from the scientific and industry viewpoint.

As in the previous articles, [41] review, further addresses the main fields of use of NFC and its compliance of specifications, protocols and technical difficulties.

Madlmayr et al. [29] includes a short overview on operating modes and case studies of the device design of NFC Technology utilizing mobile phones. Chapter also provides an overview of the various forms of tags and their formats.

The study in [24] focuses primarily on the ability of NFCs for cell phones and connected apps. The thesis included an in-depth analysis and survey of the mobile phone ecosystem, standards, structures, functionalities and standardization bodies.

The review of android apps for NFC's three modes of service, which will direct android device developers and also use cases that assist in the creation of diagnostic, contactless and peer-to-peer devices, was addressed in the chapter [27].

Chen et al. [11] lists the potential compliance breaches that could have existed for NFC specifications such as ISO/IEC 18092, ISO/IEC 14443, ECMA 385 and ECMA 386. The main focus was on the safety analysis of the two NFC operating modes see Table 4. In the other side, [19] deals with problems relating to contactless communication, the writers have proposed biometric-based NFC communication especially in the fields of payments including apps.

The writers in [47] made an overview and planned a number of applications for the NFC transport system. NFC Smart KIOSK: used for route transmission, accomplished by positioning an assortment of NFC-based display units at multiple terminal locations that offer route information, timings, etc. while the consumer reads NFC-compatible phones.

Table 4 Safety risks against NFC [11]

Operating modes	Card emulated mode	Reader/writer mode
Compliance	Denegation of service attack	Identity authentication
	Eavesdropping in the card emulated mode	Phishing attack
	Relay attack	Ticket cloning

This Users may also have the facility to search for information by providing the end to the end of the route.

According to [54] , The authors developed an NFC-based lighting framework and explored the justification for the usage of the Lighting method designed for older people. They carried out a survey of 30 elderly people: the study is essentially to verify the ease of use. The findings suggested that older citizens preferred the Lighting method owing to expected ease of usage.

NFC Systems may or may not be narrowly categorized on the basis of sensor application. Many devices are equipped for a mix of Sensor and NFC hardware, while some use either NFC tags or NFC compatible products. The Fig. 3 provides a brief classification of NFC applications.

3 NFC Technology with Sensors

NFC-based applications are often equipped with sensors to track, capture, power, etc. This segment discusses some of the NFC-based literature survey and the innovations implanted for their prototypes. A comparative study of NFC sensor based application suggested from
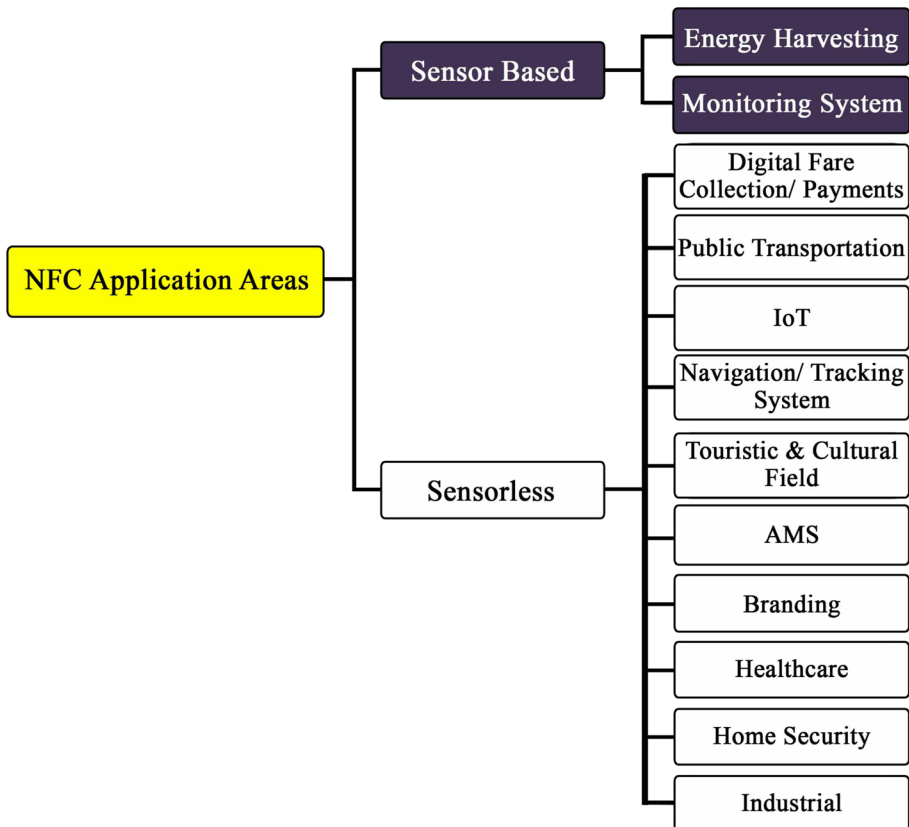

Fig. 3 Classification of NFC application areas

articles is also provided in Table 5. In [5], a system for measuring the level of humidity, temperature and relative humidity was proposed. The prototype was designed to calculate the measured data with a micro-controller and programmed to send the processed data to NFC via I2C (Inter-Integrated Circuit) protocol. Systems designed to measure parameters using battery-free sensors or the power required are produced using the reader's magnetic field. This is done through the creation of inter-digital condensers.

Another battery-free configuration of the sensor is also shown in [6], the authors suggested a device containing a color sensor connected to a low-power micro-controller operated by the reader's own magnetic field. An in-depth analysis of NFC reader energy harvesting is performed and introduced to check the pH level with a color sensor. It was also discussed to translate color sensor data to pH values.

In [28] a battery less smart diaper is proposed by measuring the pH value of urine through capacitive moisture detector, which then communicated through a NFC enabled smart phone. Measuring the pH value suggested in [45], is to track wound control, uses mobile NFC to interact. This system keeps track of the wound healing process measured by infrared light resulting in pH value and communicated through NFC mobile.

Wide range of NFC use is introduced in automatic fare collection (AFC) systems, [17] shows the novel paradigm of attacks involved in AFC with NFC enabled smart phone. The author has defined two main properties in this context, which are anomalies in the back end domain that impact a significant number of users. To test the attacks, a host-based emulation card software has been built to anticipate less-pay assaults.

NFC technology has increased benefits in public transport systems by replacing traditional paper based ticketing system. A study has been made in [18], to develop an advanced infrastructure for public transportation ticketing. The authors proposed a server based ticketing system which can be utilized anywhere in the world for issuing a ticket. Which are achieved by focusing on server based ticketing, usage of NFC enabled mobile phones, comparison of existing system of closed loop system, and gathering live feedback from user or passengers.

A system requirement and design of a NFC based indoor navigation system has been proposed in [40], with a case study to analyze the prototype implementation. The paper suggests indoor navigation by placing NFC tags in the appropriate locations of the entire building. The customer needs to tap his/her NFC activated mobile phone to placed tags for his/her location or path to a destination inside the building and also has to access the internal map from the network of a specific building. This will show the position/route of users on their pre-installed mobile device. In [12], a unified indoor and outdoor navigation system was developed with the aid of Global Positioning System (GPS), Bluetooth and NFC technologies. An app has been created for this navigation system, which in effect utilizes outdoor GPS, whereas indoor uses Bluetooth and NFC together. The guidance system is achieved by transferring the map to the remote server and is available for download.

Tourist society is one of the applications of NFC processing, a case study for Italian museum was proposed in [8], which contains mobile application, smart posters with NFC tags, QR codes, a content management system (CMS) with a middleware which allows mobile application to communicate, and Wi-Fi access points. Each posters embedded with tags and QR codes, visitor like to know about the information has to tap the NFC tag with their NFC enabled smart phone or can scan the QR code for the same.

Among all others, NFC technology plays a vital role in Attendance management system (AMS) one such methodology has been proposed in [33], the paper focuses on student AMS. In which professor/tutor hold the NFC reader and who places the course for which attendance to be updated. On placing the course details, students with NFC enables smart

Table 5 Comparative study of different articles on NFC applications

Authors	Implementation	Application/study	System components
Boada et al. [5]	Energy harvesting by design of inter digital capacitor	IoT based monitoring	Microcontroller (μC), humidity, temperature sensor, digital capacitor
Boada et al. [6]	Power drawn trough readers magnetic field	pH measurements in swimming pool and aquarium waters	μC, color sensor
Lazaro et al. [28]	Moisture detection in diaper through changes in capacitance	Baby or elderly monitoring	μC, capacitive moisture detector
Rahimi et al. [45]	pH value using indium tin oxide (ITO) films	Wound monitoring and indentification	pH sensor—ITO fabricated
Dang et al. [17]	Host based emulation card software has been built for attacks	Testing attacks on AFC using NFC phones	LessPay app and cloud side server
Demir Alan and Birant [18]	Server based ticketing system on cloud fare calculations	Comparative study on intelligent public transport system	AFC, Card manager, fare, payment, mobile, and terminal engine
Ozdenizci et al. [40]	Indoor navigation through map tag with the help of NFC internal application developed	A study to implement cost effective indoor navigation system using NFC	Map tag, location tag and NFC internal application
Cheng et al. [12]	Indoor cum outdoor navigation through GPS, Bluetooth and NFC	App based positioning with Bluetooth, NFC for indoor and GPS for outdoor. Have to download a map from the server.	NFC tag, Gimbal beacon
Ceipidor et al. [8]	Multimedia user guide for the visors of museum	Design better user interface for visitors of museum	Application with profile updating, RFID tag, reading, QR code capability, etc
Mohandes [33]	Cost effective and easy to access anywhere anytime by the professor	An app is used for tutor to access and its students attendance, will updated in centralized server	Android app, web server, database and administration website
Ghosh et al. [20]	Swingpay money transfer achieved by peer to peer communication between hardware to server, then server to bank	Single card implementation for users all payments	μC, fingerprint sensor, NFC reader, GSM module, display and Capacitive switches

phone has to place it near the professors NFC mobile. Professor save the attendance details once the class is over that will be updated in the central server which will be used to generate the report of student's attendance.

Payment of money through personal digital assistants (PDA) are becoming more and more common. This article [20] put forward a building block called swing pay, which uses contactless card to card money transfer using NFC. A solitary card is used for all type of money transferal and also personality informations The module consist of a micro-controller, fingerprint sensor, NFC reader, display, GSM module, and capacitive switches. Using those components the money transfer is achieved by a hardware module lead into with cloud and bank server to make the transaction to be happen which includes the proof of user ID. To communicate with server GSM module has been used. In the process of validation, finger authentication is also made over fingerprint sensor in both the ends receiver cum sender.

4 NFC Applications in Various Area's

4.1 Public Transport

Mobile devices such as smart phones and tablets are playing an important role in providing access and information anytime anywhere. Example: information about the places, nearby buildings, transport availability, traffic conditions, weather situations, journey suggestions, ticketing services with payment options, etc. Some of the Indian public transport using contactless card/smart cards are Delhi metro smart card, Namma metro smart card (Bengaluru), Kolkata metro smart card, Bus pass smart card (Mumbai), Mumbai suburban railways, etc [60]. Mainly NFC [22] offers following modes of operation in public transport Fig. 4, Card emulation, Fig. 4a and Card reader modes, Fig. 4b. In case card emulation mode NFC phones will act as a transport card, whereas information about the balance, travel history and other travel related data organized through NFC phones come under Card reader mode.

To implement NFC based fare management systems in Public Transport (PT), Public Transport operator (PTO) has to consider some of the following specifications, Fig. 5

- Testing of NFC mobiles gadget for attainability before they support for PTs
- Neglecting to give interoperability, PTO's ought to have a reinforcement plan for client doesn't have practical cell phone

(a) Card Emulation   **(b)** Card Read

Fig. 4 Modes of operation in public transport

Fig. 5 Considerations to be carried out to implement fare management system in PT's [22]
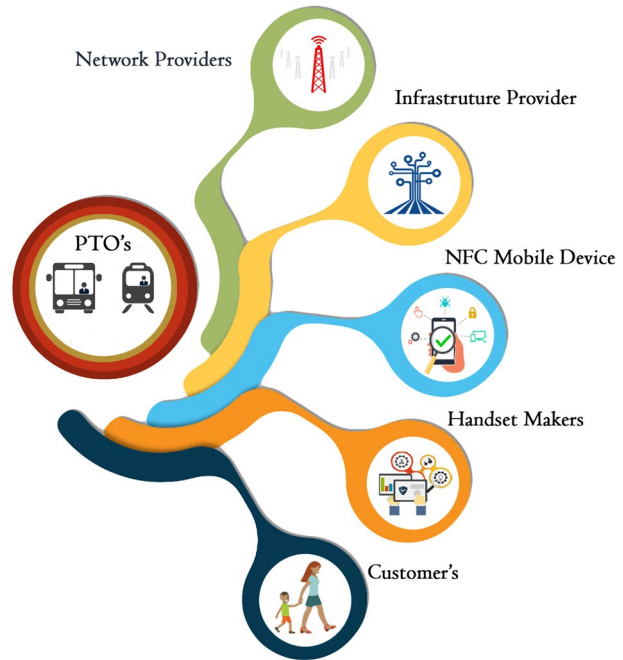
- Explanation and learning ought to be given to PT client about their cell phone is appropriate for specific PT framework
- Handset creators have needed to confront an uneven PT passage the board framework. There is No reasonable measurements was offered to direct them in characterizing which highlights and gauges must be fortified by a NFC cell phone so as to be interoperable with all comprehensively applicable PT foundations

4.2 Brands and Retailers

Some of the retail technologies defined [7] are NFC Short-lived network innovation that causes shoppers to associate with a universe of comfort, data, and improved encounters at home, around town, or when they travel. RAIN RFID UHF (Radio Frequency Identification), Mobile technology is often used to monitor and store network software to nearby inventories. Passive RFID tags on products and containers produce teamwork information that must be scanned with an odd handheld peruser within a distance of 3–10 m. RFID usually also facilitates single line communication. Barcode/QR Code (Quick Response code)

A graphical barcode that may open a web page or access data when scanned. The client must have the barcode reader app installed and accessible on their mobile to scan the barcode. Bluetooth Beacons, Mobile technology that is integrated with most cell phones and various electronic gadgets. Bluetooth bolsters two-way communications within a 10-m radius. Bluetooth Beacons can set up a shop or setup, and push the substance to supporters who have pre-installed stores or scenes with versatile applications. To be a fruitful brands and retailers need to contend all the more adequately in an omnichannel world. For retailers and brands, NFC can prompt income development, better client encounters, new bits of knowledge through client examination, and more profound, durable associations with the

individuals who purchase and utilize their items. NFC innovation offers a large number of approaches to fortify an association between buyer all through their voyage—pre-purchase, instore and post Purchase Fig. 6.

Preceding buying, an affiliate buyer spends his energy web based analysis, updates inspections via internet-based networking media, and tests on prices, just as he experiences publicizing via various media. This would be the perfect opportunity to communicate with the customer to provide instructive information, to express product marketing in a forward-looking way, and to inspire customers to shops or to get an extremely personalized shopping history. The pre-purchase phase lets retailers exchange feedback and access product data, smart labeling, scheduling showroom appointments, ADS built into print and out-of-home news. Pre-sale brand communication, connect to wi-fi shop, consumer encryption, digital signage, connection to product information (virtual sales person), quick, simple, safe purchase, connect to chat bot to answer questions, link to e-commerce retailers when an item is not available in stores, connect to social media and/or comments may be provided to retailers/customers during their store experience. Providing easy access to product sales data. In post-purchase buyer can post-sale brand notification, link with group of shared interests, automatic or delivery orders, connect to help & customer service, contract verification, customized rewards, item re-order. Holding the partnership and the review running.

NFC is the best instrument to improve brand relations and boost customer experience by making available and post-deal engagement clear and persuasive. According to the 2015
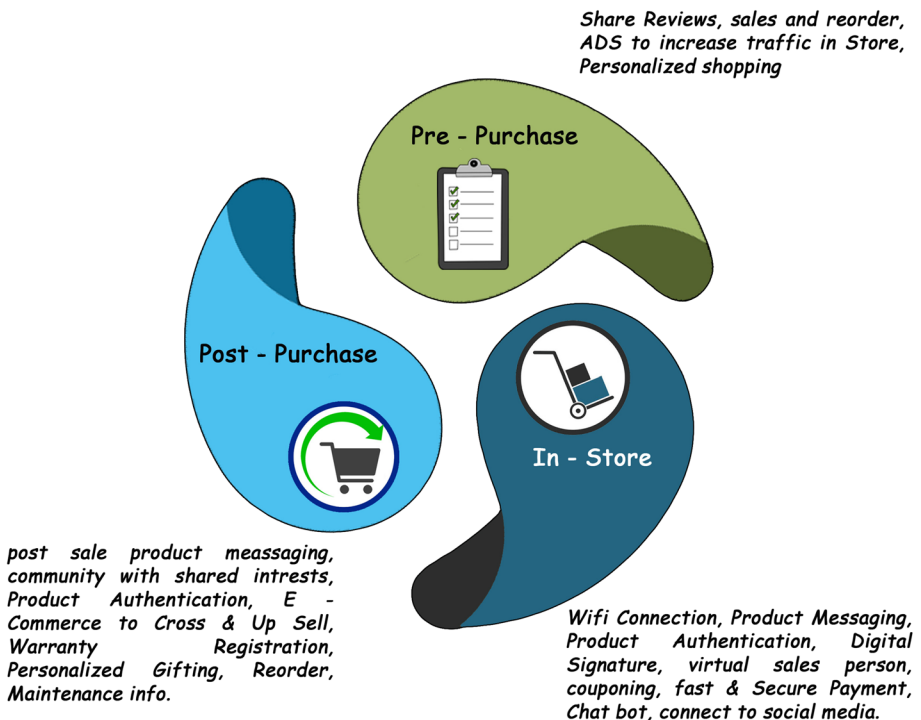

Fig. 6 Association between buyers and sellers [7]

study [3], the total market size was 1.2 trillion in 2021 and 1.5 trillion in 2026 for related labeling and labels. 90% of cell phone holders use their devices when they visit [51]. A research shows that by 2020 there will be 2.2 billion NFC-powered handsets [53].

4.3 IoT

IoT gadgets [46] in warm homes mean more safety, convenience, and abilities. Usefulness in smart homes has to design, request, and monitor IoT gadgets. NFC is tackling many of today's problems of handling IoT systems in smart homes. To make progress, our primary focus is on smart home. Data from linked smart home devices should know our preferences and change the systems accordingly. How NFC can benefit from Smart Home Systems? Where a single tap executes a user's intention even when there is no device interface, requiring nearness for correspondence and data sharing, Enabling protocol and open read and write capabilities for secure data exchange, sharing information independent of power parameters, and Retrieves low energy. Three significant benefits of NFC in IoT-savvy homes are interfaces, commissioning and control.

In reality, the IoT arrangement is conceivable only through the collaboration of a few empowering advances. Among all other innovations, RFID plays an important position in IoT [50]. One of the key drawbacks for IoT systems is the right configuration and their upgrades. NFC can be used for system tuning via wireless connection, so network paring is also feasible [57]. Bringing two NFC-powered gadgets closer together is all you need to do. It helps in installation and monitoring of IoT systems in the home, manufacturing, distribution, factory automation, etc [34]. Lighting, heating, door, windows and home appliances remotely operated by smartphone or computer can be accessed in a variety of configurations using NFC cards. Smart lighting technology can be designed to add energy efficient lighting to a smart home [9, 59].

4.3.1 Bluetooth Pairing Using NFC

You can connect wearable gadgets or different connections to Bluetooth [4], which offers a protected association using NFC. Tapping an NFC gadget can connect your mobile phone or tablet to a quick and secure Bluetooth environment, as in the Fig. 7. The tap flips the computer on and attaches to another network technology, such as Bluetooth and Wi-Fi. In contrast to the communication configuration, an operation such as submitting a paper to a printer or connecting to a speaker can also be activated by the NFC touch. The justification for using Bluetooth Secure and Easy pairing with NFC is hassle free communication, manual or software configuration is not necessary, and without interruption from specific internet connected devices synchronization can be accomplished. Many NFC Safe Pairing Possibilities include Computer peripherals, portable, wireless, human services, sports equipment, electronic devices, games, health, mobile accessories, and so on

4.4 Health Care Applications

A portion of the advancements in human services applications are, the point at which an individual arrives at the facility, the specialist's cell phone can check through the NFC gadget during the test. Subsequently, the investigator will be recognized and the doctor will be prompted to choose the patient's mobile determination [30]. Healthcare is seeing an increase in M2M connectivity in its medical devices. As these gadgets become shrewd and interconnected, there

Fig. 7 BLE pairing with the NTAG [32]

will be an expansion in the interest of information moving between gadgets available outside the body (In Vitro) and inside the body (In Vivo) [36].

4.4.1 Cloud and Mobile Based Healthcare Using NFC

The patient may maintain all or vital Electronic Health Records of the consumer on the internet, on a Medicare card that is accessible by means of a cell phone, or on a patient's cell phone. A Healthcard kept on a cell phone can hold the entire Electronic Health Card, including reports and tests [49]. Use of the Cloud-based NFC public healthcare system would verify the consumer and the expert, who will give the right treatment to the compassionate and who will also be checked by ill-advised clients by addressing the safety hazards of providing better assistance for individuals [35, 55]. The NFC-based system can be mechanized by using a PDA, which will obviously track the condition of patients and establish cautions and, therefore, hold indications on the cloud server and, therefore, get to learn the concept of NFC with the patient tag and, therefore, fewer paperwork [21].

4.4.2 Specific ID or Wrist Band

Another solution to the feasible use of the NFC-based system, through adding the name badge to the person, is that the client already has a clear identifiable sample number that will be the Id for the NFC tag. Throughout enrollment, permanent information will also be held in the wrist band and NFC cards in both instances [26, 42, 52].

4.4.3 NFC Clinical Services

In what way could requests of NFC human services be used in medical investigations? [43]. More secure drugs: at the point where the pharmacist adds an NFC tag to the drug mark, patients can tap labels with their phones at that point to send information on the drug. Therapeutic gadgets: In the case that anyone in the facility has to worry about the recently released devices, they'll only keep their NFC-powered cell phones next to that gadget and have the option to watch a clip which offers them a bit of a chance to grasp a variety of gadget forms. Collaborations: At the patient's consultant office to document an assessment visit; on viewing documents that may move to the site or on videos that are increasingly addressed in a medical report; or even on the armlet which displays vitals and utilizes NFCs to transmit information to the cell phone of the investigator.

4.5 Home and Industry

NFC-based support program for the classification of individuals and the detection of medicinal substances in a person-specific medical assistance framework for elderly and disabled people, that satisfies the necessity and provides a secure alleviation of their ordinary life conditions in the home situation for medically assisted people/elderly persons [44]. Use case given in [58],Shows clearly NFC-based secure home locking frameworks with NFC-powered cell phones.

On the other side, the use of NFCs in industrial surveillance, regulation, processing, development areas, etc. is also important. Equipment such as circuit breakers, relays, power units, detectors, etc. used for industrial purposes is reached with a restricted GUI (Graphical User Interface) with more modifications. NFC powered smartphones can be used as a mobile device with a sophisticated touchscreen-based design and ease of setup. Some of NFC based Industrial use cases are demonstrated in first exhibit at embedded world 2017, Nürnberg [56]. Setup settings for any machine can be set to NFC, which can be used later to redo the hardware. NFC also helps to maintain immediate system status, stats and device analysis without disassembly of equipment and Firmware upgrades can be rendered wirelessly. The Wireless Firmware Upgrade feature shown in [37], Earnings following aspects, First, the MCU (Microcontroller Unit), power to re-program flash in a field while installed on a PCB, This could be done by ISP (In-System Programming) or IAP (In-Application Programming). Second, the information moves, the NFC connects the portable to the MCU. Fig. 8 shows the software upgrade cycle

Arduino and raspberry pi boards can be used to evaluate and build NFC-based device prototypes. These modules are commonly used for prototype testing. The core activity of the NFC modules (see Fig. 9) is interpreted and written to the NFC tags. The design specification of each module is readily available as a manufacturer data sheet. While designing a prototype, most attention must be paid to the implementation of algorithms and sensor interfaces.
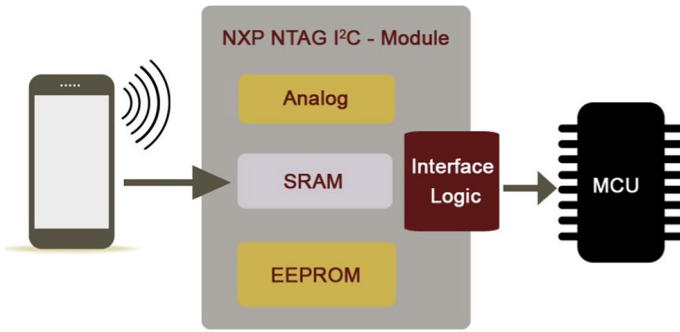
Fig. 8 Update process for firmware [38]

Fig. 9 Market ready NFC reader module's

(a) PN532 Module

(b) RC522 **(c)** ACR122U

5 Conlcusion

NFC based application design or research getting more attention in last decade, here we have presented total number of articles published on IEEE alone over a decade see Fig. 10. This research presented different options for the deployment and architecture of NFC-based applications. From this review, the majority of applications built for NFC is more stable and consistent with smart phones Since the mobile environment has been modified at a rapid pace, the use of NFC technologies will also have its new dimensions.
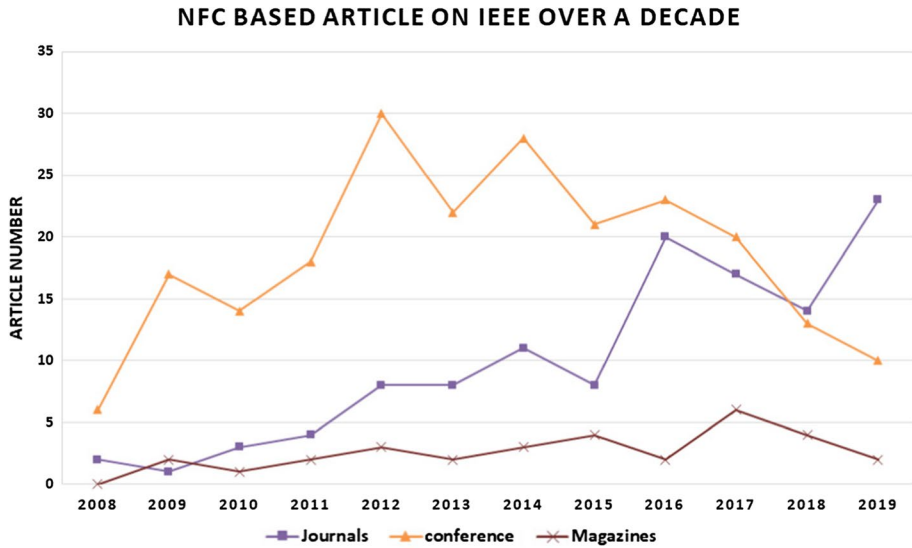
Fig. 10 Article concerning NFC technologies on IEEE

We also come across some of the research articles that have given for their application in the areas of navigation and battery less monitoring systems, which allow innovative use of this technology. Even though each technology has its own drawbacks, an effective program may be well built for this technology. This work allows analysts and application developers to look at current applications.

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