The Power of Choice:
From Standard NFC to Secure Solutions

Understanding Near Field Communication (NFC) Technology

Executive Summary

Payment systems and marketing loyalty programs are just the beginning for NFC technology. In addition to the mounting interest in NFC for mobile access control, NFC technology also promises to empower more efficient, effective industrial applications.

Specifically, combining NFC-enabled smart mobile devices with (rugged) RFID tags offers additional benefits when compared to traditional RFID solutions. When an application requires frequent interaction with tags at numerous process points by many different parties, the high expense of using traditional handheld readers is cost prohibitive. By replacing handheld readers with NFC smartphones at data collection points, the ROI for the application increases. ISO 15693 based tags as NFC Tag Type 5, expand the breadth of the NFC ecosystem to a huge existing professional RFID infrastructure. Nowadays the combination of NFC and RAIN® RFID is adding long-range use cases and allows the combination of professional (UHF) and personal (HF/NFC) applications.

Additionally, while the NFC standards for tags enable a broad variety of use cases and security, the concept of "trust" is not generally specified. HID Trusted Tag® Services are available to confer trust onto items conducting transactions between individuals and organizations.

This white paper explores the capabilities and technological background of NFC and NFC tags enabling organizations to evaluate the potential role NFC delivers in their market.

What is Near Field Communication - NFC?

Two Views on NFC

Use Case View

Mobile devices with NFC technology have a huge potential to make lives easier and more convenient for people. For example, with a simple touch, an NFC device can be used to pay for groceries or a bus fare. NFC is not limited to just payment and mass transportation. It is also used to gain access to office buildings, hotel rooms and a home, further increasing convenience. In addition, an NFC device can be used to:

- Access a URL from a smart poster or business card and perform the function specified by the code.
- Authenticate whether goods, equipped with an NFC tag, are genuine, and display additional information about the items.
- Simply emulate a card or high-frequency (HF) RFID tag to perform access control or payment functions.
- Replace a traditional HF reader/writer to interact with RFID tags.
- Read data from a banking credential for the purpose of processing a payment at a Point of Sale (POS) terminal (POS emulation).
- Communicate with another NFC device for the purpose of file sharing, data transfer, gaming and data streaming (i.e., video, sound, and printing).
- Pair Bluetooth or Wi-Fi with another object like tapping on a speaker to play a music stream on it.

Technical View

NFC is a short-range wireless connectivity technology (also known as ISO 18092) that provides intuitive, simple and safe communications between electronic devices over a close distance using industry standards. Key features include:

- Based on RFID technology operating at 13.56 MHz (HF)
- Operating distance is typically up to 1.6 inches or 4 cm (often less – like touch)
- Compatible with today's field proven contactless RFID technology and includes a variety of existing standards including ISO/IEC 14443 both Type A and Type B, ISO 15693 and FeliCa
- Data exchange rates: 106, 212 or 424 kbit/s
- Defines the data format and protocols, but not the chips that are used

NFC Operation Modes

NFC devices are unique. They can change their mode of operation to be in read/write mode, peer-to-peer mode or card emulation mode. The different operating modes are based on the ISO/IEC 18092 NFC IP-1 and ISO/IEC 14443 or ISO 15693 contactless smartcard standards. In order to obtain an NFC certification, devices must support at least two of the three modes.

Card Emulation

When an NFC-enabled device is used in card emulation mode, the smartphone is viewed more as a smartcard to the external reader rather than a mobile device. This enables NFC mobile phones to be used for contactless payments, ticketing and access control without the need to exchange existing infrastructure, such as door locks or payment terminals. Secure card emulation applications run in a "Secure Element", see the following chapter.

Reader/Writer mode

In read/write mode, the NFC device is capable of reading NFC Forum-specified tag types, such as an NFC smart poster. The tag can contain instructions for sending a short message or launching the browser with a specific URL. These capabilities make it possible to provide services, such as interactive and location-based advertisements or coupons. This mode is also useful for many industrial or logistics applications where interaction with an RFID tag is required - for example, monitoring maintenance actions. Another potential use case is enabling a guard to use a mobile device to read an access control card of a visitor or "check in" at wall mounted tags to prove his presence.

Peer-to-Peer mode

In peer-to-peer mode two NFC devices can actively exchange data by simply tapping together. For example, a tap can set up a Bluetooth or Wi-Fi connection, or exchange content such as virtual business cards and digital photos or print a file from a mobile phone by just touching an NFC-enabled printer. Also, data migration between NFC enabled phones when moving a personal phone from one generation to the next can be initiated via NFC-tap between the phones.

Devices can act in two sub-modes:

- Passive Communication: The initiator device provides a carrier field and the target device emulates a transponder

- Active Communication: Both initiator and target device communicate by alternately generating their own field

NFC Devices

NFC-enabled devices typically come in the form of a smartphone with an integrated NFC chipset. There are hundreds of NFC-enabled phones on the market today, including Android, Windows Phone and Blackberry devices. iPhones up to version 6 are not NFC-enabled, but hardware add-on solutions are available to give the iPhone this communication capability. iPhone 7 and above with iOS 11 support reading of NFC tags via a generic APP. iPhone XS/XR with iOS 12 support reading of NFC tags natively and starting with iOS 13 also tag writing is supported by Apple phones.

Beyond smartphones, NFC can be included in PCs, laptops, vending machines, loudspeakers, cameras etc. The range of potential uses is quite broad.

One of the key benefits of NFC is: As NFC-enabled phones and tablets become the norm, virtually everyone will have an RFID reader/writer in their hand. Suddenly, technology that previously required costly and bulky devices operated by specialists is available to anyone. Historically, companies had to equip workers with phones and specialized RFID readers. Now they eliminate the cost of providing the extra RFID reader, benefit from the more advanced application programming environment and connectivity options of smartphones.

The core NFC functionality is inherently built into the operating system of NFC-enabled smartphones, so reading a tag and processing the URL, contact information or launch action stored on the tag requires no extra software to be installed. With Windows 10, native NFC support also came to desktop PCs, provided that a NFC enabled reader (e.g. Omnikey 5021) is either integrated or connected via USB. Independent of native OS support, dedicated NFC applications can always be used as alternative way to fulfill special requirements.

NFC Tags

What is an NFC Tag?

In General

Any standards-based HF RFID tag can be used with most NFC devices in reader/writer mode. Technically there is a distinction between NFC tags and NFC Forum tags, but in practice, both typically work well in today's devices.

- An NFC Tag is a contactless tag which operates with ISO 14443, Felica or ISO 15693 infrastructures and NFC devices as defined by the NFC Forum, and is capable of storing NFC Data Exchange Format (NDEF) formatted data.

- An NFC Forum Tag is compatible to one of five NFC Forum Tag platforms capable of storing NDEF data. Only NFC Forum tags may carry the "NFC logo," called N-Mark, typically indicating where the phone/reader shall be placed when the tag is tapped.

All NFC Forum tags are also NFC tags, but not vice versa; e.g.: Tags with MIFARE® Classic from NXP can be NFC tags but are not NFC Forum tags, whereas MIFARE DESFire® EV1/EV2/EV3 - or MIFARE UL-based tags are also NFC Forum compliant.

In practice, the user or application programmer will not notice any difference and all tags work well with most devices. Typically, NFC Forum compliant tags are supported by all kinds of NFC handsets, whereas other NFC tags are supported by certain models only.

To write data in the proper NFC format to a tag, several free applications exist in the app-stores of NFC enabled Smartphone platforms.
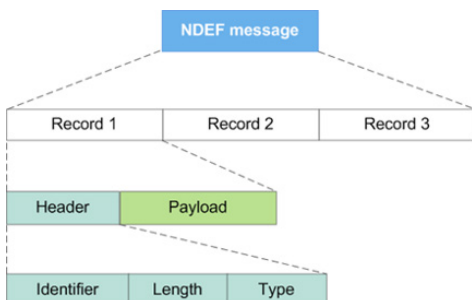
NFC Forum Tag Types

To date, the NFC Forum (www.nfc-forum.org) has standardized five tag types (Type 1-5). These tag types differ in technical details like memory size and protocol, and typically cover more than one chip model per type. Examples of the most common NFC tag chip types are the following:

Tag Type	Use Case	Chip Examples	User Memory (bytes)*	UID Length (bytes)	Cost
Forum Type 1	Specialized	Innovision Topaz	90 - 454	4	$
Forum Type 2	Most common, low cost, single application like smart poster, personal label etc.	NXP MIFARE UL, MIFARE UL-C, NTAG 203, 210, 212, 213, 216 etc. Incl. NFC+RAIN combo chips like the em|echo-V family	46 – 142	7	$
Forum Type 3	Specialized, Asian markets	Sony FeliCa (Lite)	224 – 3984	8	$$$
Forum Type 4	High memory applications, high security (in non NFC mode)	NXP MIFARE DESFire EV1 to EV3, Inside Secure VaultIC 151/161, HID Trusted Tag™, NTAG 413 / 424 DNA	1536 - 7678	7	$$$
Forum Type 5 (NFC-V / ISO 15693)	Typically industrial rugged tags in various form factors	NXP ICODE SLIx family, EM4233, Fujitsu FRAM MB89R118C, MB89R112, HID Vigo™	32 – 32KB	8	$ - $$$
MIFARE Classic/EV1	Very common, high memory – not an NFC Forum standard tag type!	NXP MIFARE Classic EV1 1K, 4K	716 - 3356	4 or 7	$$

* Note: the actual usable maximum size of NDEF text (e.g. a URL or plain text) is typically at least 7 bytes less than the available user memory specified by the chip vendor.

While tag types 1-4 exist since the early days of NFC definitions in ~2006, NFC forum added the ISO 15693 based Tag Type 5, in June 2015. Typically Android, Windows Phone 10 and iOS ≥ 11 can work with type 5 tags. However, there may be differences in chip types and some devices may support the reading of NFC tags only.

NDEF Data Format

The NDEF specification defines a message encapsulation format to exchange information; e.g., information between an NFC Forum device and another NFC Forum device, or an NFC Forum Tag. The logical structure is very simple and consists of a sequence of identifiers as well as length and payload records.

An extensive set of identifiers are already defined in the standard, including URLs, contact information, plain text, phone numbers, images, SMS, e-mail, geo location and application launch commands among others. When an NFC-enabled phone's OS reads such an identifier, it inherently knows how to process it without needing any additional application software to be installed. For example, reading a URL type of NDEF message causes a browser to open the specified URL, while reading a contact causes the contact application to open and import the contact.

Multiple NDEF records can exist within one message on a single tag, but it is the message type that determines which action the smartphone's operating system performs when a tag is tapped. NFC and non-NFC data may coexist on one physical tag to support legacy applications.

Today, most NFC tag applications simply follow a URL that is stored on a tag. Some custom "NFC" applications working with tags are actually not using the NDEF data format at all. They simply read the unique ID of the chip to identify the tag and access an external database record on the phone or on-line (where the rest of the data for this tag is stored). To the end-user this still appears like an NFC application, although no NDEF specific data is stored on the tag.

Physical Form Factors of NFC Tags

NFC tags can come in any form that is typically available for traditional RFID tags. Essentially, the entire HF tag portfolio of HID Global can be used as NFC tags. This includes tiny embeddable discs like Piccolino or ClearDisc, ruggedized flame-resistant tags for industrial use like the IN Tag™, Poly Tag®, LogiTag™ or SlimFlex™ and Seal Tag families, as well as ISO cards, key fobs and printable on metal stickers or clear labels.

The Convergence of NFC and RAIN® RFID

While NFC HF tags are designed for short-range, personal interaction, there is sometimes also the desire to combine the tag with RAIN UHF technology to reach up to several feet/meters read-range for logistics purposes like reading a box of tagged goods moving through a dock gate in a warehouse.

New generations of RFID chips and tags that combine both technologies have entered the market.

NFC's Cool Value:

- To access the data or initiate engagement, you no longer need dedicated RFID reader equipment or software. Any modern NFC-enabled smartphone may be used as a reader.

- Consumer interaction for brand authentication or enhanced customer loyalty communication is possible.

- Highly secure cryptographic authentication can be integrated without special software by using HID Trusted Tag® Services. It provides proof of presence and genuine product verification without an APP.

- True IoT dedicated interaction with an individual item or product by a simple "tap".

RAIN RFID Cool Factor:

- Improved logistics using long-range bulk scanning allows clients to read whole pallets or truckloads of goods quickly and accurately.
- Highly standardized and interoperable regardless of applications.
- Variety of reader and antenna designs to match a multitude of industrial use cases.

Combining These Technologies is Even Better

While RAIN RFID is used in most industrial and logistics uses cases due to its long range and bulk scanning capabilities, there are limitations when it comes to end-user interaction due to the required special RAIN RFID readers. Also, when intentional interaction with only one item within a set is desired, the long reading distance of RAIN RFID can become a disadvantage. Fortunately, modern tag designs now allow combining the best of both worlds. This can be achieved in two ways:

1. **Separate RAIN RFID and NFC chips**
    In this case, a RAIN RFID chip + antenna and an NFC chip + antenna are embedded into the same RFID tag housing. With this method, any chip combination from the market across different vendors is supported. This allows utilization of specific properties from each chip. Additionally, this tag design is ideal for migration scenarios because the existing infrastructure may be re-used. The caveat is both chips do not talk to each other and need to be programmed and read separately.

2. **One chip that can utilize RAIN RFID and NFC**
    In this case, a single chip can talk via both interfaces. This has the advantage of shared memory and serial numbers efficiently accessed through either interface. For newly installed applications, this is the solution to choose.

Real-Life Applications

Today, there are two main applications for this combined technology:

- **Retail**
  Applying a combo tag allows the RAIN RFID capability to power supply chain, logistics and inventory applications in the backend. However, when the product is sold in the storefront, the trusted NFC technology can be easily used by consumers or employees with their mobile phones to determine if the product is genuine or interact with the brand via the web to read instructions, re-order supplemental materials or for marketing engagement.

- **Industrial RTI and Logistics**
  Using a combo tag does not need to necessarily involve consumers. Industrial Returnable Transport Items (RTI) like steel kegs or containers can also benefit from this technology. For example, a keg would be identified via RAIN RFID during its refill, cleaning and shipping lifecycle. The user of the keg, a bar or restaurant can use an NFC interface to identify content or expiration dates, or place reorders with a simple tap from a smartphone, thereby avoiding investments into RFID readers and software. This also saves time and resources to manually reorder new supply.

Furthermore, migration scenarios, from an existing HF (NFC or non-NFC) workflow to RAIN RFID (UHF), are perfectly supported by combo RFID tags. The reader and tagged product infrastructure can be gradually exchanged over time instead of all at once.

Outlook

Quite often a converged technology tag does not have to be an either-or decision. Modern RFID combo tags provide the best of both frequency worlds and are efficient to use for both logistics and itemized scenarios. The extended use cases and saved infrastructure costs strongly support the amortization of such RFID solutions around the globe.

NFC Security

Normally NDEF records are stored in plain text and the only security applied is a "write lock" that is configured when writing data to a tag the first time. A device reading a standard NFC tag cannot detect whether the message read is authentic. For example, if smartphone users are tapping NFC tags containing URLs, without some level of integrity protection, a tag containing a malicious URL could launch a phishing attack. Signing the NDEF record protects the integrity of the contents and allows the user to identify the signer if they wish.

In April 2015 the NFC forum released the signature record type (SRT) definition 2.0 that defines how a digital signature shall be appended to an NDEF record. The NDEF record itself remains in the clear (not encrypted) so any NFC tag reader will be able to read the signed data even if they cannot verify it.

The signature adds a few hundred bytes to the message, therefore, requires larger memory NFC tags. This creation involves a proper registered digital PKI certificate and keypair. Today, verification of the signature often requires the use of an App that executes the verification until the functionality is implemented in all NFC enabled operating systems.

Although such a signature helps identify the creator of the NDEF message on the tag, it does not prevent the message incl. signature to be copied to other NFC tags or keep the content confidential.
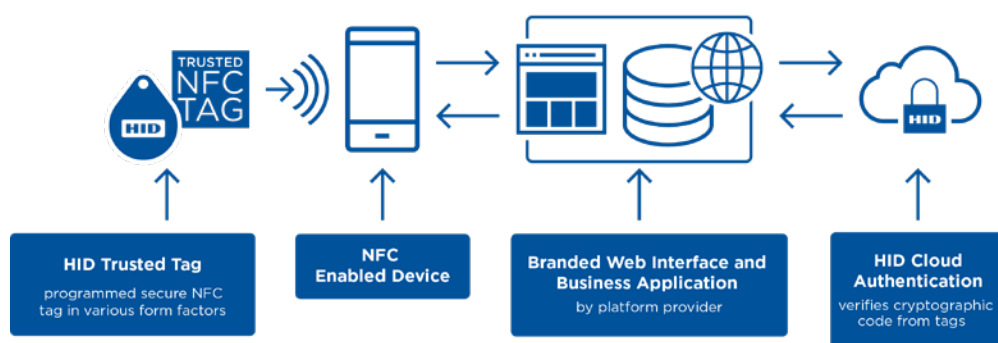
Most NFC tags act as a memory store only and simply return the data that was written to them when they are read. Some tag chips are able to append the serial number of the tag to the message, but the **same tag** will still always return the **same message** on every tap.

Copying the data of a normal NFC tag is very easily done with one of the free NFC applications from the app-stores. But there is even an easier way to "imitate" an NFC tap, just remember the URL returned by a NFC tag in the browser (e.g. as a favorite) and re-use-it. The server accessed via that URL has no way to distinguish whether an actual NFC tag was tapped or somebody just happened to know the URL. While this is no issue for promotional uses of NFC tags, it becomes an issue when the NFC tag is meant to be used of security purposes to create trust from the tap.

Trusted NFC Tags

HID Global provides a unique trusted tag that has the capability to generate a cryptographic authentication code every time the tag is tapped and appends the code to the URL read from the tag. This makes every tap unique and also prevents the tag from being cloned. HID Trusted Tags are NFC Forum Tag Type 4 compliant and work with any NFC forum compliant device. HID Trusted Tags are available in multiple form factors including rugged or tamper evident designs and are based on chipsets from major chip vendors like EM, NXP or SIC operating under a common authentication platform.

To the tapping device, the URL displayed appears like any standard URL and directs access to the desired web server without requiring any special App installation. The web server subtracts the authentication code and sends it to the HID Cloud Authentication service for verification.

HID Trusted Tag	**NFC Enabled Device**	**Branded Web Interface and Business Application**	**HID Cloud Authentication**
programmed secure NFC tag in various form factors		by platform provider	verifies cryptographic code from tags

Tap	http://...ABCD	✅
Tap	http://...7635	✅
Refresh	http://...7635	❌
Tap	http://...B423	✅

HID Trusted Tags contain a secure embedded URL

This unique functionality allows the server to distinguish true taps of a particular tag from someone accessing the server via URL refresh or URL sharing. It's up to the platform provider to decide whether a shared URL should lead to denial of the service or just logged for statistical purposes. Also, the web user interface and application logic exposed to the user tapping the tag is completely owned by the platform provider and independent of HID Global which avoids potential privacy issues by design.

When such a trusted tag is affixed on a particular location like a certain room, every valid tap represents a "proof of presence" of the tapping at this location. This is especially important for presence based services like home healthcare (Electronic Visit verification – EVV) or Guard tour – Proof of Presence verification.

Other potential use cases involve authentication of tagged goods for brand protection and Digital out of Home marketing when there is a valuable asset e.g. a download or sweepstake involved.

See the HID Trusted Tag overview and How it Works videos.

NFC Use Cases with HID Global

HID Global's NFC-enabled systems are used for many different applications by customers around the world today, and this is just the beginning of the emerging NFC market. Get inspired by some of the examples below:

Industrial Application: Harvest Logistics

HID Global, in partnership with system integrator Fundación Ada Byron (FAB), worked with Bodega Norton Winery in Argentina to develop a solution to replace a cumbersome, outdated tracking system that was used for compensating employees.

The old system was based on the manual distribution and collection of thousands of aluminum and plastic chips that tracked the amount of grapes picked by harvesters. The chip system presented inherent administrative and logistical difficulties. The paper-based system required that one day a week was allocated for collecting, counting and processing the chips, therefore halting production in the fields.

With the new solution, each harvester was issued an armband equipped with a unique contactless MIFARE®-based ISO card. Grape collection bins were tagged with HID Global Epoxy Disc tags and vineyard supervisors were outfitted with NFC-enabled smartphones. The new system now enables vineyard supervisors to simply place their smartphone next to the harvester's armband, which triggers an audible beep assuring both the harvester and supervisor that the collection bin has been counted and credited appropriately.

See the video and case study for more details.

Industrial Application – Proof of Presence Monitoring

Combining all the technologies (NFC, GPS, GSM) in one device is very beneficial for attendance workflow.

- Proof that staff visits checkpoint locations (Patient rooms, devices to monitor, buildings/doors to check etc.)
- Alerts in the event a location is not visited
- Versatile recording of other dates; e.g.,
- start/end shift, time of visit, incidents, etc.
- Instructions can be displayed on screen, detailing routes and tasks to be performed
- Worker may use multimedia e.g., take pictures
- Central real-time and historic view of data
- Easy messaging to staff, etc.
- Only one device to carry and charge
- Ensure that visits / guard tours invoiced by a contractor actually took place.

See the Trusted Tag - Proof of Presence video and related website for more details.

Commercial Applications - Loyalty Marketing Programs

NFC tags have been used in commercial retail applications for many years. Generally, these tags are pre-encoded with NFC data formats (NDEF) to launch URLs, play multimedia messages, etc. on NFC-enabled smart mobile devices.

HID Trusted Tag Services offers unique functionality allowing a server to distinguish true taps of a particular tag from someone accessing the server via URL refresh or URL sharing. The platform provider can decide whether a shared URL should lead to denial of a service or just log the information for statistical purposes.

HID Trusted Tag Services add value for Digital out of Home (DOOH) marketing campaigns because the URL cannot be copied, cloned or shared. Example programs include:

- Customer loyalty programs or sweepstake campaigns can ensure the customer was physically present to receive a service, where a certain number would grant the discount.

- Trusted reviews and on-table ordering like in the example to the right, implemented in form of a NFC Trusted Tag + BLE combination tag by our partners see case study.

- Free downloads of sponsored songs when touching an NFC enabled poster ensures only people actually interacting with the poster receive the intended reward, avoiding the URL being shared and used via a blog or social site without the desired NFC experience.

- Brand protection of valuable goods that can be authenticated with any standard NFC phone and provide enriched product specific customer information via the web. The dynamic code generation of HID Trusted Tags avoids the need for a dedicated App to be installed on the phone while still providing strong cryptographic authentication of the tapped good. See for example the Old Kempton Whisky Distillery utilizing HID Trusted Tag for that purpose.

See the Trusted Tag - DOOH video for more details.

Mobile Access

While the above examples use the NFC read/write mode to interact with physical tags, the NFC card emulation can also be used so the NFC device can act like a card or tag towards other readers or door locks, for example. Several cards or other logon credentials can be converged into a single NFC-enabled mobile phone and provisioned or revoked over the air. From the perspective of a NFC reader (e.g. a door lock or Windows PC), the phone appears no different than a card because it is simply using its secure element or HCE to emulate this card.

Keys and access cards in daily life

Converged into NFC-enabled smartphone

Used to open different types of doors and Windows®

Especially for Access Control - also Bluetooth Low Energy (BLE) may be used as alternative technology to NFC. As an advantage it works with all modern phones, but requires BLE enabled door locks whereas NFC can interact with existing infrastructure. See for example the Starwood Preferred Guest keyless entry service.
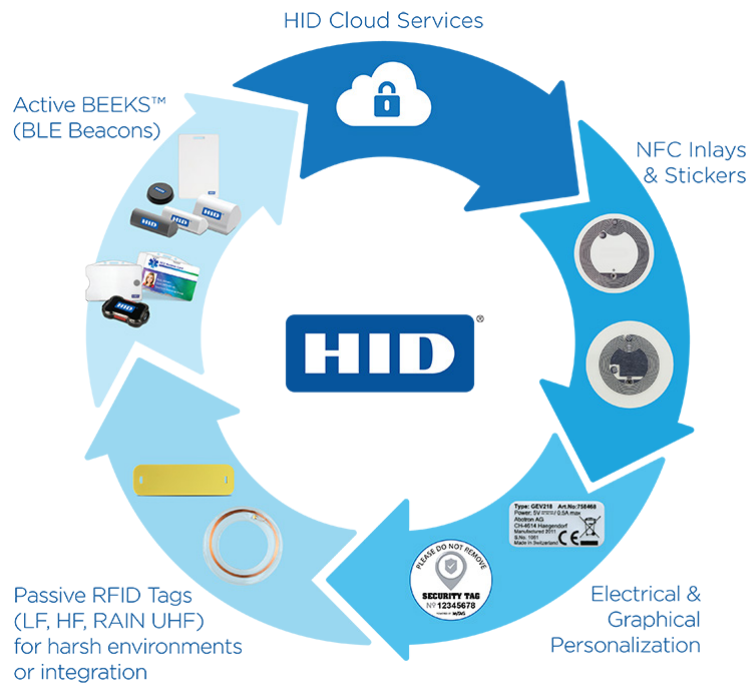

Readers and Reader Boards
Finally, HID Global offers a set of NFC-enabled readers or reader boards.

- Readers may be door locks or
- Connect via USB to a PC/laptop for interacting with software e.g. Windows Hello logon
- Reader boards are embedded by OEMs into custom housings like vending machines or time attendance systems to add general RFID or NFC functionality to them.

Summary

The worldwide availability of NFC-enabled devices enables the large population of smartphone users to take advantage of RFID capabilities, opening new use case possibilities and reducing costs at the same time. Besides the most common payment case, there is a myriad of other potential uses for NFC – some of them still to be discovered.

The proven HID Global tag portfolio from standard NFC labels to rugged special application tags and RAIN® RFID support stands ready to support these new applications. Additional offers such as HID Trusted Tag™ Services or HID Secure Identity Services™ for mobile access applications add security and convenience where needed.

About HID Global

HID Global is the trusted source for innovative products, services, solutions, and know-how related to the creation, management, and use of secure identities for millions of customers around the world. The company's served markets include physical and logical access control, including strong authentication and credential management; card printing and personalization; visitor management systems; highly secure government and citizen ID; and identification RFID technologies used in animal ID and industry and logistics applications. The company's primary brands include ActivID®, Bluvision™, EasyLobby®, FARGO®, IdenTrust®, LaserCard®, Lumidigm®, LUX-IDent®, Quantum Secure® and HID®. Headquartered in Austin, Texas, HID Global has over 4,000 employees worldwide and operates international offices that support more than 100 countries. HID Global® is an ASSA ABLOY Group brand. For more information, visit www.hidglobal.com

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