DESIGN AND IMPLEMENT NFC APPLICATIONS

SESSION 4: NFC READER LIBRARY

SW SUPPORT FOR NFC FRONTENDS AND NFC CONTROLLERS WITH CUSTOMIZED FIRMWARE

October 2016

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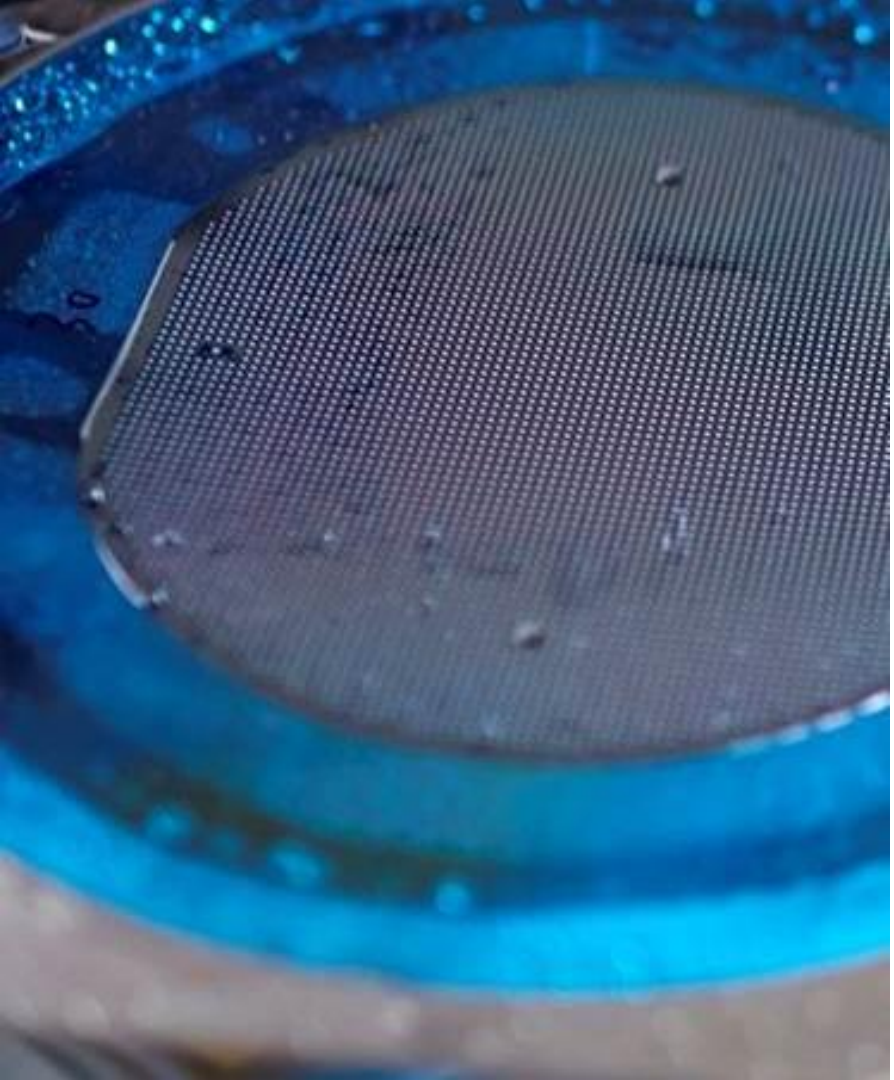
NXP

SECURE CONNECTIONS FOR A SMARTER WORLD



Agenda

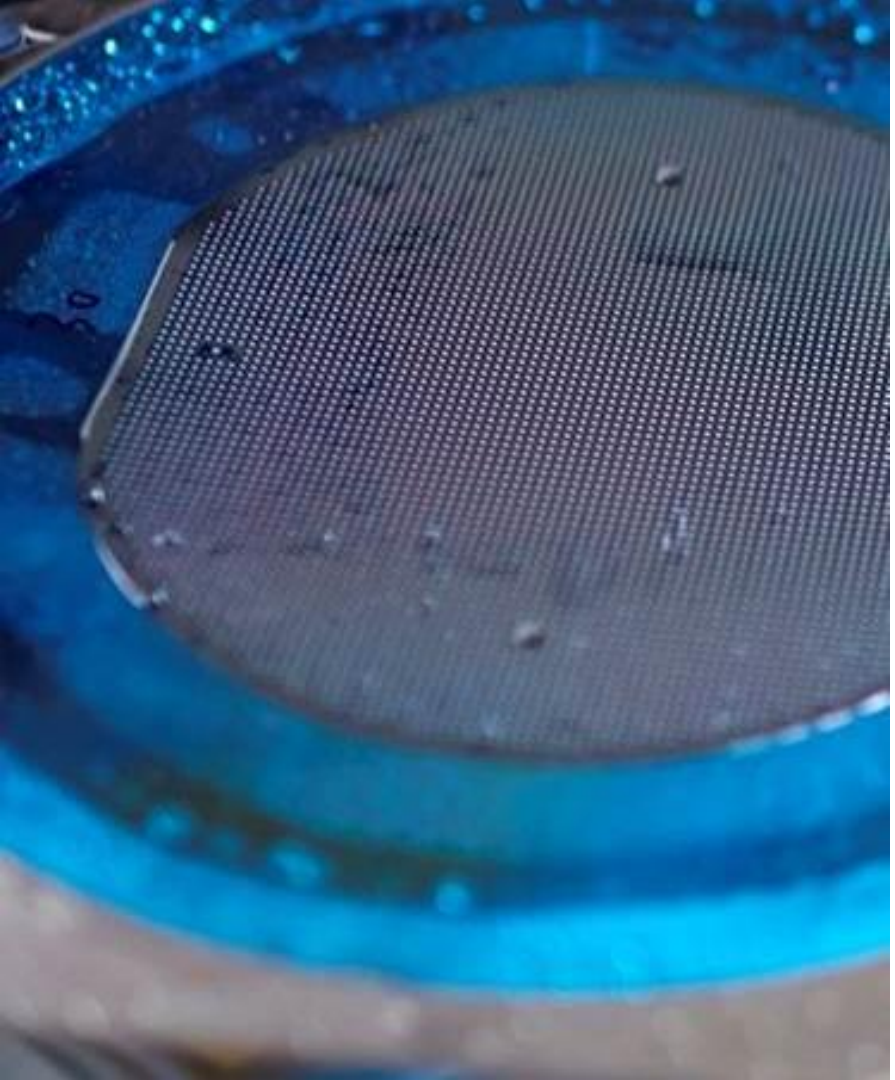
Design and implement NFC applications

Session I, 7th September
Product support package for NXP NFC readers
https://attendee.gotowebinar.com/rt/2329750067403618817

Session II, 28th September
Antenna design considerations for NXP NFC reader solutions
https://attendee.gotowebinar.com/rt/282682617345186049

Session III, 18th October
The NFC Cockpit - the complete design tool for engineers
https://attendee.gotowebinar.com/rt/4665515186055692545

Session IV, 31st October
NFC Reader Library - SW support for NFC frontend solutions
https://attendee.gotowebinar.com/rt/7151741873899128067



Agenda

Design and implement NFC applications

Session 4, 31st October
NFC Reader Library: SW support for NFC frontends and NFC controllers w. custom. FW

- Introduction to the NFC Reader Library
- NFC Reader Library architecture
- Using the NFC Reader Library
  - Building the SW stack
  - Discovery loop configuration
  - Simplified API
- Software examples
- Documentation

Our support for NFC

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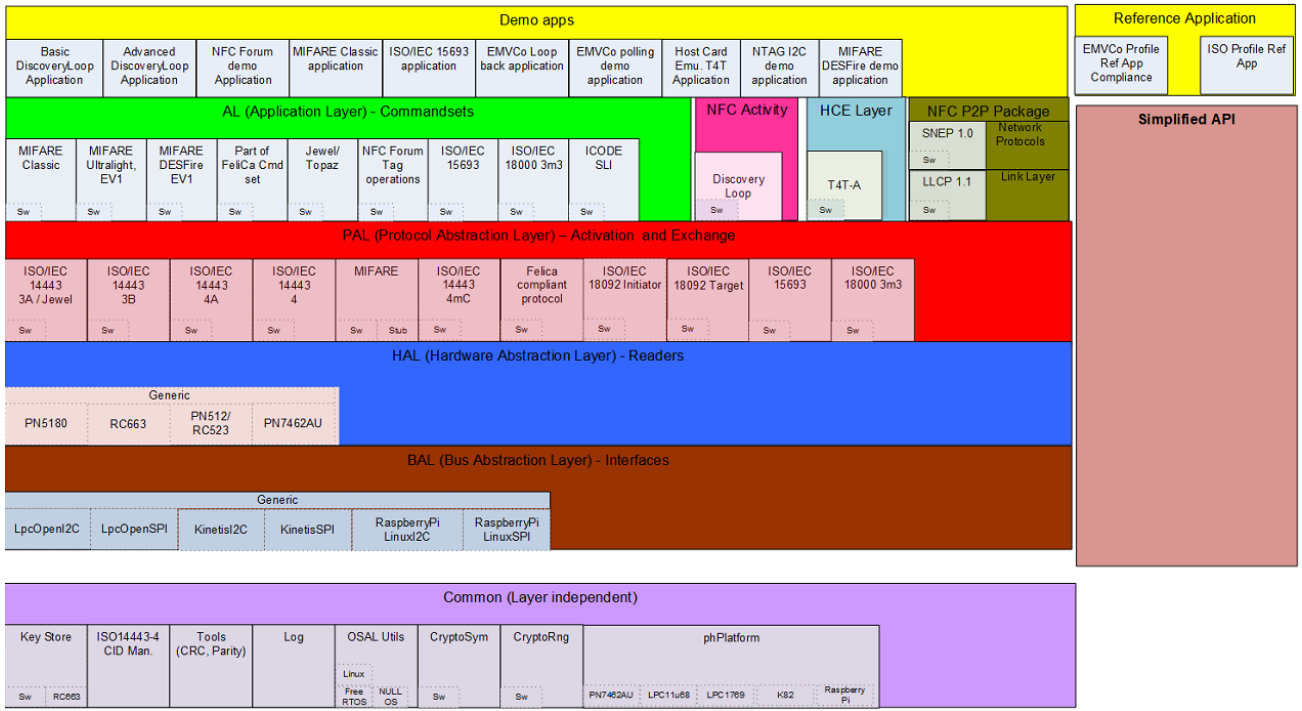
INTRODUCTION TO THE
NFC READER LIBRARY

NFC Reader Library

Everything you need to create your own software stack and application for a contactless reader



- Modular
- Multi-layered
- ANSI-C language
- Portable to multiple design environments and platforms
- Free download

Info and source code: http://www.nxp.com/pages/:NFC-READER-LIBRARY

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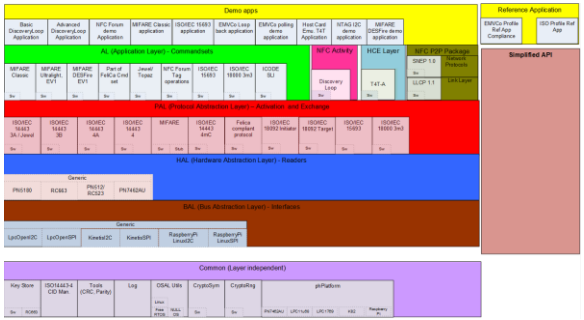
NFC Reader Library

Benefits



Scalability: *Only required software components and protocol implementations need to be enabled, so the final application has a smaller footprint.*

Optimum performance: *Fine-tune your design with built-in MCU support, interrupt-based event handling, free RTOS support and compilers that produce highly compact and efficient code.*

Faster development: *Save time and effort by using the APIs and the rich set of sample applications for all the most common functions.*

Simpler certification: *Get ready for certification with test applications for EMVCO L1, NFC Forum and ISO/IEC10373-6 PICC/PCD*

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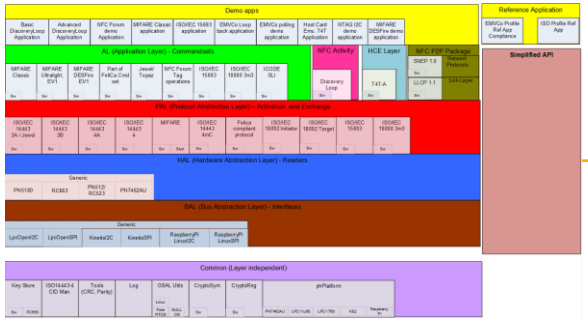
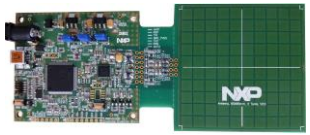
NFC Reader Library

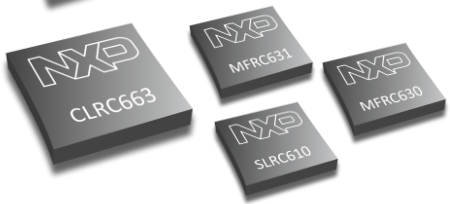
The same software stack for PN512, CLRC663, PN5180 and PN7462 solutions

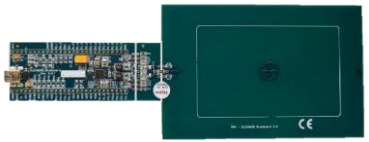


SW support for NFC frontend solutions



OM25180FDK





CLEV663B

PNEV512B

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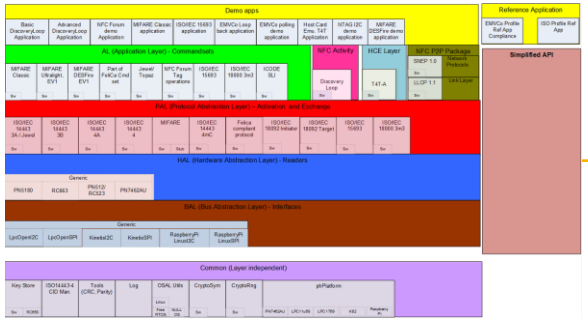
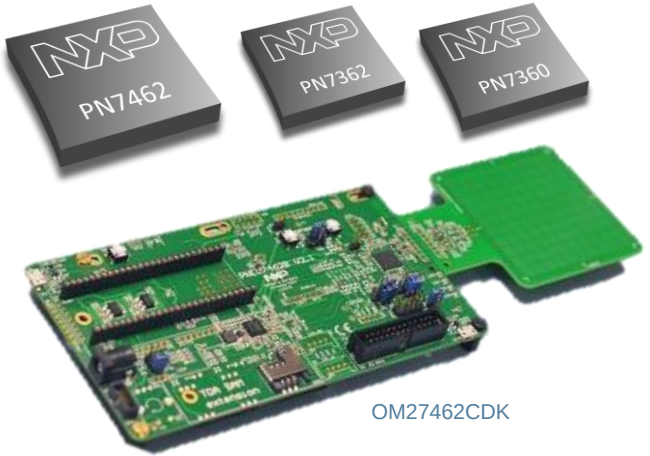
The same software stack for PN512, CLRC663, PN5180 and PN7462 solutions



SW support for NFC controllers with customizable firmware



OM27462CDK

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NFC Reader Library

Support for multiple platforms

LPC MCUs

Kinetis MCUs

Linux OS

i.MX MCUs *

*Available soon

NFC Reader Library v4.040.03.001640 supports:
LPC1769/LPC11U68 connected to PNEV512B, CLEV663B and PNEV5180B boards
FRDM-K82 connected to PNEV512B, CLEV663B, PNEV5180B and PNEV7462B boards
Raspberry Pi connected to PNEV512B, CLEV663B, PNEV5180B and PNEV7462B boards

NFC Reader Library

Release contents

NFC Reader Library API

Software examples

Documentation

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NFC Reader Library

Development environment

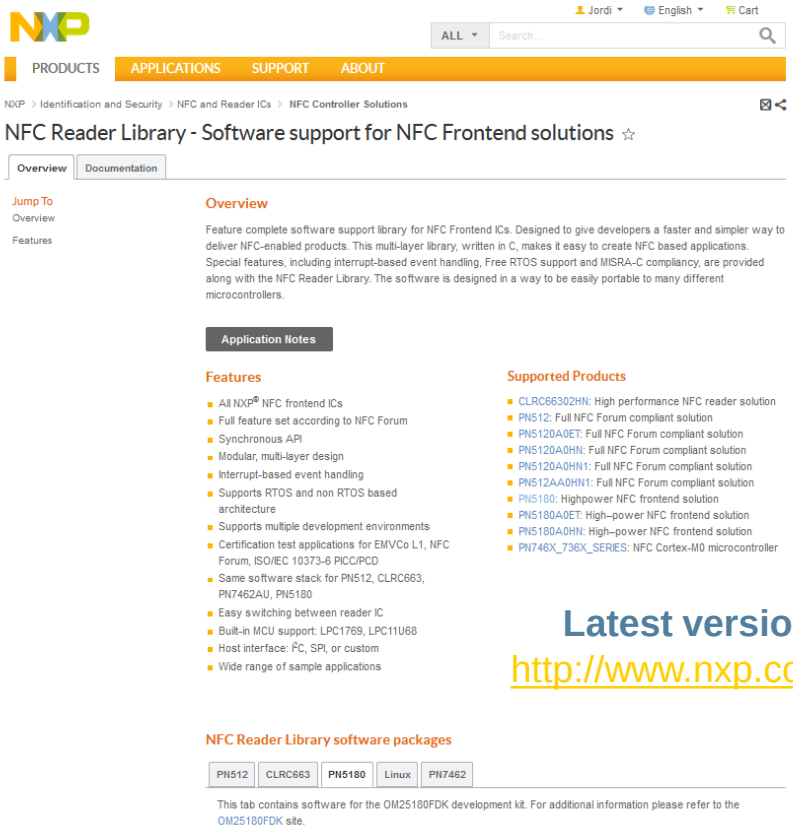
1. Choose an NFC product and pick its development board.
2. Download the corresponding NFC Reader Library package depending on your platform.
3. Install a development IDE.
4. Import software examples.
5. Evaluate functionality, re-use code and start developing.

LPCXPRESSO

Note: LPC-Link2 board may be required as a stand-alone debugger as well

NFC Reader Library

Where to get it



Latest version and information available at:

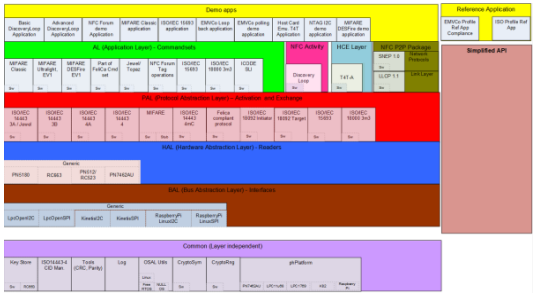
http://www.nxp.com/pages/:NFC-READER-LIBRARY

NFC READER LIBRARY
ARCHITECTURE

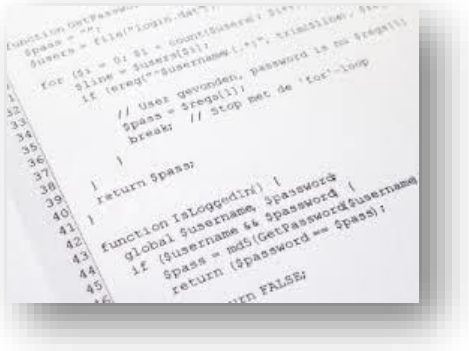
NFC Reader Library

Release contents

NFC Reader Library API



Software examples



Documentation

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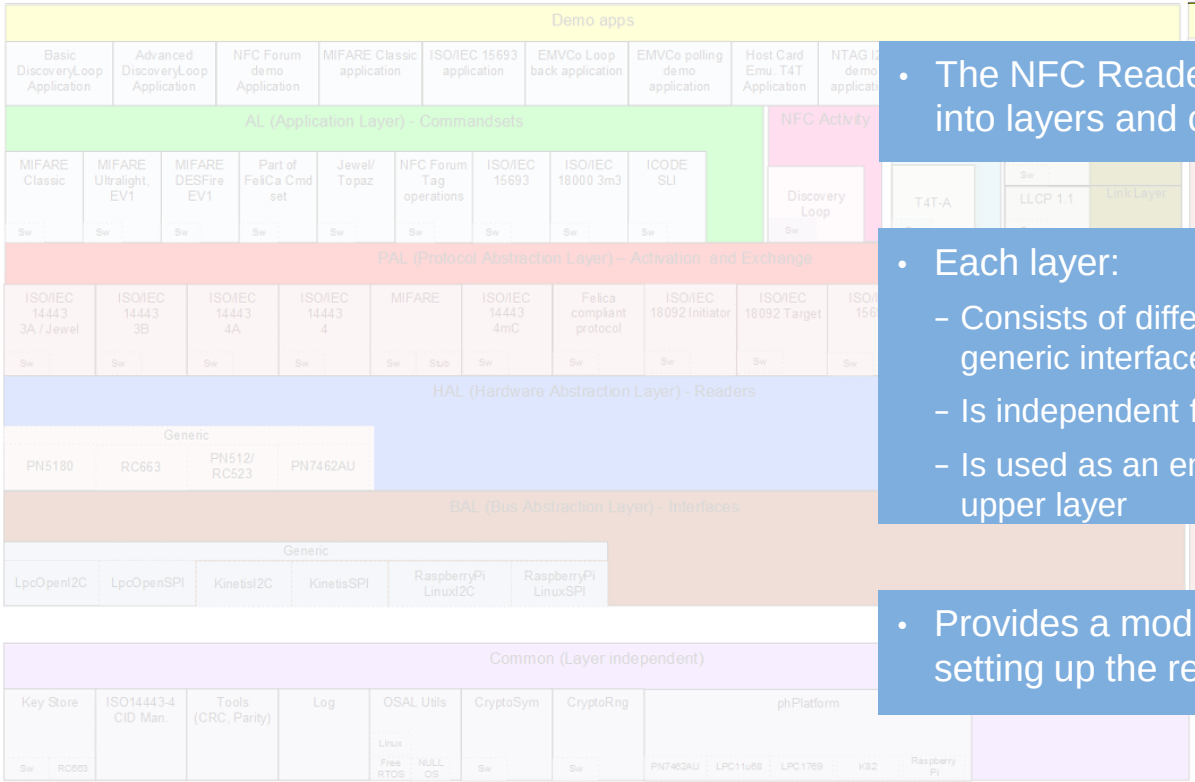
NFC Reader Library

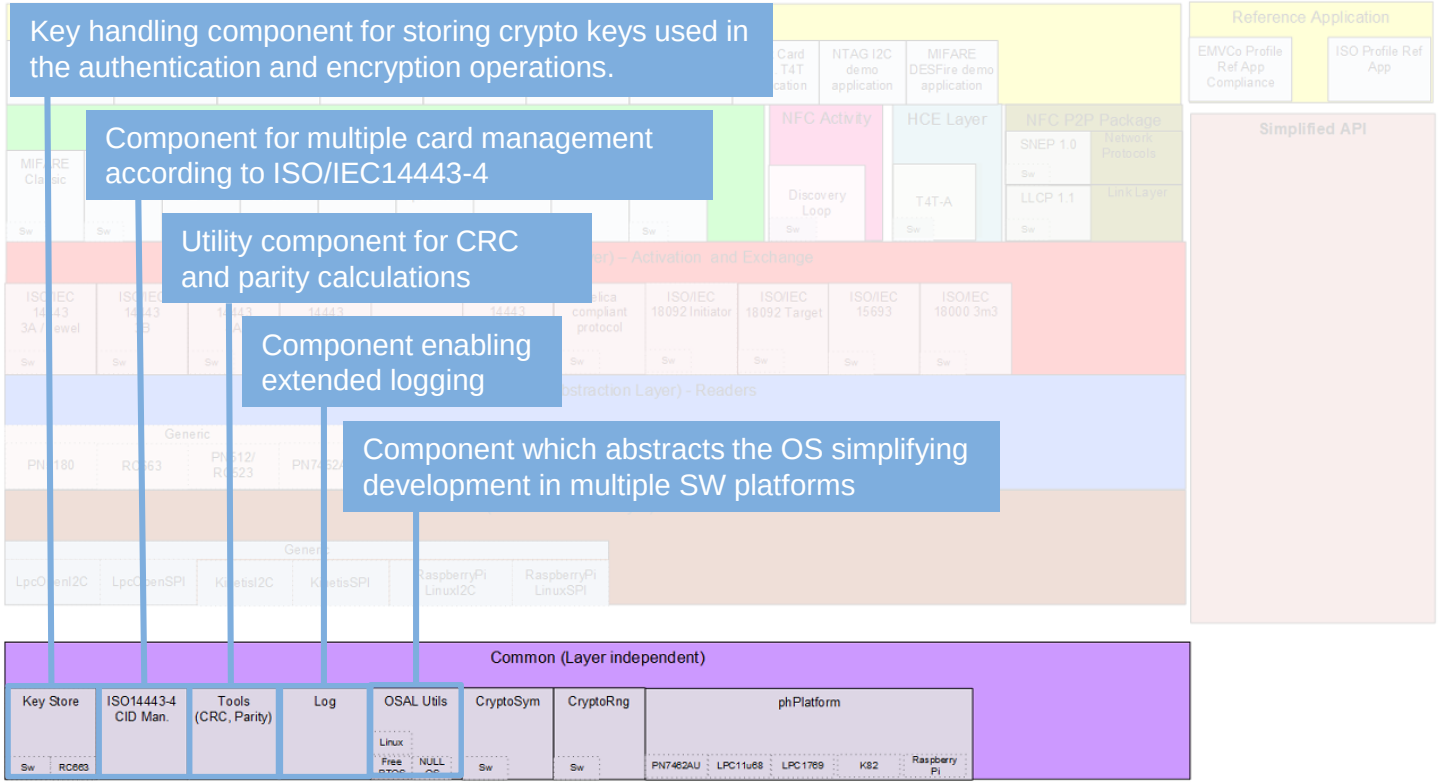
Architecture



- The NFC Reader Library is encapsulated into layers and components.
- Each layer:
  - Consists of different components, having a generic interface and specific implementation
  - Is independent from the other layers
  - Is used as an entry point for the immediate upper layer
- Provides a modular way of programming and setting up the reader interface.

NFC Reader Library

Common Layer



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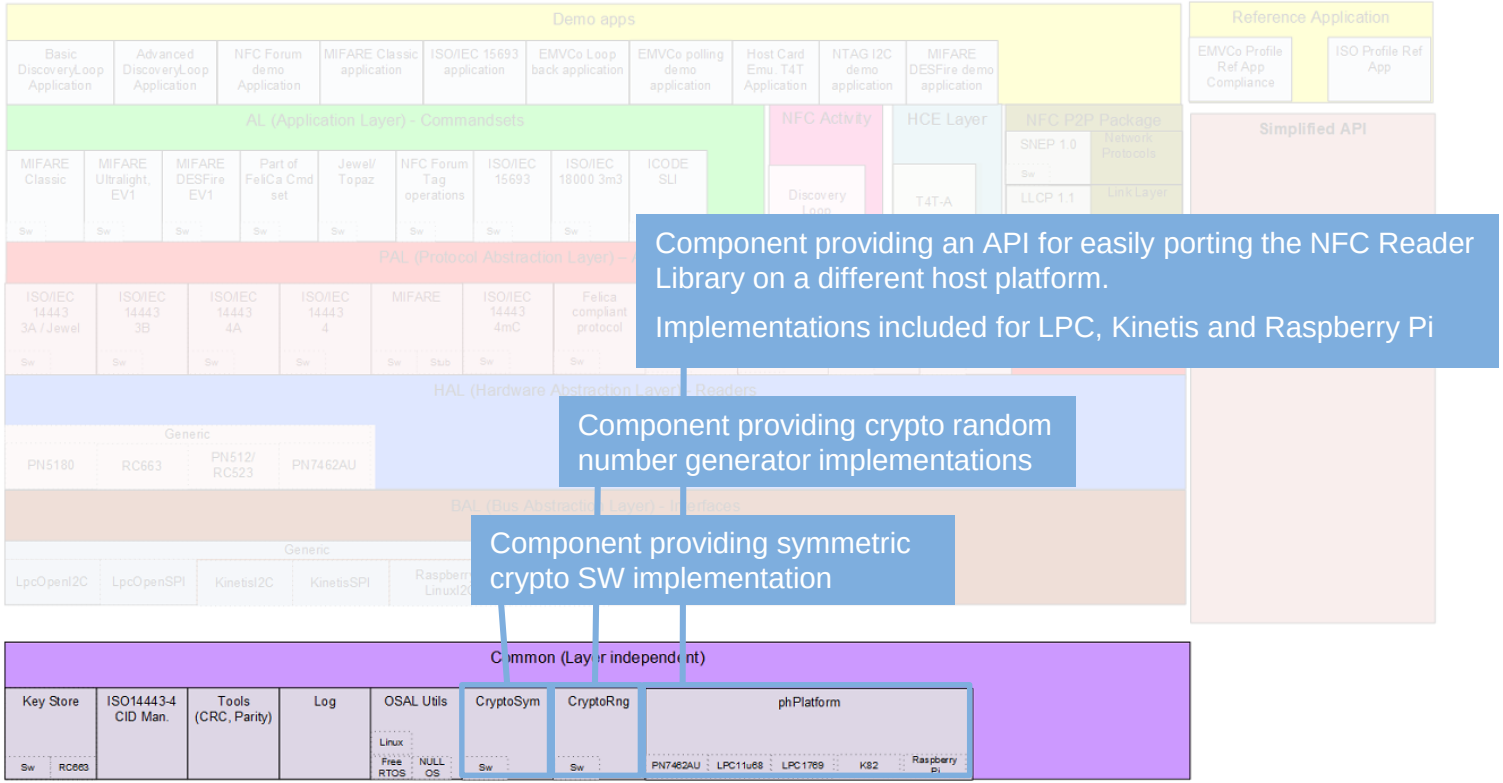
NFC Reader Library

Common Layer



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NFC Reader Library

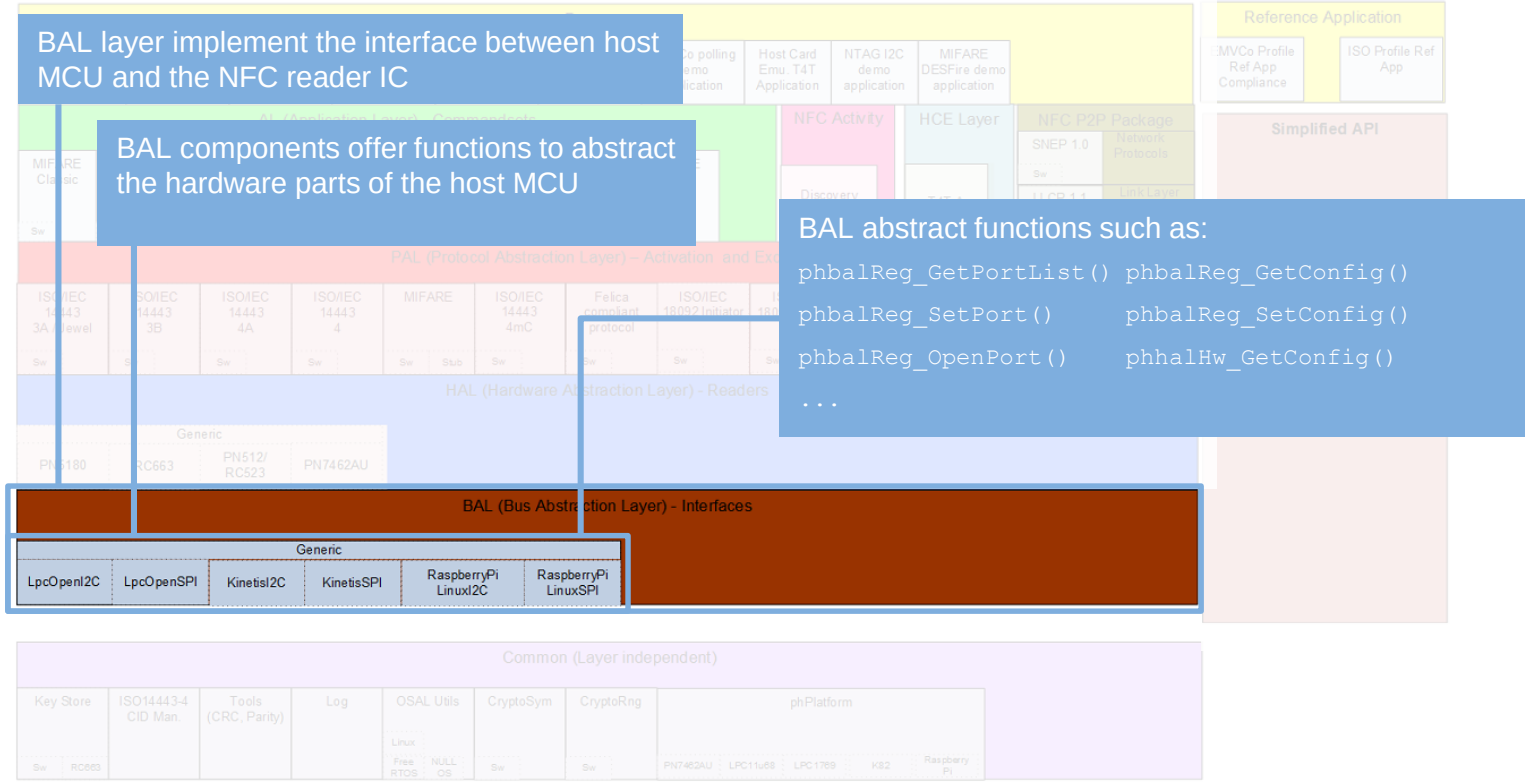
Bus Abstraction Layer (BAL)

BAL layer implement the interface between host MCU and the NFC reader IC

BAL components offer functions to abstract the hardware parts of the host MCU

BAL abstract functions such as:

```
phbalReg_GetPortList()   phbalReg_GetConfig()
phbalReg_SetPort()       phbalReg_SetConfig()
phbalReg_OpenPort()      phhalHw_GetConfig()
...
```



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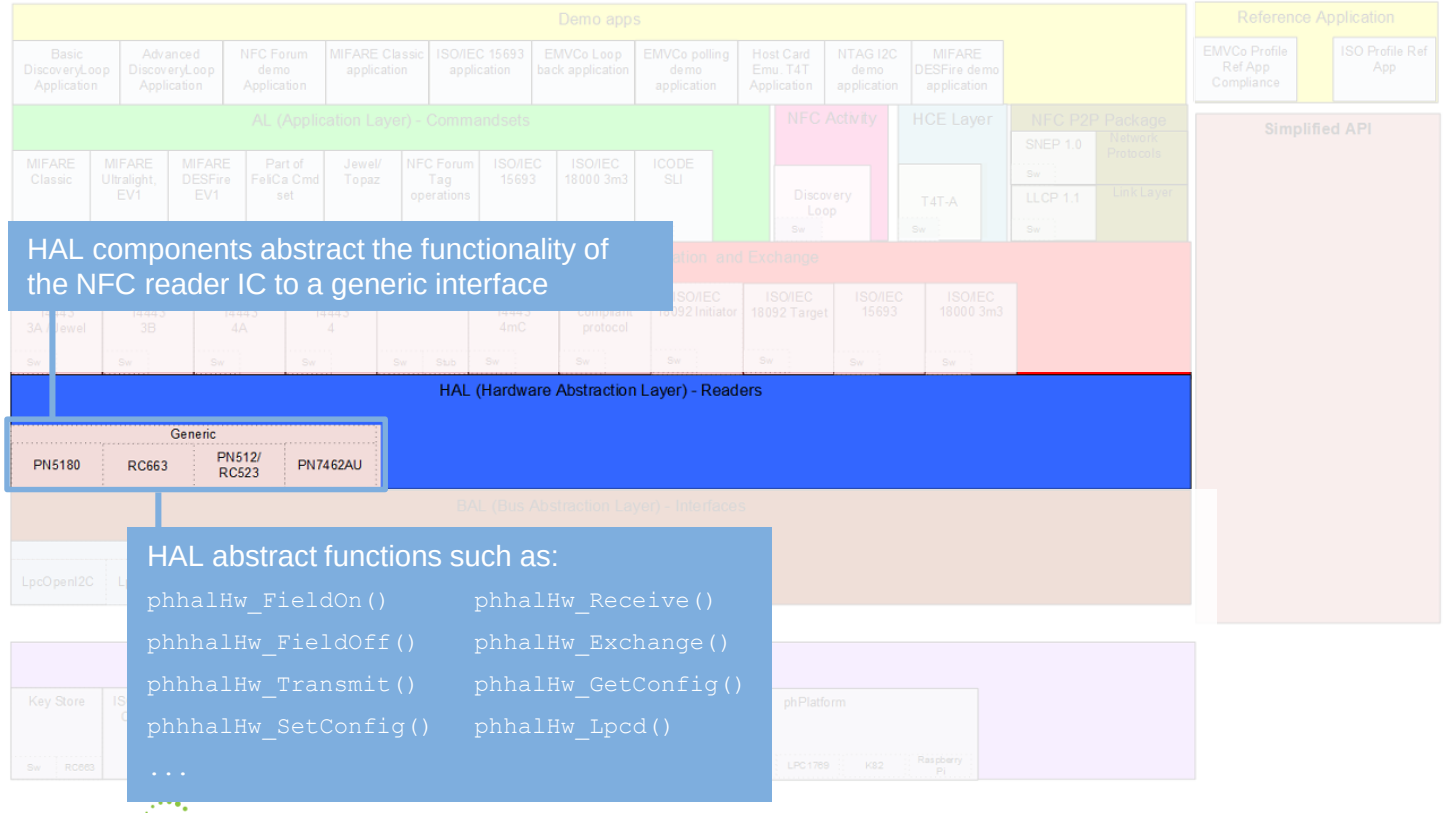
NFC Reader Library

Hardware Abstraction Layer (HAL)



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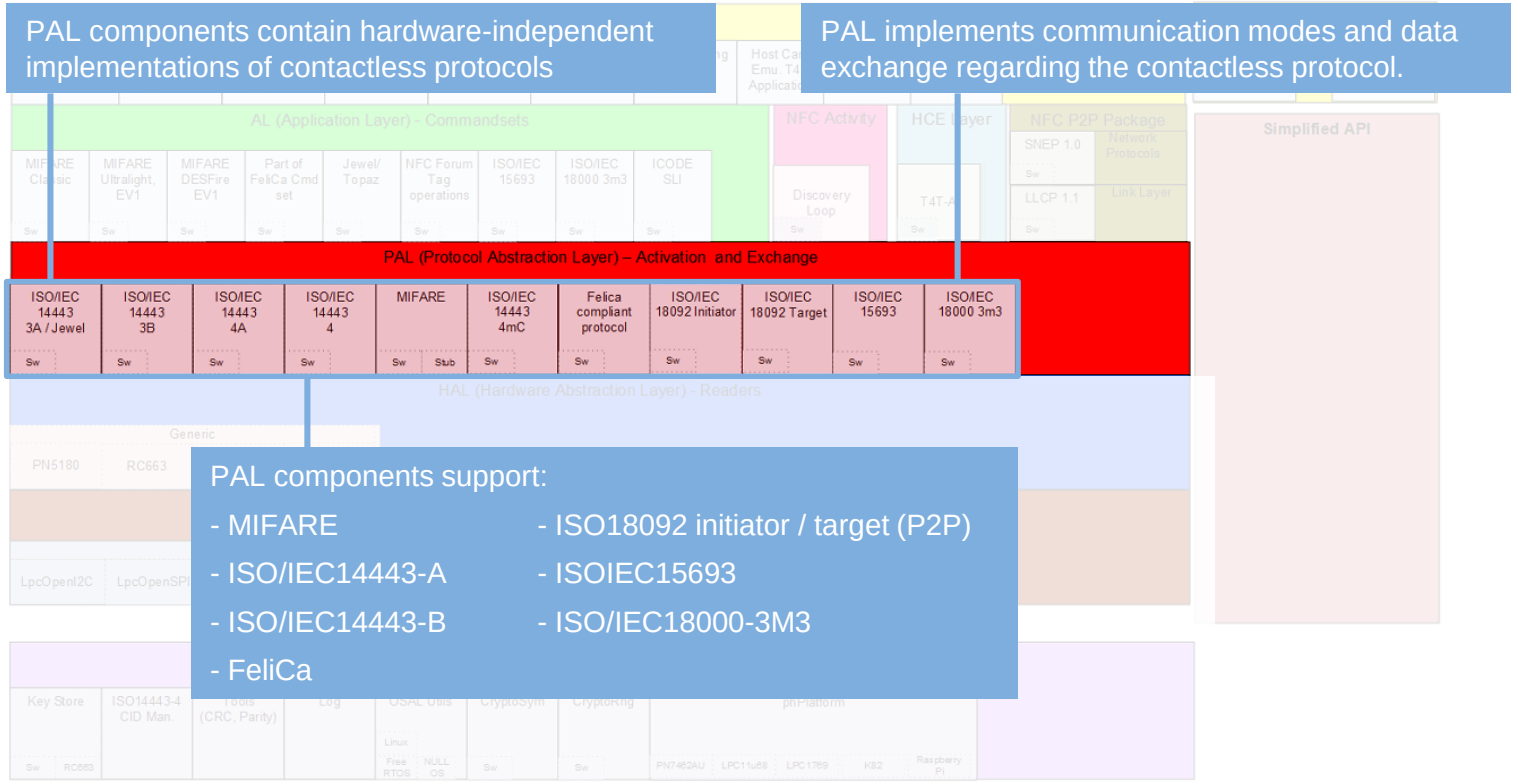
NFC Reader Library

Protocol Abstraction Layer (PAL)

PAL components contain hardware-independent implementations of contactless protocols

PAL implements communication modes and data exchange regarding the contactless protocol.



PAL components support:

- MIFARE
- ISO/IEC14443-A
- ISO/IEC14443-B
- FeliCa
- ISO18092 initiator / target (P2P)
- ISOIEC15693
- ISO/IEC18000-3M3

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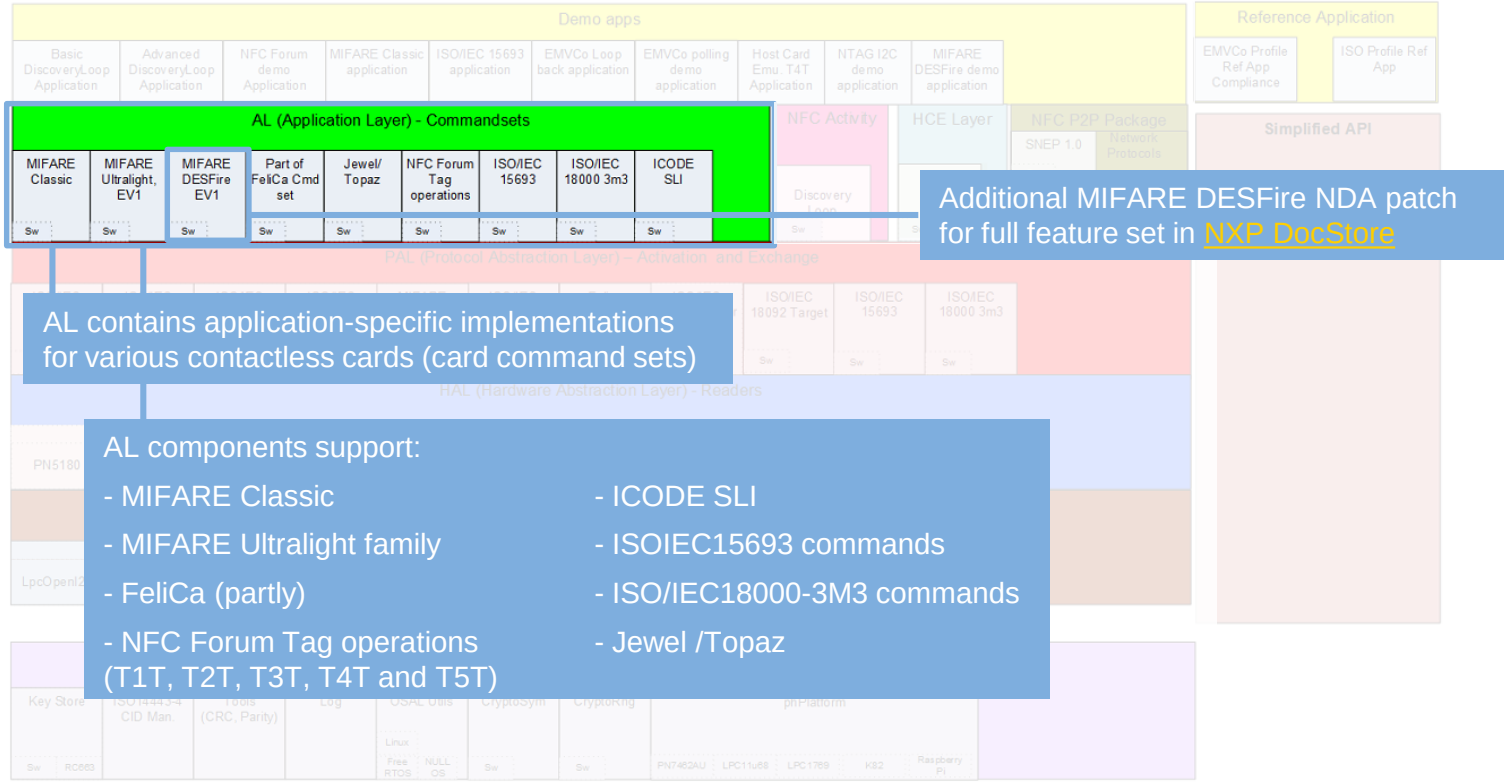
NFC Reader Library

Application layer



Additional MIFARE DESFire NDA patch for full feature set in NXP DocStore

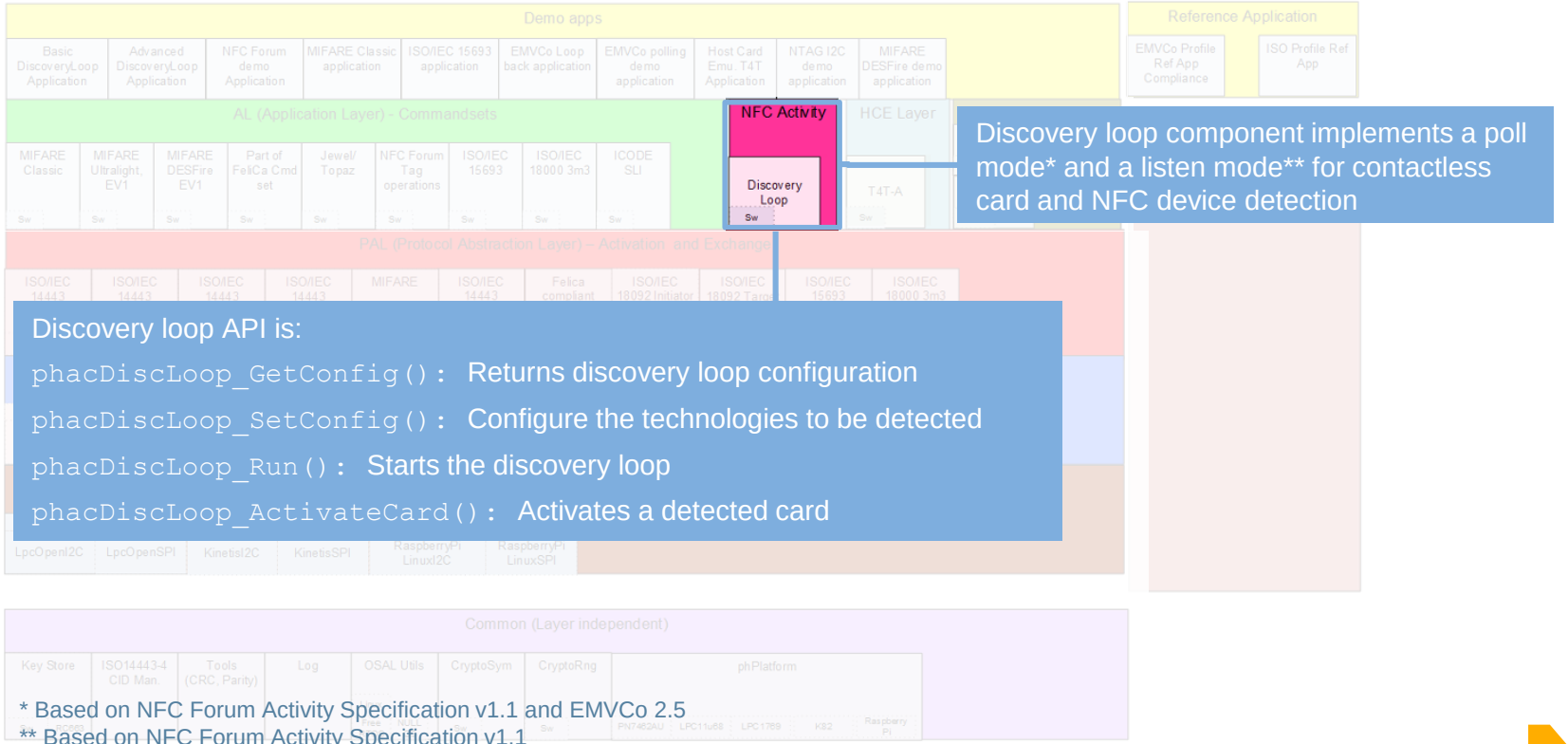
AL contains application-specific implementations for various contactless cards (card command sets)

AL components support:

- MIFARE Classic
- MIFARE Ultralight family
- FeliCa (partly)
- NFC Forum Tag operations (T1T, T2T, T3T, T4T and T5T)
- ICODE SLI
- ISOIEC15693 commands
- ISO/IEC18000-3M3 commands
- Jewel /Topaz

NFC Reader Library

Activity layer



Discovery loop component implements a poll mode* and a listen mode** for contactless card and NFC device detection

Discovery loop API is:

`phacDiscLoop_GetConfig()`: Returns discovery loop configuration

`phacDiscLoop_SetConfig()`: Configure the technologies to be detected

`phacDiscLoop_Run()`: Starts the discovery loop

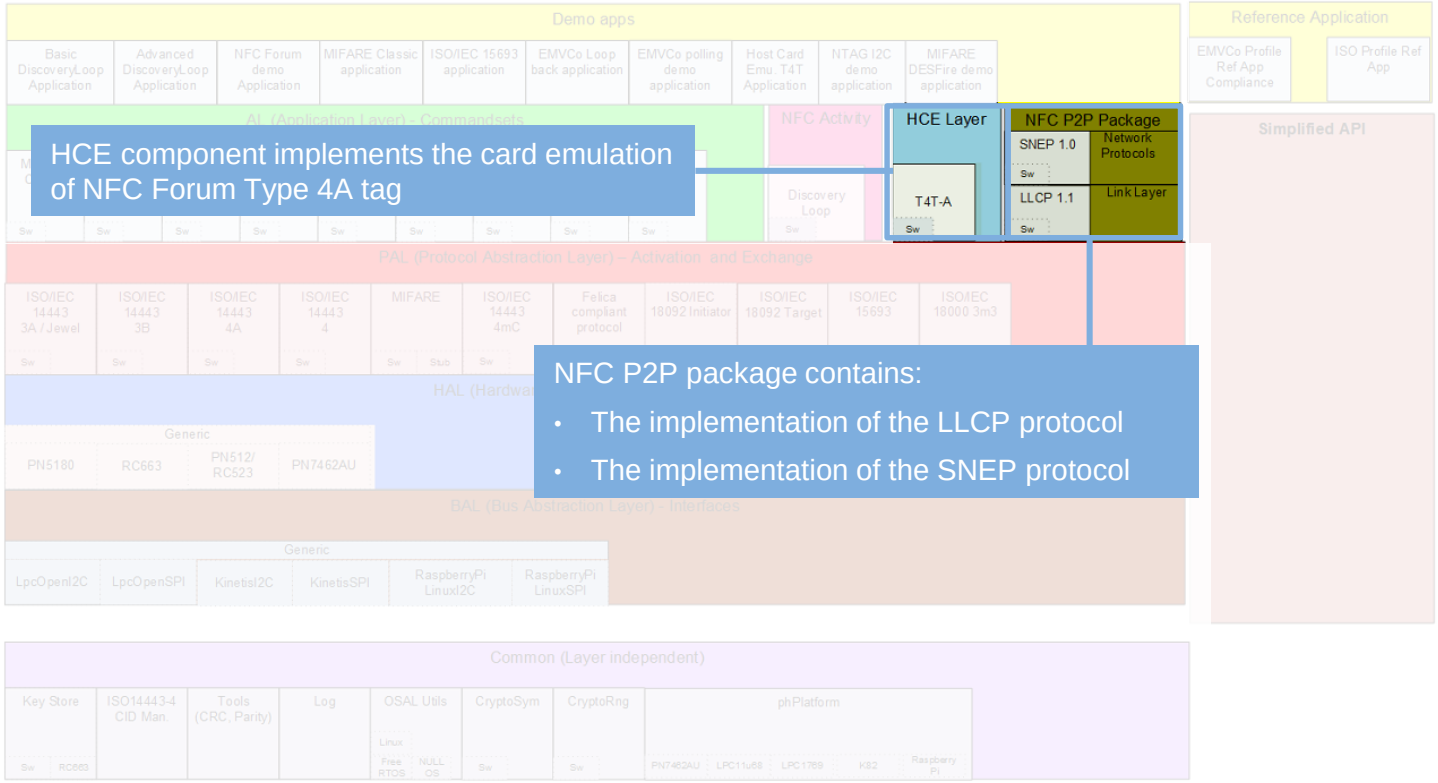
`phacDiscLoop_ActivateCard()`: Activates a detected card

* Based on NFC Forum Activity Specification v1.1 and EMVCo 2.5

** Based on NFC Forum Activity Specification v1.1

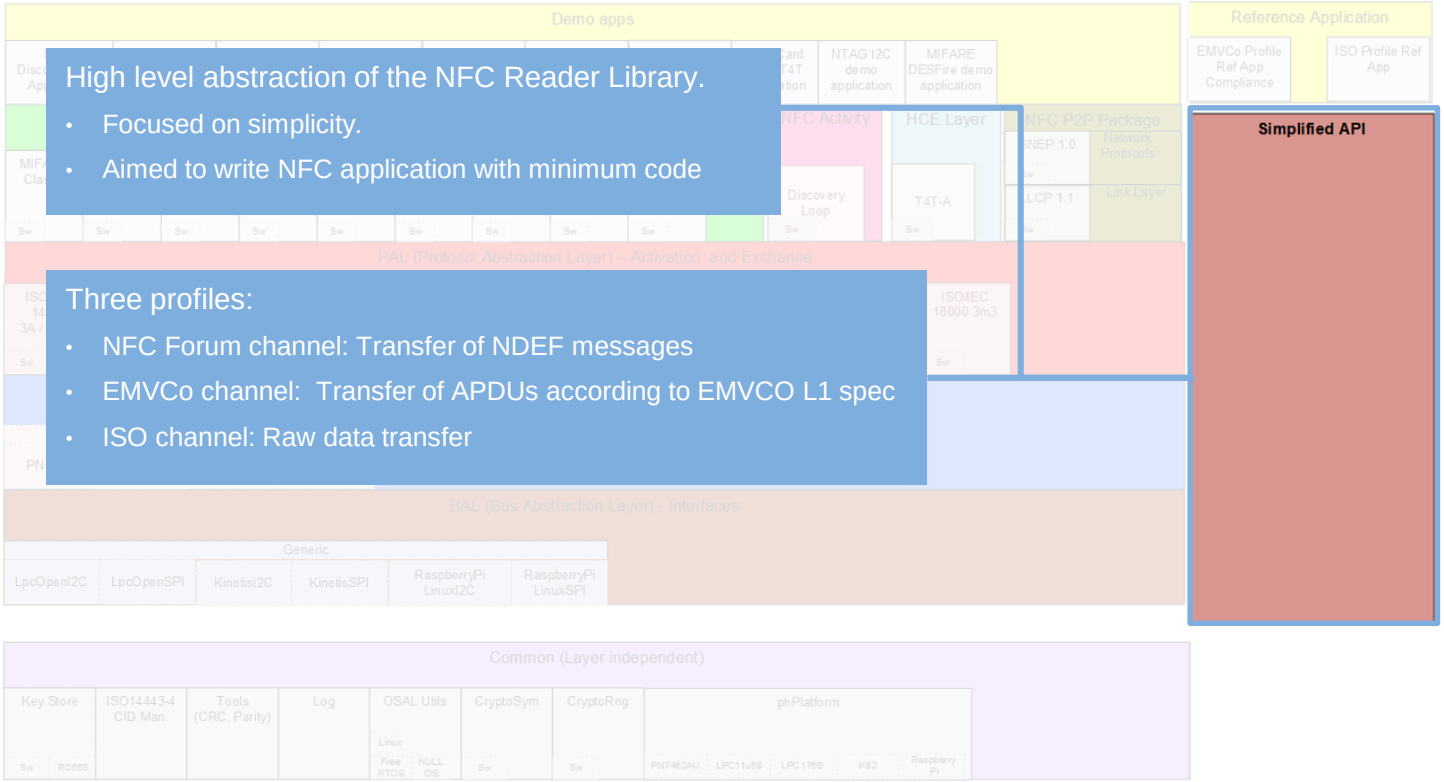
NFC Reader Library

HCE and P2P layers



NFC Reader Library

Simplified API



High level abstraction of the NFC Reader Library.

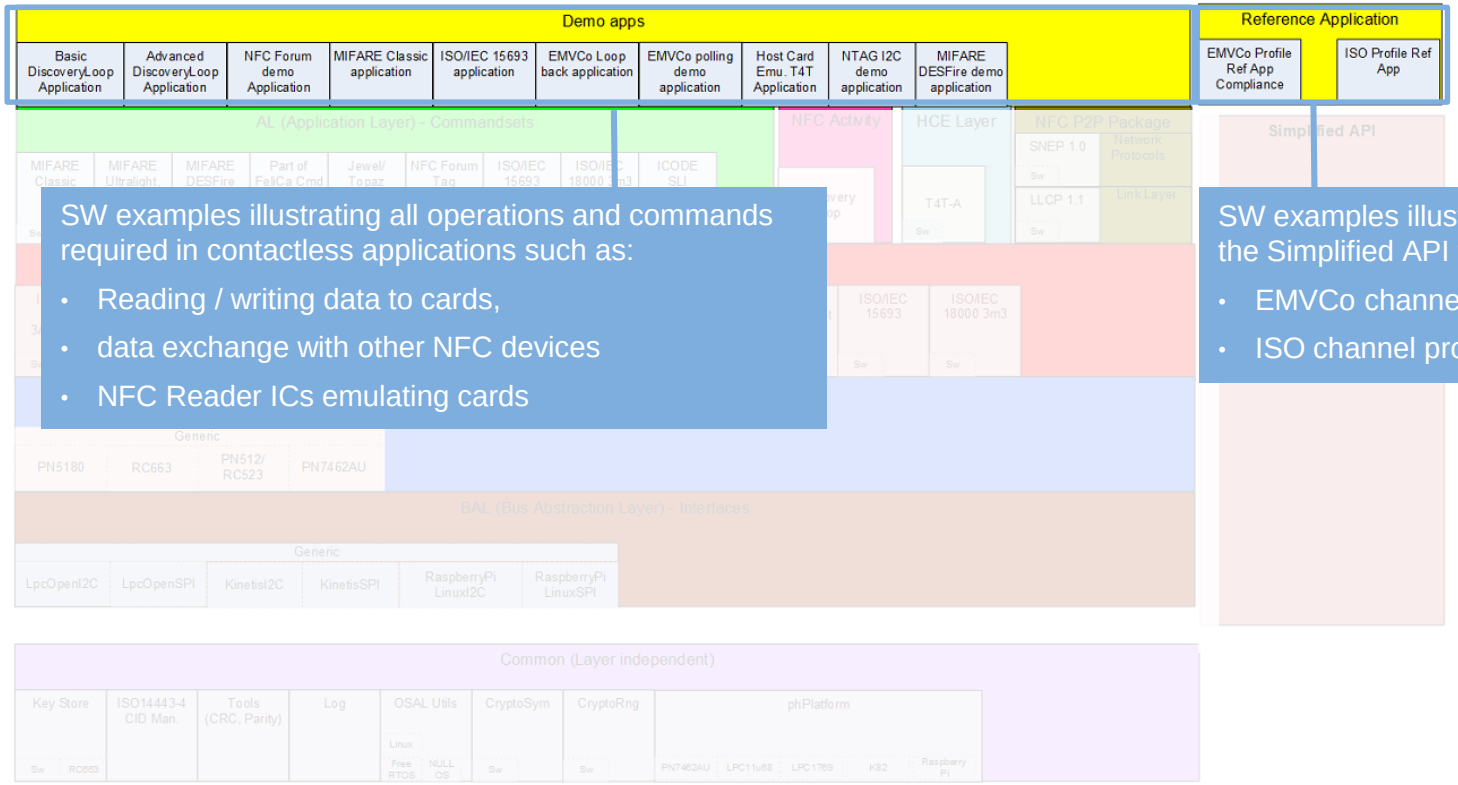
- Focused on simplicity.
- Aimed to write NFC application with minimum code

Three profiles:

- NFC Forum channel: Transfer of NDEF messages
- EMVCo channel: Transfer of APDUs according to EMVCO L1 spec
- ISO channel: Raw data transfer

NFC Reader Library

Demo apps and reference applications



SW examples illustrating all operations and commands required in contactless applications such as:

- Reading / writing data to cards,
- data exchange with other NFC devices
- NFC Reader ICs emulating cards

SW examples illustrating the use of the Simplified API for:

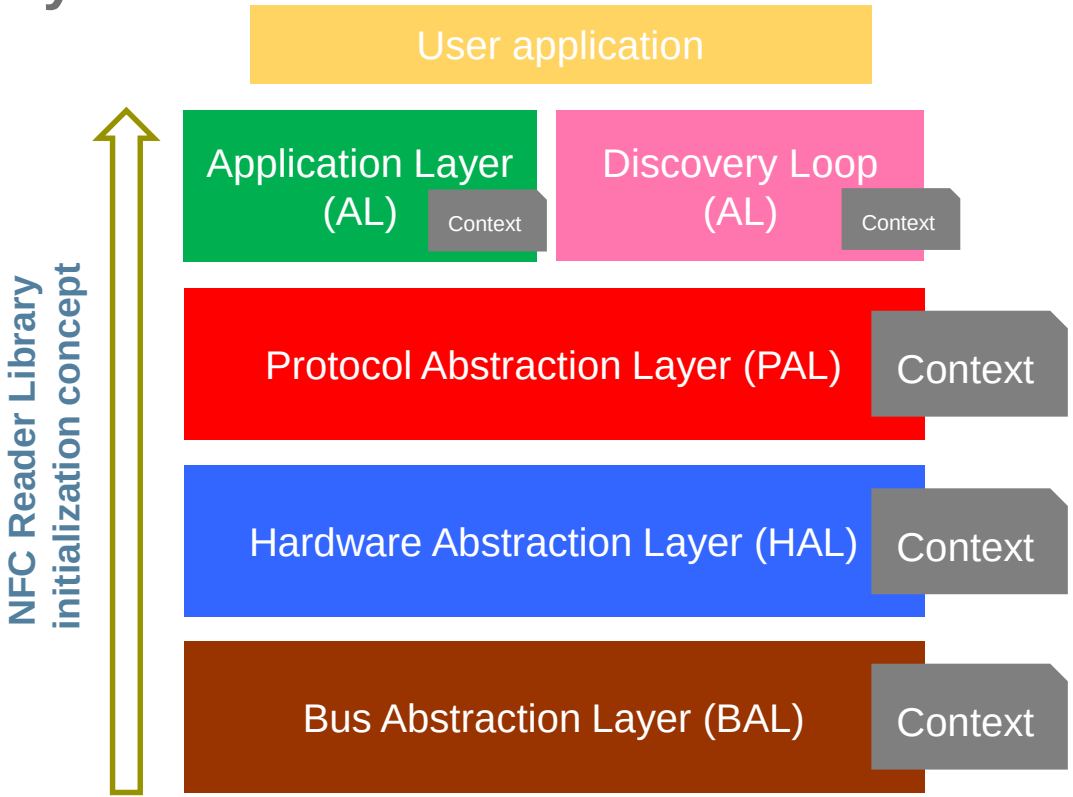
- EMVCo channel profile
- ISO channel profile

USING THE NFC READER LIBRARY:
BUILDING THE SW STACK

Using the NFC Reader Library

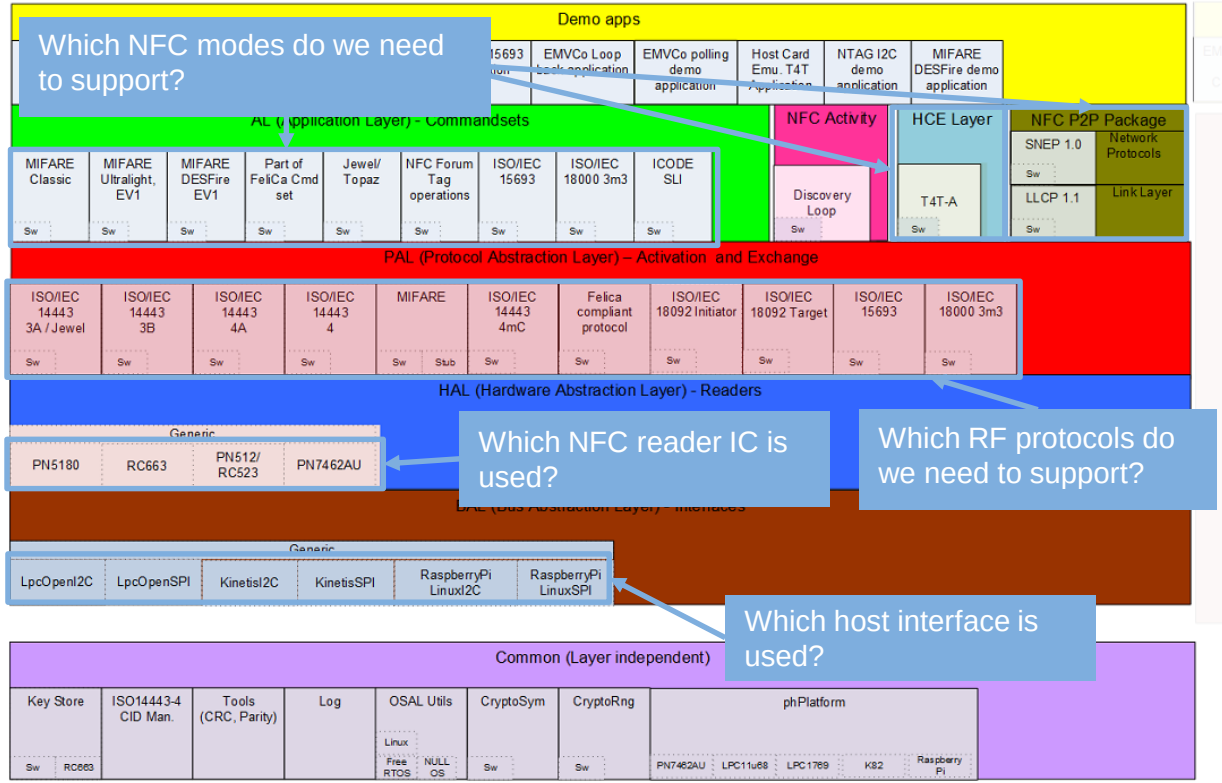
Building the SW stack

- To use the NFC Reader Library, a stack of components has to be initialized.
- Each layer generates a context data which is used as an entry point for the immediate upper layer.
- The component initialization must be built up by a ***bottom to top*** approach



Using the NFC Reader Library

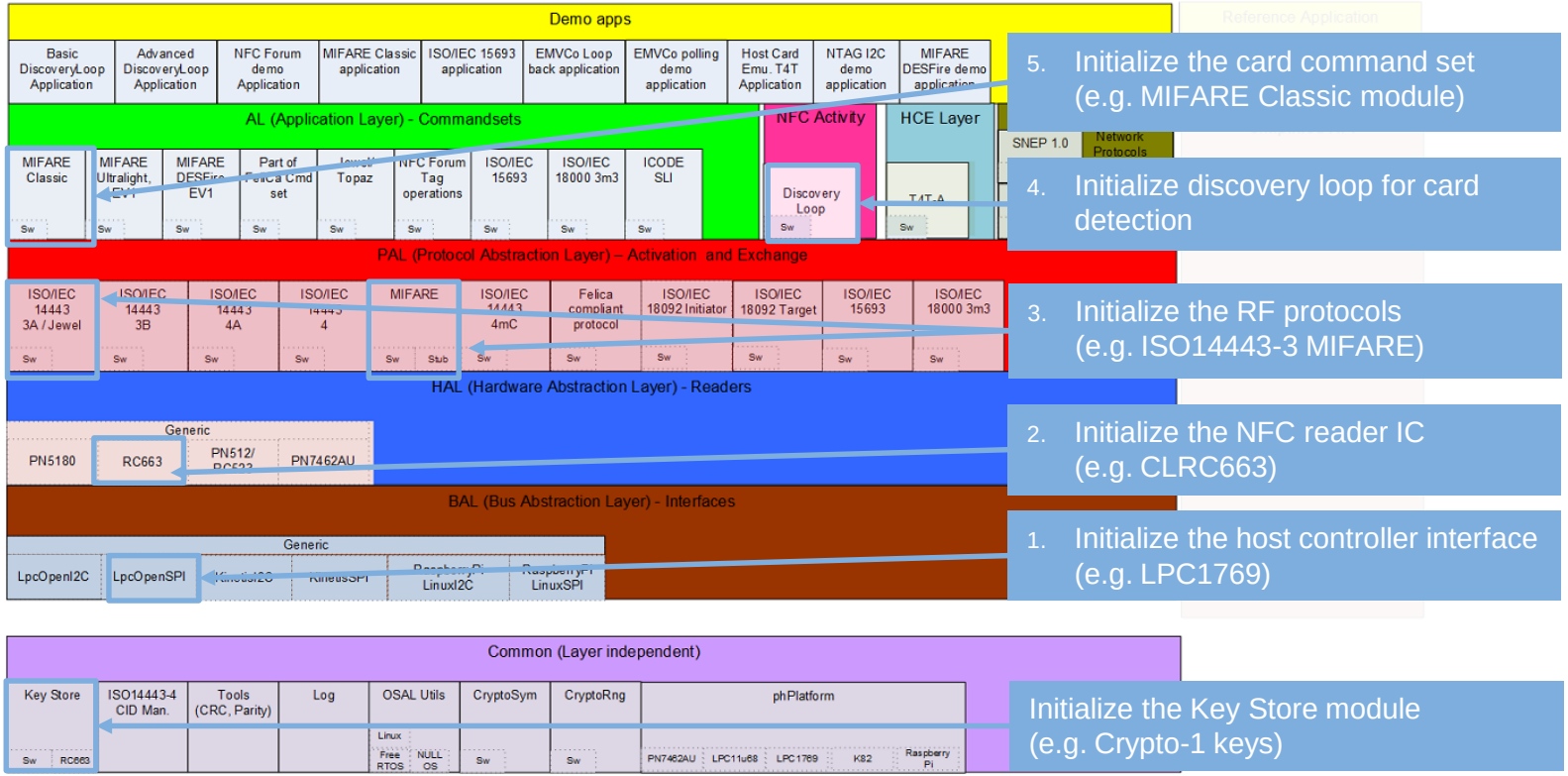
Building the SW stack (Example)



- The application requirements define which **modules need to be enabled**.
- NFC Read/Write, P2P and Card Emulation modes are supported by separate components
- In the following slides, we will show an example with these parameters:
  - **MIFARE Classic** application
  - NFC Reader IC: **CLRC663**
  - Host controller: **LPC1769**

Using the NFC Reader Library

Building the SW stack (Example II)



5. Initialize the card command set (e.g. MIFARE Classic module)
4. Initialize discovery loop for card detection
3. Initialize the RF protocols (e.g. ISO14443-3 MIFARE)
2. Initialize the NFC reader IC (e.g. CLRC663)
1. Initialize the host controller interface (e.g. LPC1769)

Initialize the Key Store module (e.g. Crypto-1 keys)

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Using the NFC Reader Library

Building the SW stack (Example III)

1. Host interface initialization generates a data context used to initialize and configure the upper layer (HAL)

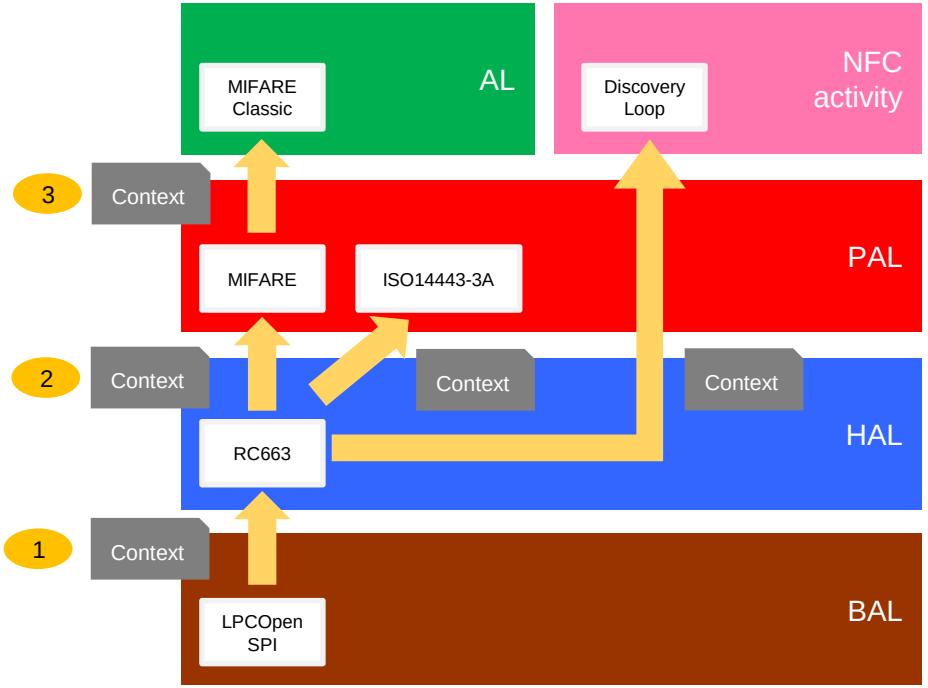
```
phhalHw_Rc663_Init(…, void *pBalDataParams, …)
```

2. NFC Reader IC initialization generates a data context used to initialize PAL and Discovery Loop components

```
phpalMifare_Sw_Init(…, void *pHalDataParams,…)
phpanI14443p3a_Sw_Init(…,void *pHalDataParams,…)
phacDiscLoop_Sw_Init(…, void *pHalDataParams, …)
```

3. MIFARE PAL initialization generates a data context used to initialize MIFARE Classic component

```
phalMFc_Sw_Init(…, void *pPalMifareDataParams, …)
```



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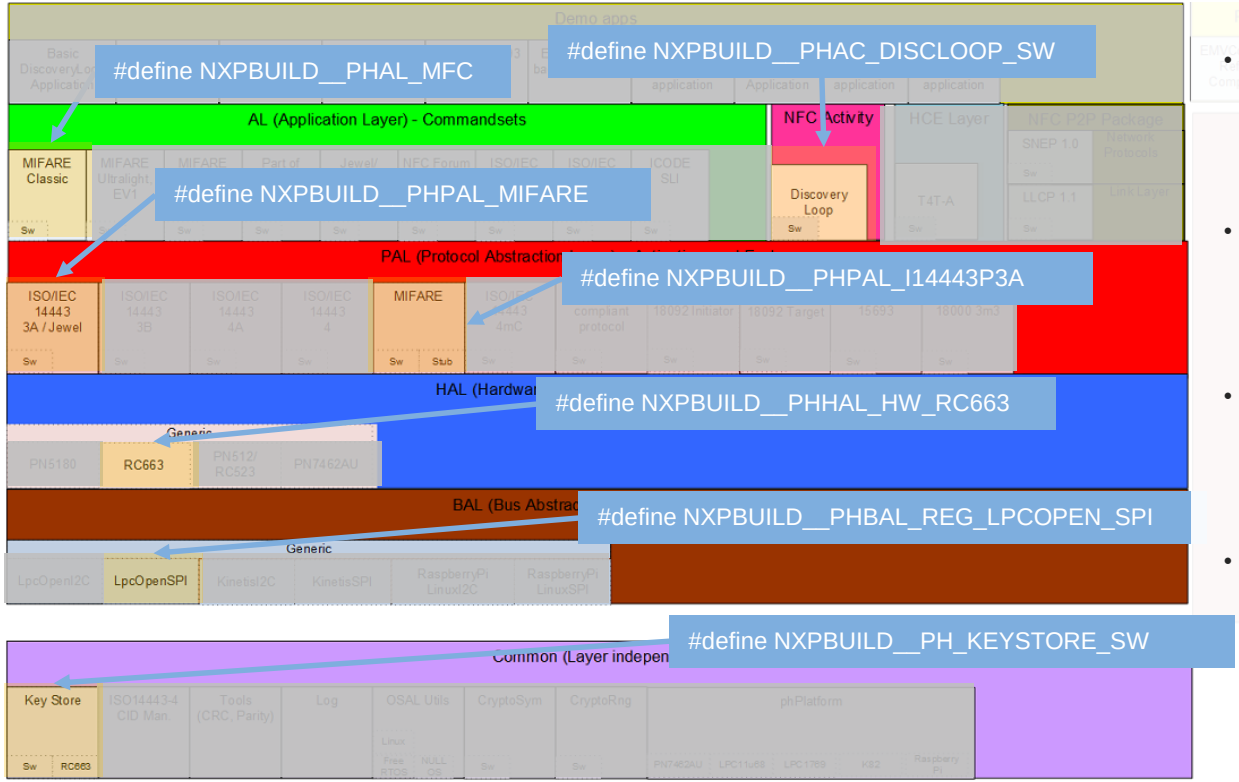
Using the NFC Reader Library

Building the SW stack (Example IV) - Project build setup (`ph_NxpBuild.h`)



- The build setup and functionality is set in the file: **`../intfs/ph_NxpBuild.h`**.
- This file defines the modules to be **included** into the build setup or to be **excluded** from the build setup .
- There is a specific **macro** defined for including / excluding each SW component
- Components can be included / excluded depending on the application requirements or to optimize memory footprint.

Components not included in the project build

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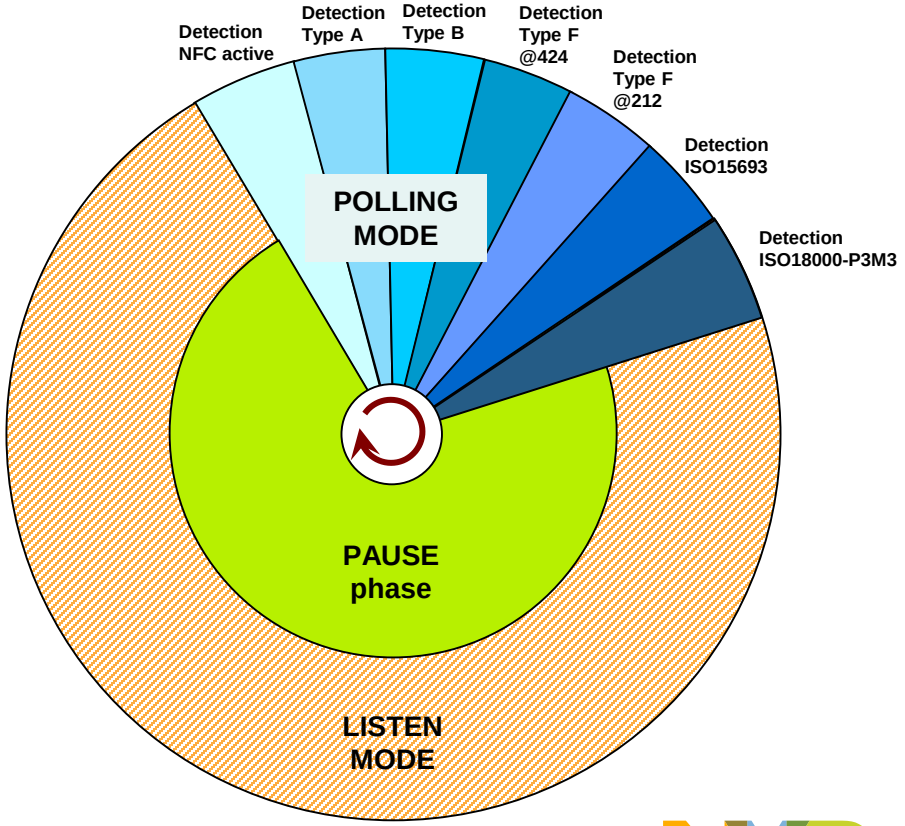
USING THE NFC READER LIBRARY:
DISCOVERY LOOP CONFIGURATION

Using the NFC Reader Library

Discovery loop

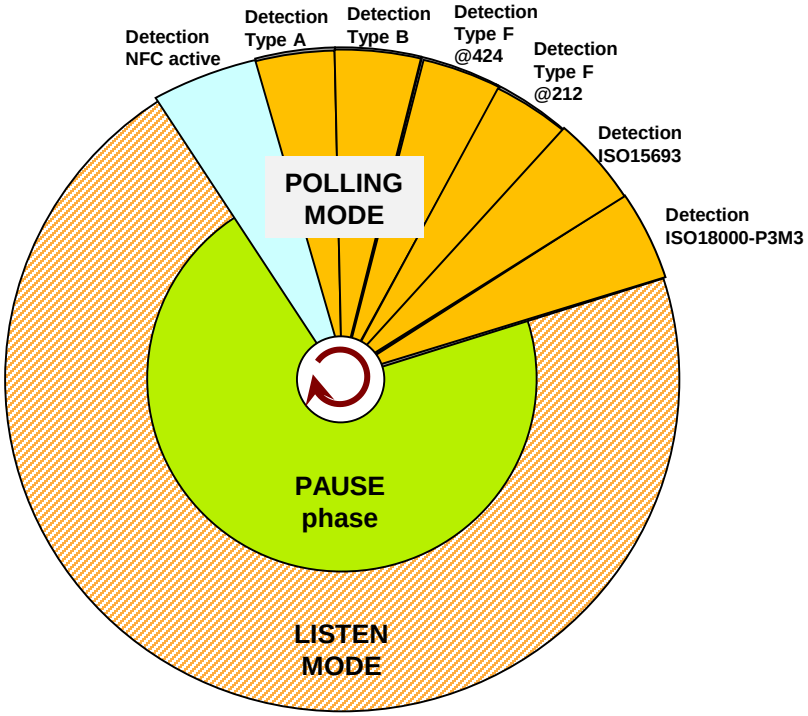
- It is a routine that sequentially sets the reader IC in different functional states and configurations so it can discover the presence of tags or NFC devices in the RF field.

- The discovery loop completes the following functionalities:
  - **Technology detection**: Detects whether there is another device or tag to communicate with and, if so, what technologies it supports.
  - **Collision resolution**: Detects the presence of multiple devices or tags and enumerates the different identifiers.
  - **Device activation**: Activates a particular device or tag to establish a communication.



Using the NFC Reader Library

Discovery loop – Configuration settings



phacDiscLoop_SetConfig(…,
PHAC_DISCLOOP_CONFIG_PAS_POLL_TECH_CFG)

```
/** Configure technologies to be detected in passive poll mode */
 #PHAC_DISCLOOP_POS_BIT_MASK_A -> Detect Type A.\n
#PHAC_DISCLOOP_POS_BIT_MASK_B -> Detect Type B.\n
#PHAC_DISCLOOP_POS_BIT_MASK_F212 -> Detect Type FELICA @ 212K
#PHAC_DISCLOOP_POS_BIT_MASK_F424 -> Detect Type FELICA @ 424K
#PHAC_DISCLOOP_POS_BIT_MASK_V -> Detect Type V / ISO 15693.\n
#PHAC_DISCLOOP_POS_BIT_MASK_18000P3M3 -> Detect ISO 18000p3m3
```

For scanning just Type A cards:

phacDiscLoop_SetConfig(…,
PHAC_DISCLOOP_CONFIG_PAS_POLL_TECH_CFG,
PHAC_DISCLOOP_POS_BIT_MASK_A)

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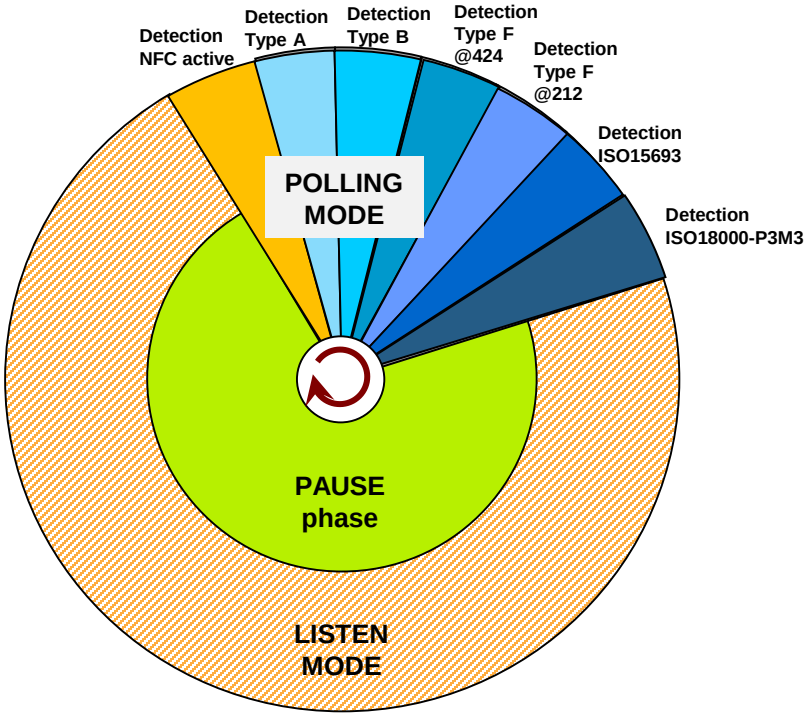
Affected discovery modes for the macro

Using the NFC Reader Library

Discovery loop – Configuration settings



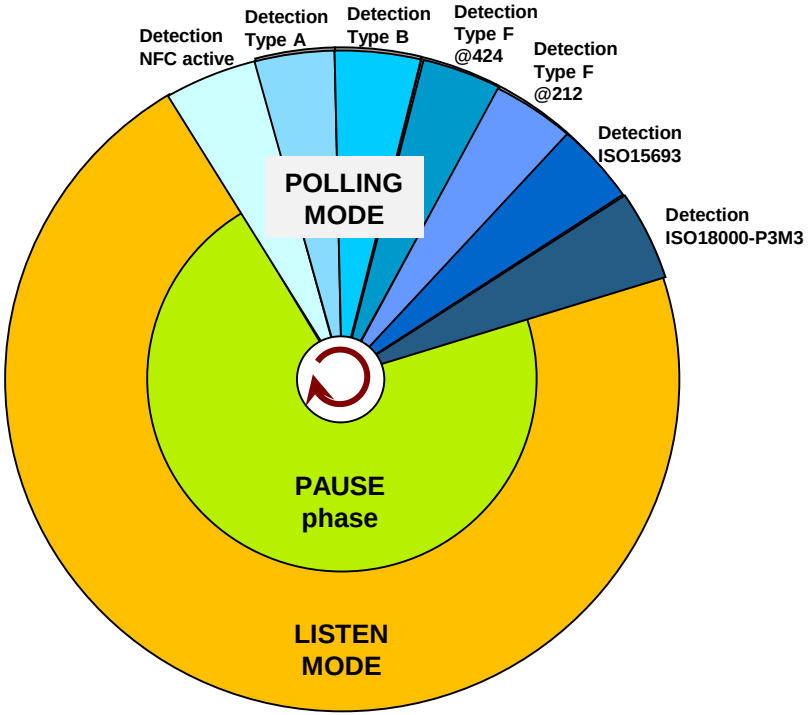
phacDiscLoop_SetConfig(…,
PHAC_DISCLOOP_CONFIG_ACT_POLL_TECH_CFG)

```
/* Configure technologies to be detected in passive poll mode */
 #PHAC_DISCLOOP_ACT_POS_BIT_MASK_106 -> Detect active target @ 106K
 #PHAC_DISCLOOP_ACT_POS_BIT_MASK_212 -> Detect active target @ 212K
 #PHAC_DISCLOOP_ACT_POS_BIT_MASK_424 -> Detect active target @ 424K
```

Affected discovery modes for the macro

Using the NFC Reader Library

Discovery loop – Configuration settings



phacDiscLoop_SetConfig(…,
PHAC_DISCLOOP_CONFIG_PAS_LIS_TECH_CFG)

```
/* Configure technologies to listen for in passive listen mode. */
 #PHAC_DISCLOOP_POS_BIT_MASK_A -> Listen for Type A.\n
#PHAC_DISCLOOP_POS_BIT_MASK_F212 -> Listen for Type FELICA @ 212K
 #PHAC_DISCLOOP_POS_BIT_MASK_F424 -> Listen for Type FELICA @ 424K
 #PHAC_DISCLOOP_POS_BIT_MASK_B -> [Not supported]
 #PHAC_DISCLOOP_POS_BIT_MASK_V -> [Not supported]
 #PHAC_DISCLOOP_POS_BIT_MASK_ISO18000-3M3 -> [Not supported]
```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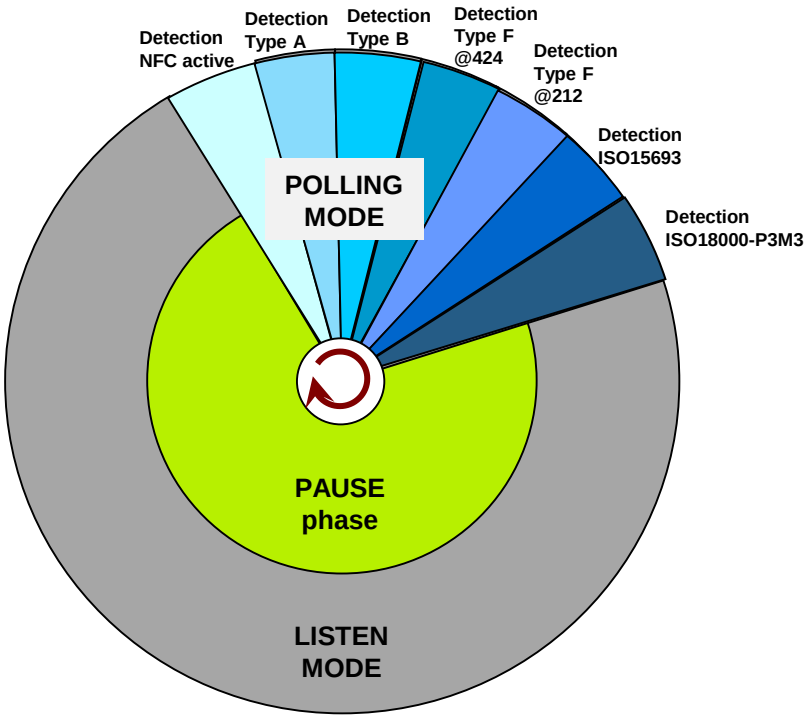
Affected discovery modes for the macro

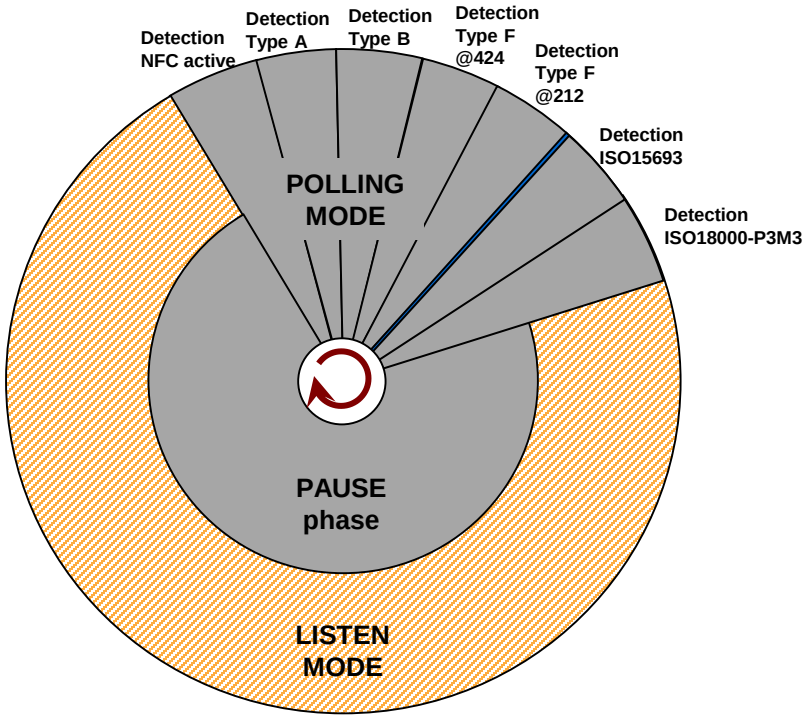
Using the NFC Reader Library

Discovery loop - Start

Disabled from the discovery loop



phacDiscLoop_Run(pDataParams, ***PHAC_DISCLOOP_ENTRY_POINT_POLL***);



phacDiscLoop_Run(pDataParams, ***PHAC_DISCLOOP_ENTRY_POINT_LISTEN***

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Using the NFC Reader Library

Discovery loop – Find detected technologies

- Get information about the detected NFC tags or NFC devices.

```
phacDiscLoop_GetConfig(
pDataParams,
PHAC_DISCLOOP_CONFIG_TECH_DETECTED,
&wTagsDetected);
```

- Macro to check that a Type A tag was detected

```
PHAC_DISCLOOP_CHECK_ANDMASK(
wTagsDetected, PHAC_DISCLOOP_POS_BIT_MASK_A)
```

- Checking whether one particular NFC tag or NFC device has been detected can be done by using the defined bitmasks

```
PHAC_DISCLOOP_POS_BIT_MASK_A
PHAC_DISCLOOP_POS_BIT_MASK_B
PHAC_DISCLOOP_POS_BIT_MASK_F212
PHAC_DISCLOOP_POS_BIT_MASK_F424
PHAC_DISCLOOP_POS_BIT_MASK_V
PHAC_DISCLOOP_POS_BIT_MASK_18000P3M3
PHAC_DISCLOOP_ACT_POS_BIT_MASK_106
PHAC_DISCLOOP_ACT_POS_BIT_MASK_212
PHAC_DISCLOOP_ACT_POS_BIT_MASK_424
```

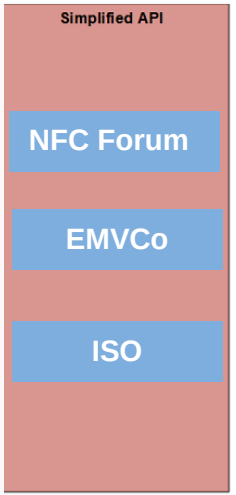
USING THE NFC READER LIBRARY:
SIMPLIFIED API

Simplified API

Write NFC applications using as little code as possible

- Provides a high level abstraction access to the NFC Reader Library.
- It is focused on simplicity and aimed to write an NFC application with minimum code
- It can be combined with the use of the “standard” NFC Reader Library stack API

- Three different channels available:
  - **NFC Forum channel:** used to transfer NDEF messages.
  - **EMVCo channel**: used to transfer ISO 7816 APDU’s over the ISO 14443-4 protocol, according to EMVCo L1 spec.
  - **ISO channel**: general channel, used to transfer raw data transfer on block/frame level.



Simplified API

Write NFC applications using as less code as possible

1. Initialize the NFC Reader Library

```
phNfcLib_Init();
```

2. Set the profile (ISO, EMVCo or NFC Forum)

```
phNfcLib_SetConfig_Value(
PH_NFCLIB_CONFIG_ACTIVATION_PROFILE,
PH_NFCLIB_ACTIVATION_PROFILE_ISO);
```

3. Activate the card or peer

```
phNfcLib_Activate(wTechnologyMask, &PeerInfo,
NULL);
```

4. Send / Receive data

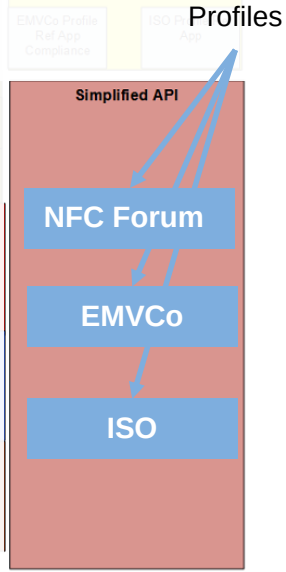
```
phNfcLib_Transmit (…);
phNfcLib_Receive (…);
```

5. Deactivate and release peer

```
phNfcLib_Deactivate(PH_NFCLIB_DEACTIVATION_MODE_RELEASE,
&PeerInfo);
```

6. De-initialize and reset internal structures

```
phNfcLib_DeInit();
```



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SOFTWARE EXAMPLES

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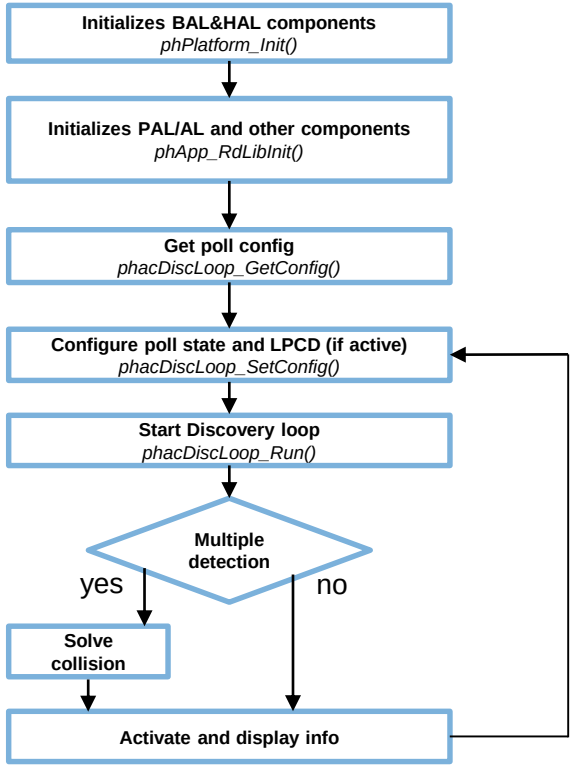
Example 1: BasicDiscoveryLoop

Functionality

- Scans for NFC tags and NFC devices and displays the detected device information (such as UID, SAK, Product Type for MIFARE cards)
- If multiple technologies are detected, the example will select the first detected technology to resolve.

Benefits

- Shows how to poll for different technologies (NFC tag, P2P, HCE), detect and activate them.
- Shows the discovery loop initialization and configuration
- Shows the use of both POLL and LISTEN discovery loop modes



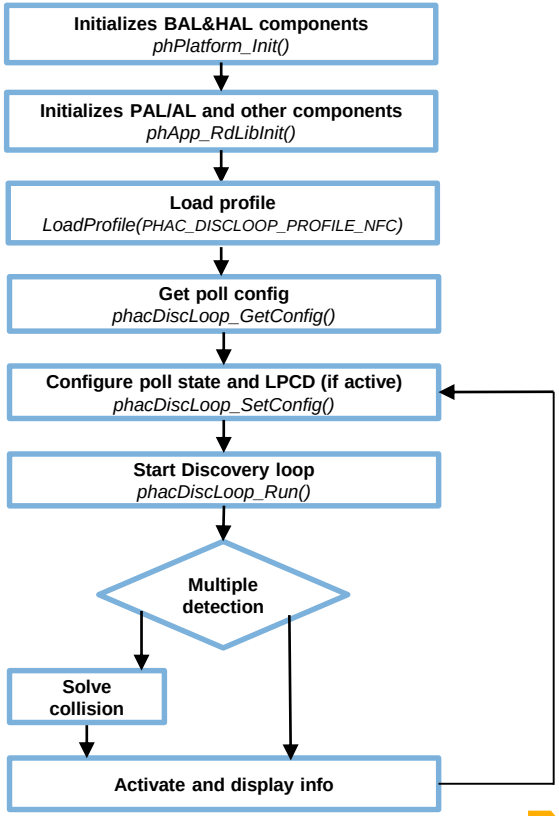
Example 2: AdvancedDiscoveryLoop

Functionality

- Scans for NFC tags and NFC devices and displays the detected device information (such as UID, SAK, Product Type for MIFARE cards)
- If multiple technologies are detected, the example will select the first detected technology to resolve.

Benefits

- Shows how to poll for different technologies (NFC tag, P2P, HCE), detect and activate them.
- Shows the different configuration options of the discovery loop.
- Shows the use of both POLL and LISTEN discovery loop modes



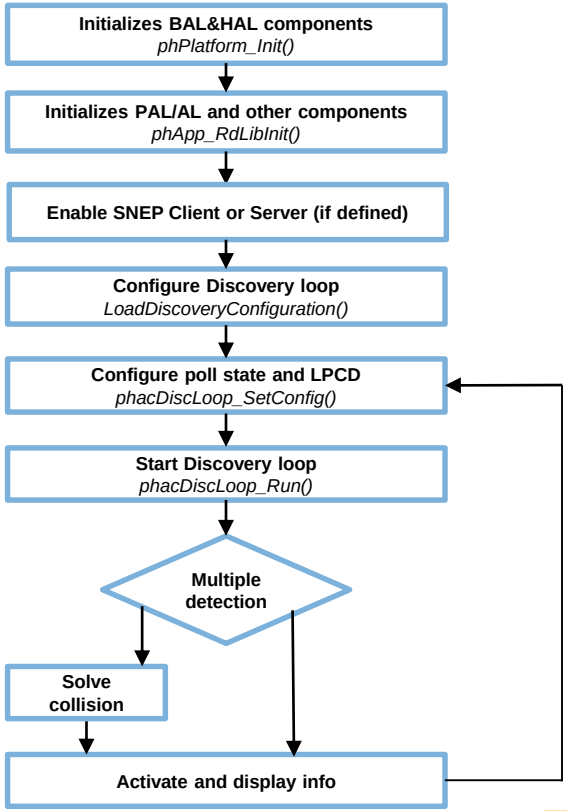
Example 3: NFCForum

Functionality

- Scans for NFC tags and NFC devices and displays the detected device information (such as UID, SAK, Product Type for MIFARE cards)
- It implements an SNEP Server and SNEP client for NDEF data exchange between peers.

Benefits

- Shows how to implement the P2P mode and reader function to detect Type A, Type B, Type F, Type V and ISO18000-3M3 tags.
- Shows how to exchange NDEF messages between two NFC-enabled devices.
- Shows active and passive communication modes.



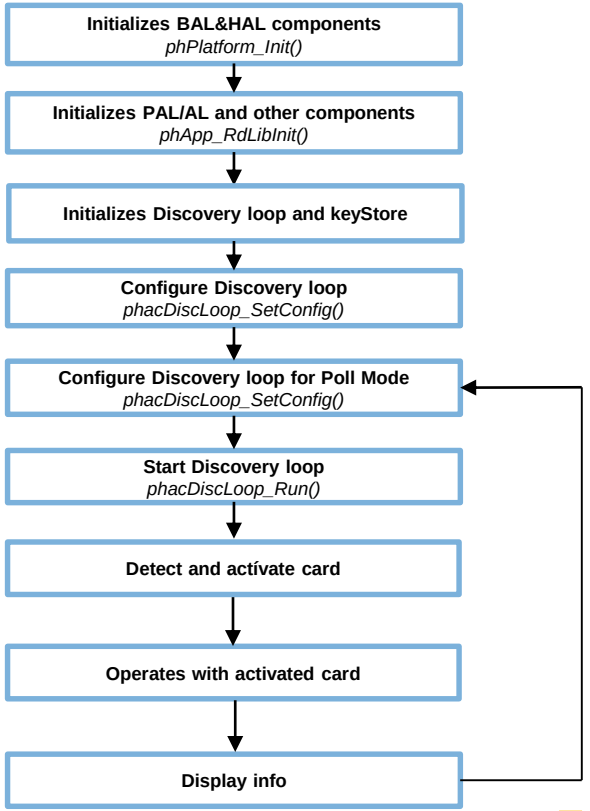
Example 4: MIFARE Classic

Functionality

- Detects MIFARE Classic cards and displays information like UID, SAK and ATQA.
- Performs a sector authentication, block read and block write operations.

Benefits

- Shows the discovery loop configuration for MIFARE Classic detection.
- Shows the usage of standard MIFARE Classic commands (Authenticate, Read, Write).
- Shows KeyStore use.



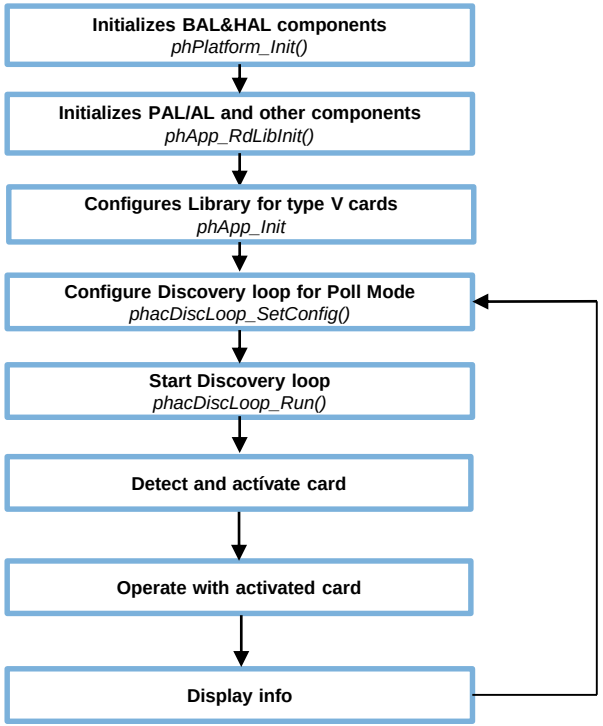
Example 5: ISO/IEC15693

Functionality

- Detects an ISO15693-compliant card and displays tag type and tag UID information.
- Performs a block read and block write operations.

Benefits

- Shows the discovery loop configuration for ISO15693-compliant tag detection.
- Shows the usage of the most important commands for working with ISO15693-compliant tags.



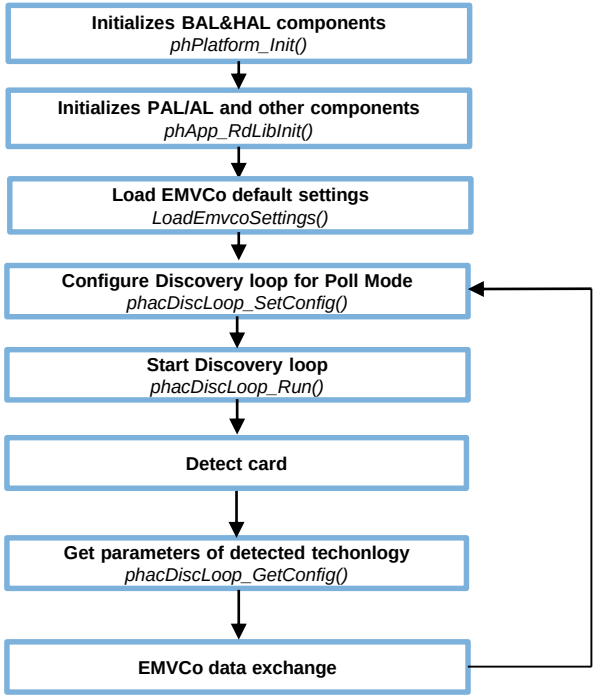
Example 6: EMVCo Loopback

Functionality

- Implements a loopback application which is used to perform EMVCo 2.5 (L1) digital compliance validation.
- It can be tested with payment cards

Benefits

- It can be used to conduct EMVCo Level 1 PCD certification



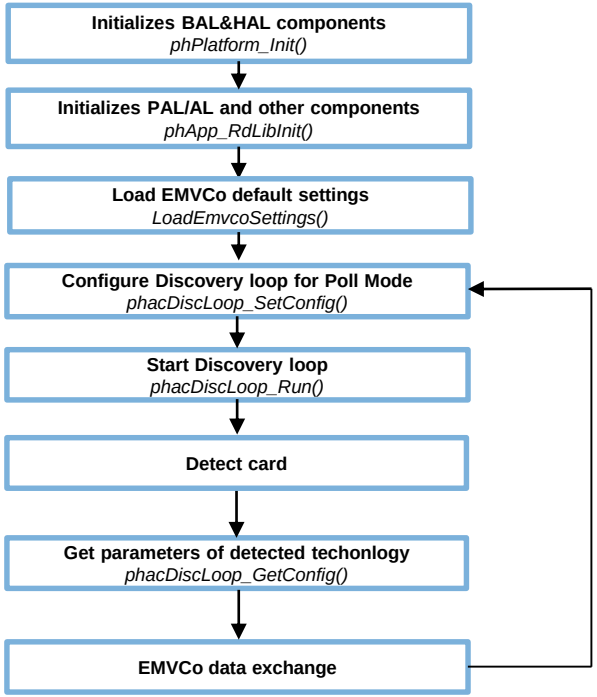
Example 7: EMVCo Polling

Functionality

- Detects an EMVCo payment cards.
- It displays the response of the detected EMVCo card after the select PPSE command.

Benefits

- Shows the discovery loop configuration for EMVCo payment card detection.
- Shows the exchange of APDU commands with EMVCo payment cards.



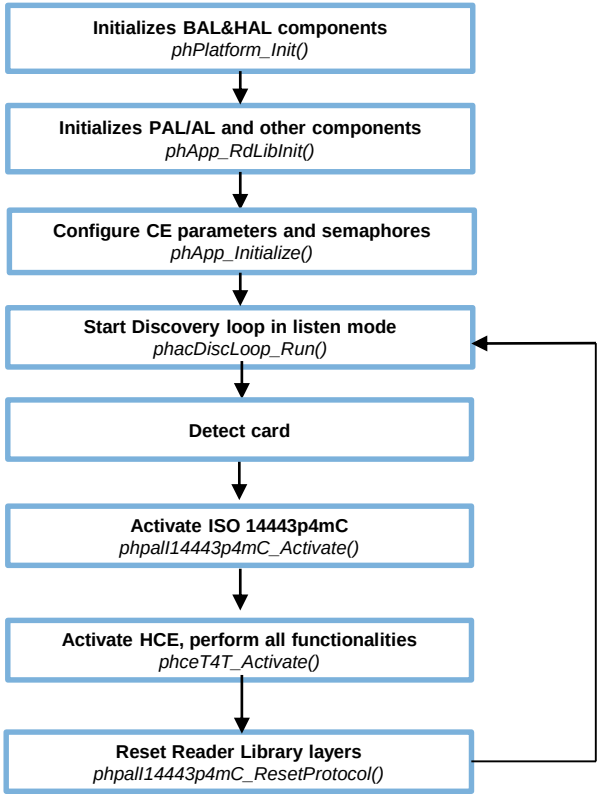
Example 8: HCE T4T

Functionality

- Implements a Type 4-A tag card emulation with a default NDEF message stored on its memory.
- It supports all specified commands such as Select, ReadBinary, UpdateBinary, etc
- It allows both reading and writing and NDEF messages into the emulated card.

Benefits

- Shows how to emulate a Type 4 tag and to perform read and write operations.
- Shows how to set NDEF data into a Type 4 tag.
- It can be used to test against ISO10373-6 PICC test specification



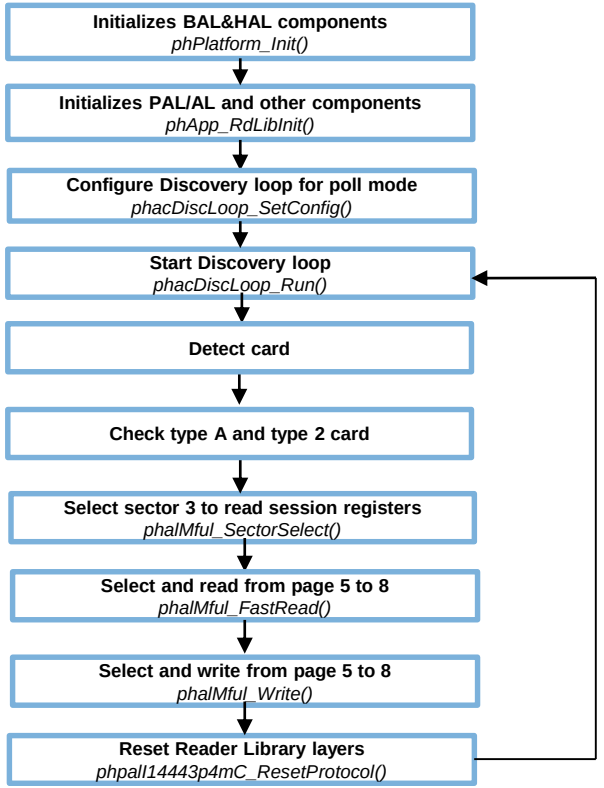
Example 9: NTAG I²C

Functionality

- Detects an NTAG I²C tag and displays information like UID, ATQA, SAK and version.
- Performs a SECTOR_SELECT, page READ and page WRITE operation.

Benefits

- Shows the discovery loop configuration for NTAG I²C tag detection.
- Shows the use of commands to communicate with NTAG I²C product



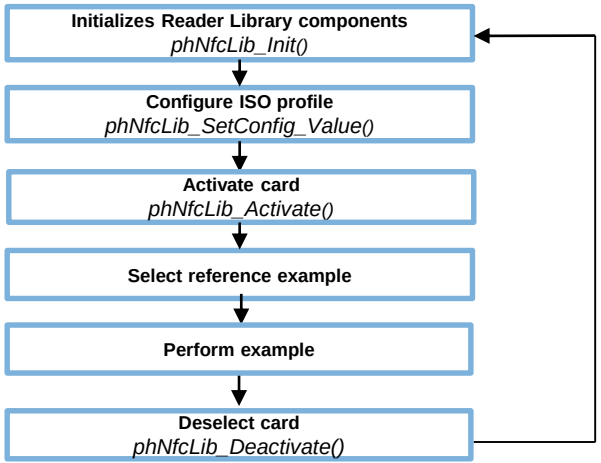
Example 10: Simplified API ISO

Functionality

- Implements sample applications for MIFARE Classic, MIFARE Ultralight, MIFARE DESFire, Type B, ISO/IEC15693 and ISO/IEC18000-3M3 using the Simplified API with an ISO profile.

Benefits

- Shows how to use the Simplified API with an ISO profile.
- Shows reference implementations for the usage of the Simplified API related to MIFARE Classic, MIFARE Ultralight, MIFARE DESFire, Type B, ISO/IEC15693 and ISO/IEC18000-3M3 tags



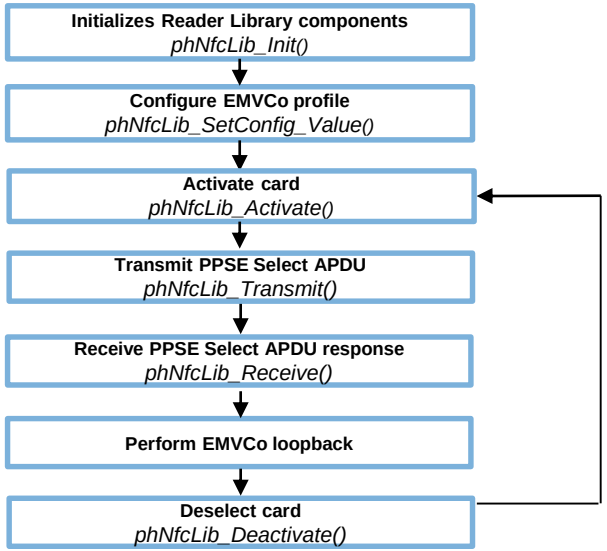
Example 11: Simplified API EMVCo

Functionality

- Implements a loopback application using the Simplified API to perform EMVCo 2.5 (L1) digital compliance validation.

Benefits

- Shows how to use the Simplified API with an EMVCo profile.
- It can be used to conduct EMVCo Level 1 PCD certification



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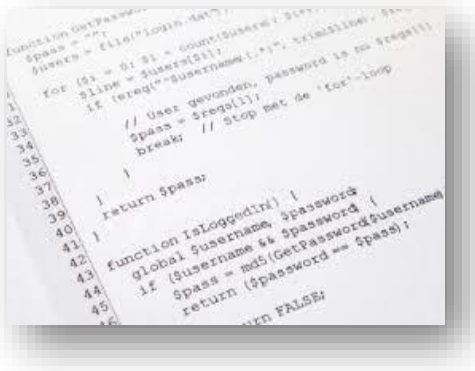
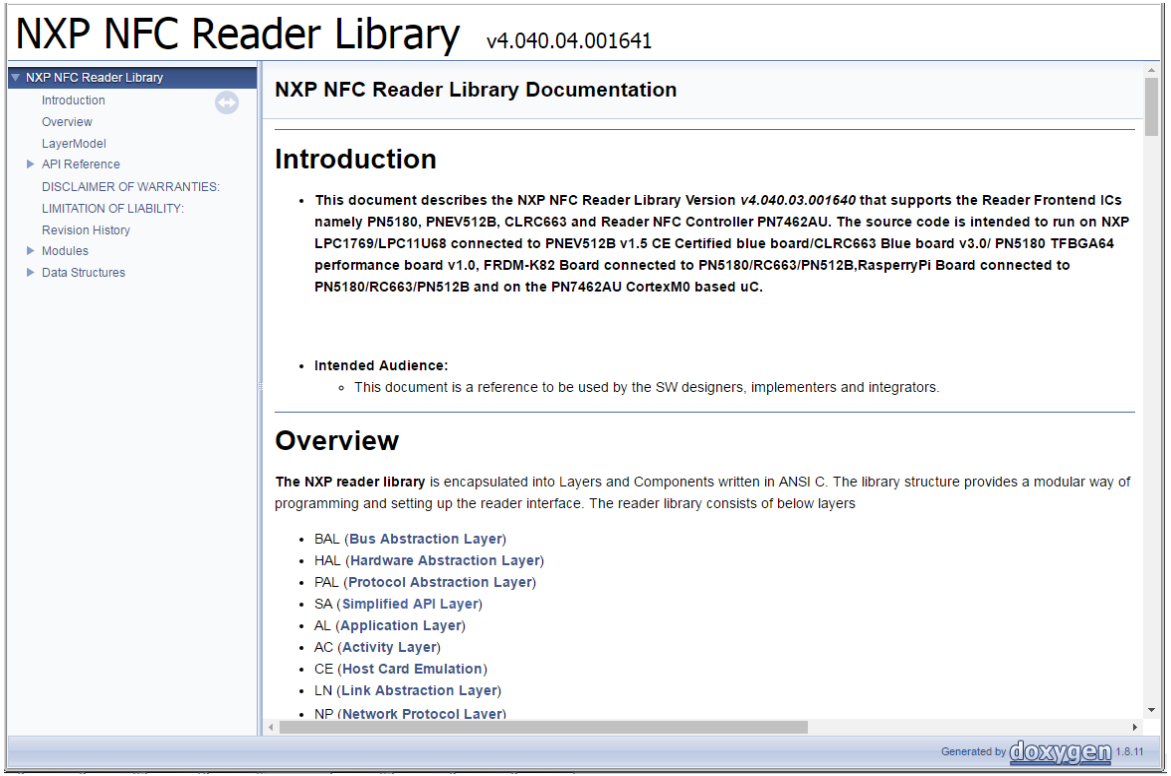


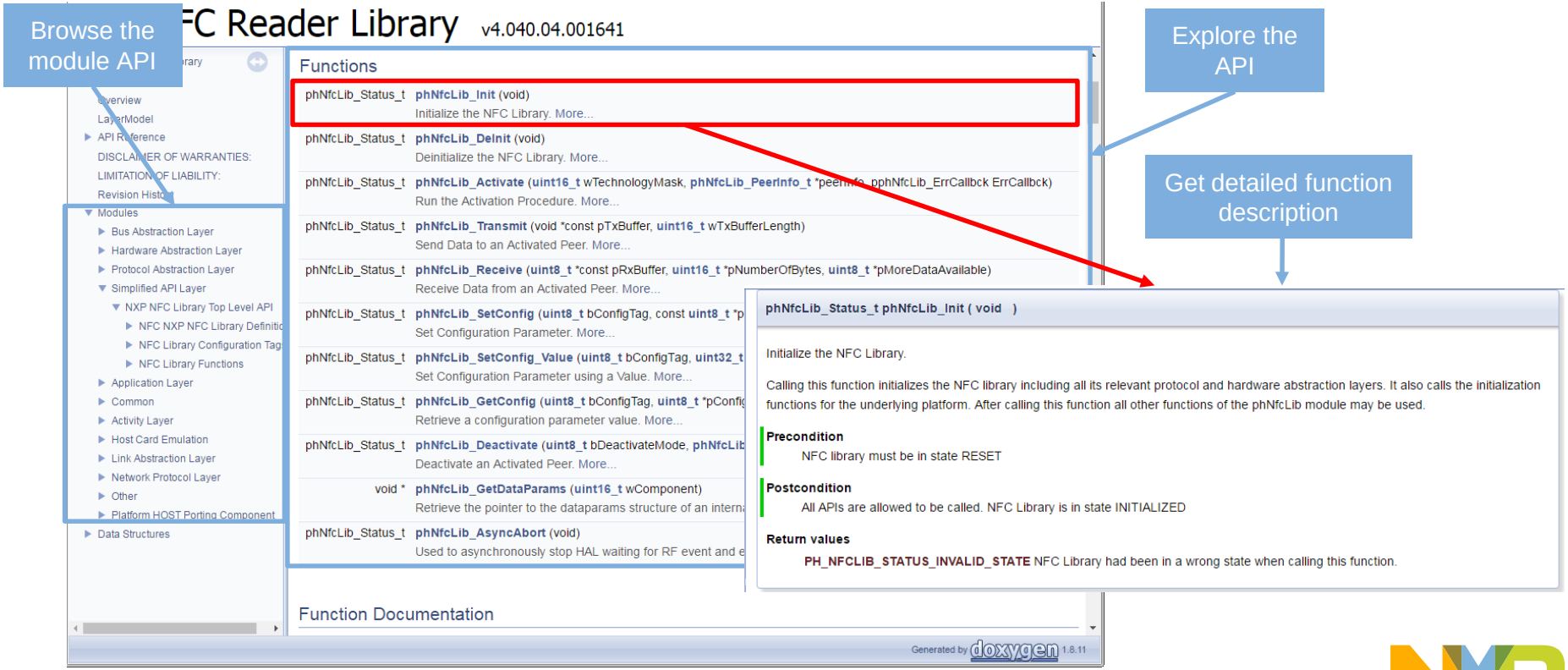
Documentation

NFC Reader Library reference API documentation

- The NFC Reader Library reference API is also delivered in HTML format.
- It is the most friendly way to go through the NFC Reader Library API
- It is generated from source code annotations
- It can be found in: "\NxpRdLib\docs\14_user_doc"



NFC Reader Library reference API documentation



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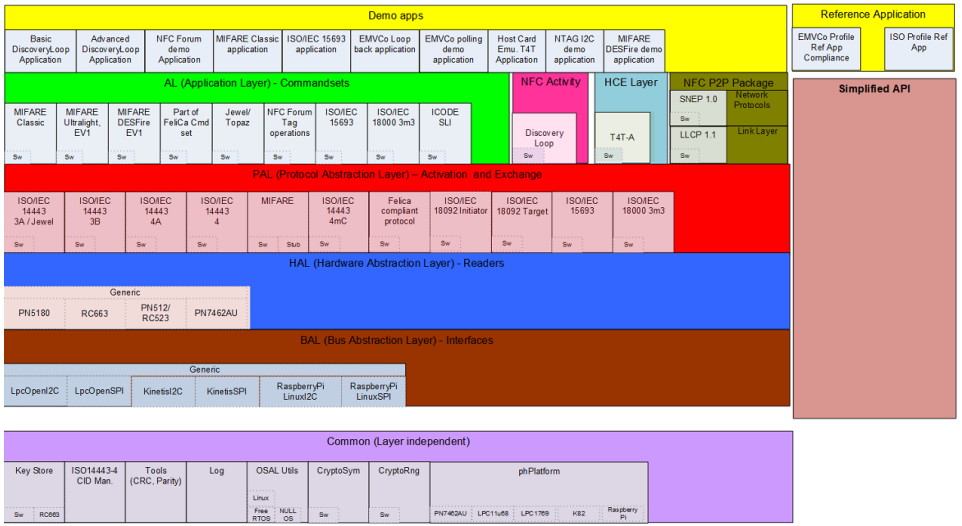
TO SUM UP

NFC Reader Library

In a nutshell

- It is the SW support for NXP's NFC frontends and NFC controllers with customizable firmware
- A modular, **free**, multi-layer software library written in ANSI-C that provides all the APIs needed to complete a design and prepare it for certification
- Easily portable to multiple design environments and platforms
- Complemented with software examples illustrating typical use cases.



Latest version and information available at:
http://www.nxp.com/pages/:NFC-READER-LIBRARY

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Hardware design and development
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Wireless communications WiFi, ZigBee, Bluetooth, BLE
Contactless antenna RF design, evaluation and testing

MIFARE applications
End-to-end systems, readers and card-related designs
EMVco applications
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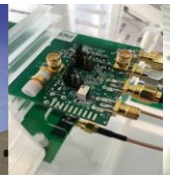
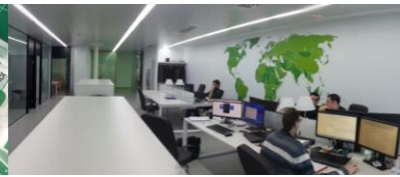
Secure Element management
GlobalPlatform compliant backend solutions
Secure services provisioning OTA, TSM services



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Design and implement NFC applications

Session 4: NFC Reader Library- SW support for NFC frontends and NFC controllers w. custom. FW solutions

Jordi Jofre (Speaker)
Angela Gemio (Host)

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