Personal Health Device Communication

Technical Specification

NFC Forum™

PHDC 1.0

NFCForum-TS-PHDC-1.0

2013-02-27

RESTRICTIONS ON USE

Contents

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1. Introduction

Personal Health Devices that are compliant with ISO/IEEE 11073 standards can communicate with each other using ISO/IEEE 11073-20601 communication protocol. ISO/IEEE 11073 standard defines two entities called Agent and Manager. An “Agent” is a Node that collects and transmits personal health data to an associated Manager. A “Manager” is a node that receives data from one or more Agents. Examples of Managers include a cellular phone, health monitor gateway, set top box, or computer system. ISO/IEEE 11073 standard defines the data formats for the various health care parameters and the communication protocol used between ISO 11073 Agent and ISO 11073 Manager.

1.1. Objectives

The objective of this specification is to define a framework for personal health devices that are compliant with the IEEE 11073 standards family and use IEEE Std 11073-20601 Optimized Exchange Protocol to report measurements using NFC Forum communication technology.

1.2. Purpose

This specification addresses a need for an openly defined standard for the exchange of personal health data between devices using Near Field Communication technology. The purpose of this specification is to provide an interoperable data transport for personal health devices conforming to the ISO/IEEE Std. 11073-20601 Optimized Exchange Protocol and NFC Forum specifications.

1.3. Applicable Documents or References

[IEEE_11073-20601] IEEE Health informatics—Personal health device communication Part 20601: Application profile— Optimized Exchange Protocol 2010, IEEE

[LLCP] NFC Logical Link Control Protocol (LLCP) Technical Specification, Version 1.1, NFC Forum

[NDEF] NFC Data Exchange Format (NDEF)Technical Specification, Version 1.0, NFC Forum

[RFC2119] Key words for use in RFCs to Indicate Requirement Levels, RFC 2119, S. Bradner, March 1997, Internet Engineering Task Force

[RTD] NFC Record Type Definition (RTD) Technical Specification, Version 1.0, NFC Forum

[T2TOP] NFC Forum Type 2 Tag Operation Specification,
Version 1.1,
NFC Forum

[T3TOP] NFC Forum Type 3 Tag Operation Specification,
Version 1.1,
NFC Forum

[T4TOP] NFC Forum Type 4 Tag Operation Specification,
Version 2.0,
NFC Forum

1.4. Administration

The Personal Health Device Communication Specification is an open specification supported by the Near Field Communication Forum, Inc., located at:

401 Edgewater Place, Suite 600
Wakefield, MA, USA 01880

Tel.: +1 781-876-8955
Fax: +1 781-610-9864

http://www.nfc-forum.org/

The NFC Forum, Inc., maintains this specification. Comments, errors, and other feedback can be submitted at http://www.nfc-forum.org/specs/spec_list/spec_feedback/.

1.5. Name and Logo Usage

The Near Field Communication Forum's policy regarding the use of the trademarks *NFC Forum* and the NFC Forum logo is as follows:

- Any company MAY claim compatibility with NFC Forum specifications, whether a member of the NFC Forum or not.
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- The logo SHALL be printed in black or in color as illustrated on the Logo Page that is available from the NFC Forum at the address above. The aspect ratio of the logo SHALL be maintained, but the size MAY be varied. Nothing MAY be added to or deleted from the logos.
- Since the NFC Forum name is a trademark of the Near Field Communication Forum, the following statement SHALL be included in all published literature and advertising material in which the name or logo appears:

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1.6. Intellectual Property

The Personal Health Device Communication Specification conforms to the Intellectual Property guidelines specified in the NFC Forum's *Intellectual Property Rights Policy*, as outlined in the NFC Forum *Rules of Procedures*. These documents are available on the NFC Forum website.

1.7. Special Word Usage

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

1.8. Abbreviations

Table 1: Abbreviations

Abbreviation	Description
APDU	Application Protocol Data Unit
IEEE	Institute of Electrical and Electronics Engineers
LLCP	Logical Link Control Protocol
NDEF	NFC Data Exchange Format
NFC	Near Field Communication
P2P	Peer-to-Peer
PDU	Protocol Data Unit
PHD	Personal Health Device
PHDC	Personal Health Device Communication
R/W	Reader/Writer
RFU	Reserved for Future Use
RTD	Record Type Definition
SDU	Service Data Unit

1.9. Glossary

Data link connection

A unique combination of source and destination service access point addresses used for numbered information transfer in LLCP layer.

IEEE Agent

A software component that uses the ISO/IEEE 11073-20601 Optimized Exchange Protocol to communicate with an IEEE Manager.

IEEE Manager

A software component that uses the ISO/IEEE 11073-20601 Optimized Exchange Protocol to communicate with an IEEE Agent.

IEEE APDU

IEEE APDUs are Application Protocol Data Units defined in [IEEE_11073-20601] that are exchanged between an IEEE Agent and IEEE Manager.

PHDC Agent

A software component that communicates with a remote PHDC Manager to allow a local IEEE Agent to exchange data with a remote IEEE Manager.

PHDC Tag Agent

A PHDC Agent that communicates with a remote PHDC Manager in NFC Forum Reader/Writer mode.

PHDC Peer Agent

A PHDC Agent that communicates with a remote PHDC Manager in NFC Forum Peer mode.

PHDC Manager

A software component that communicates with a remote PHDC Agent to allow a local IEEE Manager to exchange data with a remote IEEE Agent.

PHDC PDU

PHDC PDUs are Protocol Data Units that are exchanged between a PHDC Agent and a PHDC Manager in NFC Forum Peer mode of operation.

PHD Message

A PHD Message is an NDEF Message that starts with a PHD Record and is exchanged between a PHDC Tag Agent and a PHDC Manager in NFC Forum Reader/Writer operation mode.

Transport connect indication

The Indication that is received by IEEE Agent or IEEE Manager from PHDC Agent or PHDC Manager once the NFC Communication link is established.

Transport disconnect indication

The Indication that is received by IEEE Agent or IEEE Manager from PHDC Agent or PHDC Manager once the NFC Communication link is terminated.

2. Overview

2.1. IEEE Medical / Health Device Communication Standards

The ISO/IEEE 11073 family of standards for medical and health device communication define communication between medical, health care, and wellness devices with external computer systems.

2.1.1. Optimized Exchange Protocol

In the ISO/IEEE 11073 family of standards, the ISO/IEEE 11073-20601 Optimized Exchange Protocol defines a common framework for making an abstract model of personal health data communication in a manner that is independent of the underlying transport syntax. The transfer syntax typically includes the methods required to establish logical connections between devices and to provide presentation capabilities and services needed to perform communication tasks. The protocol is optimized to personal health usage requirements.

2.2. NFC Forum Communication Modes

The NFC Forum architecture defines two communication modes.

- An NFC Forum Device can communicate with another NFC Forum Device if both operate in NFC Forum Peer mode. This mode provides asynchronous balanced communication between the devices.
- An NFC Forum Device can communicate with an NFC Forum Tag (or an NFC Forum Device in Card Emulation Mode) if the NFC Forum Device operates in NFC Forum Reader/Writer mode. This mode allows a master–slave communication between the NFC Forum Device and the Tag.

A PHDC Manager as defined in this specification SHALL support PHDC communication in NFC Forum Peer mode and NFC Forum Reader/Writer mode.

2.2.1. NFC Forum Peer Mode

In NFC Forum Peer Mode, the Logical Link Control Protocol [LLCP] is used as the communication protocol between the peer devices. LLCP provides concurrent transport of service data units between independent service access points. Service users can choose between connection-less and connection-oriented transport modes. The connection-less transport mode provides unacknowledged data transmission that is suitable for services that are prepared to compensate for the potential loss of service data units. The connection-oriented transport mode provides a data transmission service with sequenced and guaranteed delivery of service data units over a data link connection established between two service access points prior to user data exchange.

In NFC Forum Peer Mode, IEEE 11073-20601 APDUs are exchanged over data link connections as defined in Section 3. Figure 1 illustrates the architecture in NFC Forum Peer Mode.

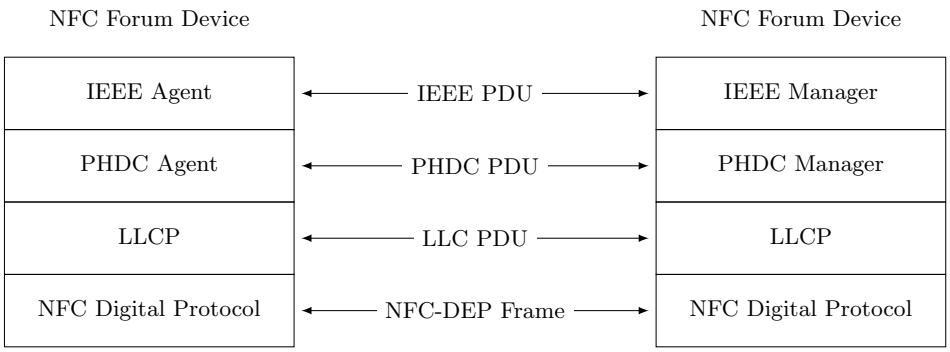

Figure 1: Architecture in NFC Forum Peer Mode

In the Architecture depicted in Figure 1, IEEE Agent and IEEE Manager are the components that are defined in [IEEE_11073-20601]. PHDC Agent and PHDC Manager are the components responsible for transceiving IEEE APDUs and notifying IEEE Agent and IEEE Manager appropriately of received IEEE APDUs. PHDC Agent and PHDC Manager are also responsible for segmentation and re-assembly of IEEE APDUs.

2.2.2. NFC Forum Reader/Writer Mode

In NFC Forum Reader/Writer mode, an NFC Forum Device communicates with an NFC Forum Tag by sending commands and receiving responses. Commands and responses defined in the NFC Forum Tag Operation specifications allow the NFC Forum Device to read or write NFC Data Exchange Format (NDEF) messages from or to the NFC Forum Tag.

In NFC Forum Reader/Writer Mode, IEEE APDUs are exchanged within NDEF records as defined in Section 4. Figure 2 illustrates the architecture in NFC Forum Reader/Writer mode.

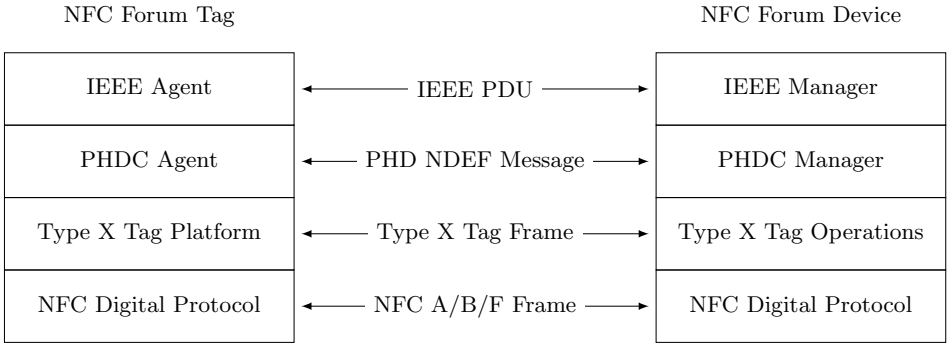

Figure 2: Architecture in NFC Forum Reader/Writer Mode

In the Architecture depicted in Figure 2, IEEE Manager and IEEE Agent are the components that are defined in [IEEE_11073-20601]. PHDC Manager and PHDC Agent are the components responsible for transceiving IEEE APDUs between IEEE Manager and IEEE Agent.

3. PHDC in NFC Forum Peer Mode

3.1. General

In NFC Forum Peer Mode, one or more PHDC Peer Agents on an NFC Forum Device can communicate with a PHDC Manager on a peer NFC Forum Device when both are in proximity. The communication between an individual Agent and the Manager is through an LLCP logical data link connection. Figure 3 illustrates the logical topology and communication means in NFC Forum Peer Mode.

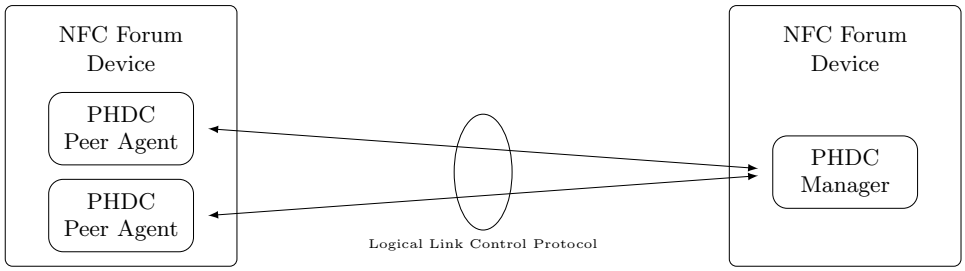

Figure 3: Logical Topology in NFC Forum Peer Mode

Further in this section, the term *PHDC Agent* is used synonymously to denote a PHDC Peer Agent and the term *PHDC Manager* to denote a PHDC Manager in NFC Forum Peer Mode.

3.1.1. PHDC Service Name

LLCP service access points can be associated with a service name that is discoverable through the service discovery procedure. This specification defines two registered service names for the purpose of personal health device communication. The PHDC Service Name “urn:nfc:sn:phdc” is used by a PHDC Manager that understands and accepts unencrypted personal health device communication as defined in this version of the PHDC specification. The PHDC Service Name “urn:nfc:sn:phds” is reserved for a PHDC Manager that understands encrypted personal health device communication, which might be defined in a future version of the PHDC specification.

3.2. Data Exchange Format

In NFC Forum Peer Mode, the PHDC Agent and PHDC Manager exchange data in the form of PHDC PDUs. The format of a PHDC PDU is shown in Figure 4.

The PHDC PDU Header SHALL consist of a 16-bit length value, encoded most significant byte first. The length field value SHALL specify the length of the PHDC PDU Information field, in octets. The PHDC PDU Information field SHALL contain a single IEEE APDU.

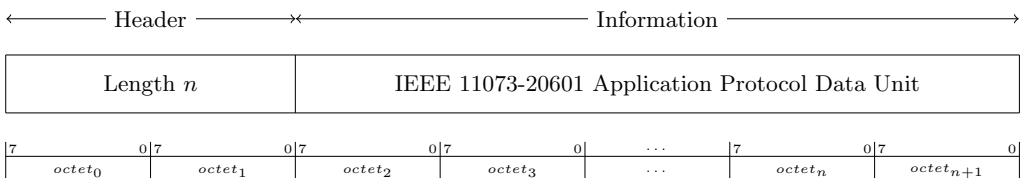

Figure 4: Format of the PHDC PDU

3.3. Data Exchange Procedure

Personal health device communication in NFC Forum Peer Mode is based on the exchange of PHDC APDUs over an LLCP data link connection between the PHDC manager and Agent. Both PHDC Manager and Agent send a PHDC APDU by transmitting LLCP Information PDUs and receive a PHDC PDU by accepting LLCP Information PDUs on the data link connection. The LLCP data link connection provides a data transmission service with sequenced and guaranteed delivery of service data units.

3.3.1. Protocol Activation

3.3.1.1. PHDC Manager Activation Procedure

The PHDC Manager Activation Procedure SHALL be started when the PHDC Manager is notified of successful LLCP Link activation. Subsequently, the PHDC Manager SHALL allocate a local service access point address, associate that address with the PHDC Service Name within the local service environment, and further await data link connection requests for that service access point. The PHDC Manager SHALL accept the first correctly formatted data link connection request and enter normal communication on the established data link connection. The PHDC Manager MAY accept further data link connection requests and perform normal communication for additional data link connections.

3.3.1.2. PHDC Agent Activation Procedure

The PHDC Agent Activation Procedure SHALL be started when the PHDC Agent is notified of successful LLCP Link activation. Subsequently, the PHDC Agent SHALL attempt to establish an LLCP data link connection with a PHDC Manager, either by using LLCP service discovery to resolve the PHDC Service Name into the service access point address of the remote PHDC Manager and connect using that address; or by transmitting the PHDC Service Name with an LLCP connect command to the remote service access point “1”.

3.3.2. Normal Communication

Upon entering normal communication, both PHDC Manager and Agent SHALL issue a transport connect indication to the local IEEE Manager or Agent.

During normal communication, both PHDC Manager and Agent SHALL:

- accept IEEE APDUs from the local IEEE Manager or Agent and send in sequence each IEEE APDU within a single PHDC PDU to the remote PHDC Agent or Manager; and
- accept PHDC PDUs from the remote PHDC Manager or Agent and send in sequence the enclosed IEEE APDU to the local PHDC Agent or Manager.

PHDC PDUs are transmitted within LLCP Information PDUs over the data link connection between the PHDC Manager and Agent. A PHDC PDU that does not fit completely into a single LLCP Information PDU SHALL be transmitted as a contiguous sequence of fragments. The first fragment SHALL at least contain the complete PHDC PDU Header. All remaining fragments MUST be transmitted in order by subsequent LLCP Information PDUs. LLCP Information PDUs carrying fragments are not required to transmit the maximimum number of octets possible and fragmentation might also be applied to PHDC PDUs that would otherwise fit completely into a single LLCP Information PDU.

Fragmentation of a PHDC PDU is illustrated in Figure 5.

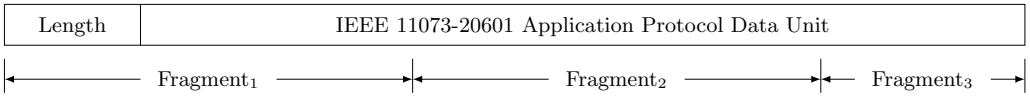

Figure 5: Fragmentation of a PHDC PDU

When leaving normal communication, both PHDC Manager and Agent SHALL issue a transport disconnect indication to the local IEEE Manager or Agent.

NOTE: The expected trigger for leaving normal communication is unintentional deactivation of the LLCP Link when the two devices are moved out of communication range and all data link connections are closed automatically. An implementation SHOULD explicitly close the data link connection if it encounters errors in the IEEE 11073-20601 communication. An implementation MAY close the data link connection for other reasons coordinated with the IEEE 11073-20601 Agent or Manager state machine transitions.

4. PHDC in NFC Forum Reader/Writer Mode

4.1. General

In NFC Forum Reader/Writer Mode, a PHDC Manager on an NFC Forum Device communicates with a PHDC Tag Agent on a NFC Forum Tag Device when both are brought into proximity. Communication between the Manager and the Agent is through reading and writing of NDEF messages by the Manager. Figure 6 illustrates the logical topology and communication means in NFC Forum Reader/Writer Mode.

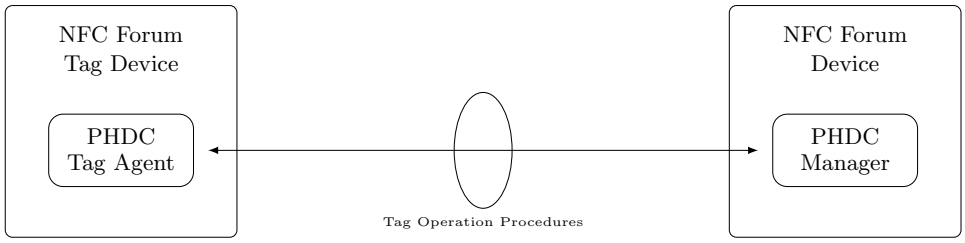

Figure 6: Logical Topology in NFC Forum R/W Mode

Further in this section, the term *PHDC Agent* is used synonymously to denote a PHDC Tag Agent and the term *PHDC Manager* to denote a PHDC Manager in NFC Forum Reader/Writer Mode.

4.2. Data Exchange Format

4.2.1. Personal Health Device Message

The Personal Health Device (PHD) Message is used by a PHDC Agent or Manager to transmit an IEEE 11073-20601 APDU. A PHD Message MUST start with a Personal Health Device Record that has the message begin (MB) flag set and MAY be followed by other NDEF records. The last NDEF record MUST close the message with the message end (ME) flag set. A PHD Message SHALL NOT contain more than one PHD record.

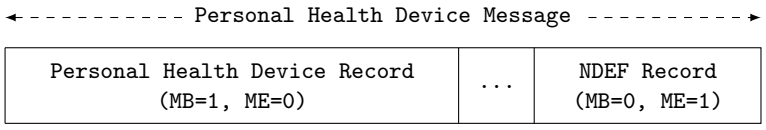

Figure 7: Personal Health Device Message Structure

4.2.2. Personal Health Device Record

A Personal Health Device (PHD) Record encapsulates a single IEEE 11073-20601 APDU for transmission. The first octet of the PHD record payload SHALL carry the Link Connected (LC) flag in bit 7, and the Message Counter (MC) field in bits 0-3. Any subsequent octets of the payload SHALL contain the octets of the encapsulated IEEE APDU in contiguous order.

The NFC Forum Well Known Type [NDEF, RTD]for the Personal Health Device Record SHALL be "PHD" (in NFC binary encoding: 0x50, 0x48, 0x44). The PHD Record header IL flag SHALL be set to 0.

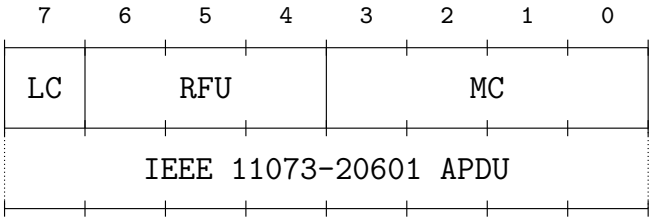

Figure 8: Payload of the Personal Health Device Record

Semantics of the Personal Health Device Record Payload Elements:

LC (Link Connected): The *LC* flag is a 1-bit flag that when set indicates that the data sent is subsequent to previously received data.

MC (Message Counter): The *MC* field is an unsigned 4-bit integer that carries a message number associated with the data transmission.

The Message Counter (MC) field is zero for the first PHD Message (from Agent to Manager) and be incremented by one modulo 16 for any subsequent PHD Message regardless of direction.

The least significant bit of the *MC* field indicates the message direction. If *MC modulo 2* is zero, data is sent from the PHDC Agent to the PHDC Manager. If the *MC modulo 2* is one, data is sent from the PHDC Manager to the PHDC Agent.

RFU (Reserved Future Use): The RFU field SHALL be set to zero when transmitted and SHALL be ignored when received.

APDU (Application Protocol Data Unit): The APDU field carries the IEEE 11073-20601 APDU intended for the IEEE Agent or Manager application. Any internal structure of the data carried within the APDU field is opaque to PHDC. The APDU field MAY be empty.

4.3. Data Exchange Procedure

Personal health device communication in NFC Forum Reader/Writer Mode is based on the exchange of PHD Messages. A PHDC Manager sends a PHD Message by performing tag operation write commands and receives a PHD Message by performing tag operation read commands. A PHDC Agent receives a PHD Message by accepting tag operation write commands and sends a PHD Message by responding to tag operation read commands. The transfer of a PHD Message may require multiple write or read commands (if the PHD Message does not fit completely into the payload of a single write or read command). Procedures for reading and writing NDEF messages are specific for each tag technology and are defined in the NFC Forum Tag Operation specifications. The PHDC specification assumes the transfer of a PHD Message as an atomic operation based on the transfer of NDEF messages.

A generic model of the interaction between a PHDC Manager and a PHDC Tag Agent exchanging data as NDEF messages is illustrated in Figure 9. In this model, both PHDC Manager and Agent

concurrently access an NDEF data area using any number of write or read operations to eventually send or retrieve PHD Messages, However, the model assumes that every wireless or wired write or read access is performed as an atomic operation on the NDEF data area. A further assumption is that the PHDC Agent component on the Host CPU receives notifications whenever a wireless write or read operation is executed. These notifications allow the PHDC Agent to determine when the PHDC Manager has finished reading a PHD Message from the NDEF message data area (the first wireless write notification after read), when the PHDC Manager has written new data into the NDEF message area, or when the PHDC Manager stops to communicate normally.

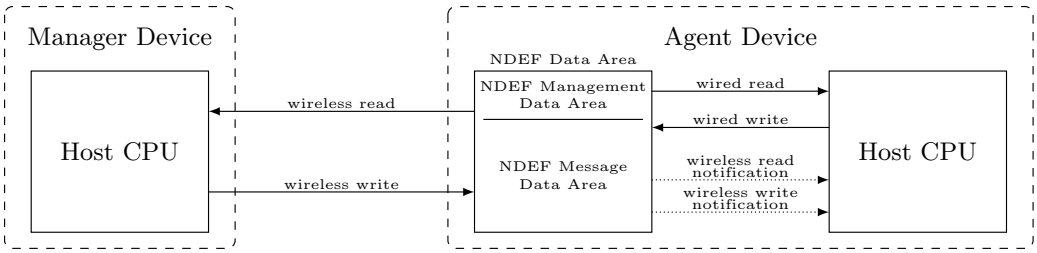

Figure 9: Generic Interaction Model between PHDC Manager and Tag Agent

4.3.1. Protocol Activation

4.3.1.1. PHDC Manager Activation Procedure

The PHDC Manager activation procedure SHALL be started when the NFC Forum Device Activity component has detected and activated an NFC Forum Type 2 Tag, Type 3 Tag, or Type 4 Tag or when the PHDC Manager encountered a timeout or message format error during normal communication.

When entering the PHDC Manager activation procedure the PHDC Manager SHALL perform the PHD message receive procedure defined in Section 4.4.2 to read an NDEF Message from the NFC Forum Tag device. If the NDEF message represents a well-formed PHD Message with the Link Connected (LC) flag and the Message Counter (MC) field set to zero, the PHDC Manager SHALL:

1. Send a transport connect indication to the IEEE Manager.
2. If the received PHD Message contains an APDU within the PHD Record APDU field send the APDU to the IEEE Manager.
3. Enter normal communication.

Until the end of normal communication the PHDC Manager SHALL keep the RF field active without interruption.

If the NDEF message does not represent a well-formed PHD Message, or if the Link Connected (LC) flag is set, or if the Message Counter field is non-zero, the PHDC Manager SHALL terminate the activation procedure and not enter normal communication.

4.3.1.2. PHDC Agent Activation Procedure

The PHDC Agent activation procedure SHALL be started on any of the following conditions:

- The PHDC Agent was activated by an NFC Forum Device.
- The PHDC Agent encountered a communication timeout.
- The PHDC Agent detected a message format error.

The PHDC Agent SHALL then wait until receipt of a wireless read notification (which normally indicates that a PHDC Manager intends to read a first PHD Message). Subsequently, the PHDC Agent SHALL perform the PHD message send procedure defined in Section 4.5.1 to send a PHD Message that has the first octet of the PHD Record payload set to zero. The PHD Record MAY contain an APDU (usually the IEEE 11073-20601 association request) if the implementation has that APDU available prior to sending a transport connect indication to the IEEE Agent.

The PHDC Agent SHALL then wait until receipt of a wireless write notification, subsequently send a transport connect indication to the IEEE Agent, and enter normal communication defined in Section 4.3.2.2.

NOTE: The notion of subsequently sending a PHD Message after the initial wireless read notification relates to the generic interaction model described in Section 4.3. It defines the latest time when the message must become available for reading.

4.3.2. Normal Communication

During normal communication, all PHD Messages SHALL have the Link Connected (LC) flag set to 1. Messages sent by the PHDC Manager SHALL have the least significant bit of the Message Counter (MC) field set to 1. Messages sent by the PHDC Agent SHALL have the least significant bit of the Message Counter (MC) field set to 0. Messages sent in either direction SHALL have the Message Counter (MC) field set to the value of the last received message plus 1 modulo 16.

4.3.2.1. PHDC Manager

The PHDC Manager SHALL perform the following steps in normal communication mode:

1. Wait up to 100 milliseconds to receive an APDU from the IEEE Manager.
    a) If an APDU was received from the IEEE Manager within the waiting time, construct a PHD Message with the APDU encoded into the APDU field of the PHD Record
    b) If no APDU was received from the IEEE Manager within the waiting time, construct a PHD Message with an empty PHD Record APDU field.
2. Execute the PHDC Manager PHD message send procedure defined in Section 4.4.1 to send the PHD Message to the PHDC Agent.
3. Execute the PHDC Manager PHD message receive procedure defined in Section 4.4.2 to receive a PHD Message from the PHDC Agent.
    a) If the received PHD Message contains an APDU within the PHD Record APDU field, send the APDU to the IEEE Manager.
    b) If the received PHD Message does not contain an APDU within the PHD Record APDU field, discard the PHD Message.
4. Continue with step 1.

4.3.2.2. PHDC Agent

The PHDC Agent SHALL perform the following steps in normal communication mode:

1. Perform the PHD message receive procedure defined in Section 4.5.2 to receive a PHD Message from the PHDC Manager.
    a) If the received PHD Message contains an APDU within the PHD Record APDU field, send the APDU to the IEEE Agent.
    b) If the received PHD Message does not contain an APDU within the PHD Record APDU field, discard the PHD Message.
2. Wait up to 100 milliseconds to receive an APDU from the IEEE Agent.
    a) If an APDU was received from the IEEE Agent within the waiting time, construct a PHD Message with the APDU encoded into the APDU field of the PHD Record.
    b) If no APDU was received from the IEEE Agent within the waiting time, construct a PHD Message with an empty PHD Record APDU field.
3. Perform the PHD message send procedure defined in Section 4.5.1 to send the PHD Message to the PHDC Manager.
4. Continue with step 1.

4.4. Tag Operation Procedures

4.4.1. PHD Message Send Procedure

The PHD message send procedure SHALL be executed by the PHDC Manager when a PHD Message is to be send to the PHDC Agent. The PHD Message send procedure depends on the tag platform implemented by the Agent device.

- For a Type 2 Tag platform, perform the *NDEF Write Procedure* defined in [T2TOP] Section 6.4.3 to write the PHD Message into the NDEF message data area.
- For a Type 3 Tag platform, perform the *Write NDEF Message* procedure defined in [T3TOP] Section 6.4.3 to write the PHD Message into the NDEF message data area.
- For a Type 4 Tag platform, perform the *NDEF Update Procedure* defined in [T4TOP] Section 5.4.7 to write the PHD Message into the NDEF message data area.

4.4.2. PHD Message Receive Procedure

The PHD Message receive procedure SHALL be executed by the PHDC Manager when a PHDC Message is to be received from the PHDC Agent. The PHD Message receive procedure depends on the tag platform implemented by the Agent device.

- For a Type 2 Tag platform, perform the *NDEF Read Procedure* defined in [T2TOP] Section 6.4.2 until a PHD Message is received from the PHDC Agent (a message from the PHDC Agent has the least significant bit of the message counter set to zero). Subsequently perform the PHD Message Receive Confirmation Procedure defined in Section 4.4.2.1.

– For a Type 3 Tag platform, perform the *Read NDEF Message* procedure defined in [T3TOP] Section 6.4.2 until a PHD Message is received from the PHDC Agent (a message from the PHDC Agent has the least significant bit of the message counter set to zero). Subsequently perform the PHD Message Receive Confirmation Procedure defined in Section 4.4.2.1.

– For a Type 4 Tag platform, perform the *NDEF Read Procedure* defined in [T4TOP] Section 5.4.6 until a PHD Message is received from the PHDC Agent (a message from the PHDC Agent has the least significant bit of the message counter set to zero). Subsequently perform the PHD Message Receive Confirmation Procedure defined in Section 4.4.2.1.

If the received PHD Message is not correctly formatted, or the PHD Record payload element LC is not set to 1, or the PHD Record payload element MC is not set to a value that is an increment by 1 modulo 16 of the MC value transmitted with the most recent Tag Operation PHD message send procedure (defined in Section 4.4.1), the PHDC Manager SHALL enter the activation procedure.

4.4.2.1. PHD Message Receive Confirmation Procedure

The PHD Message receive confirmation procedure SHALL be executed by the PHDC Manager immediately after a valid PHD Message was received from the PHDC Agent. The time intervall between the end of the PHD Message receive procedure and begin of the PHD Message receive confirmation procedure SHALL NOT exceed 50 milliseconds. The PHD Message receive confirmation procedure depends on the tag platform implemented by the Agent device.

– For a Type 2 Tag platform, perform the *NDEF Write Procedure* defined in [T2TOP] Section 6.4.3 to write the Empty NDEF Message defined in this section into the NDEF message data are.

– For a Type 3 Tag platform, perform the *Write NDEF Message* procedure defined in [T3TOP] Section 6.4.3 to write the Empty NDEF Message defined in this section into the NDEF message data are.

– For a Type 4 Tag platform, perform the *NDEF Update Procedure* defined in [T4TOP] Section 5.4.7 to write the Empty NDEF Message defined in this section into the NDEF message data are.

For the purpose of the PHD Message receive confirmation procedure, the Empty NDEF Message SHALL be defined as the octet sequence 0xD0, 0x00, 0x00 (c.f. Figure 10).

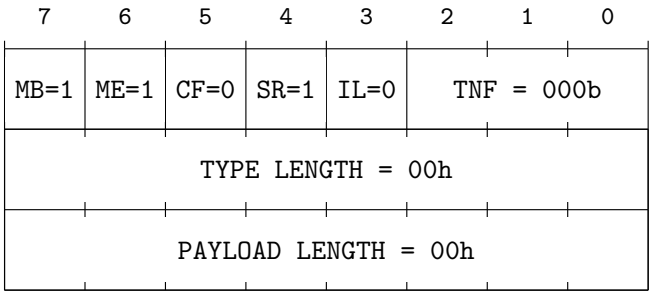

Figure 10: Octets of the Empty NDEF Message

4.5. Tag Platform Procedures

4.5.1. PHD Message Send Procedure

The PHD Message send procedure SHALL be executed by the PHDC Agent when a PHD Message is to be sent to the PHDC Manager. The PHD Message send procedure depends on the tag platform implemented by the Agent device.

- For a Type 2 Tag platform, perform the procedure defined in Section 4.5.1.1 to write the PHD Message into the NDEF message data area.
- For a Type 3 Tag platform, perform the procedure defined in Section 4.5.1.2 to write the PHD Message into the NDEF message data area.
- For a Type 4 Tag platform, perform the procedure defined in Section 4.5.1.3 to write the PHD Message into the NDEF message data area.

4.5.1.1. Type 2 Tag PHD Message Send Procedure

The Type 2 Tag PHD Message send procedure is based on the generic interaction model described in Section 4.3 and is not meant to restrict the choice of an implementation to deploy a different interaction model with optimized procedures. However, when executing the Type 2 Tag PHD Message send procedure, the implementation SHALL ensure that the data area for dynamic memory structure does contain either a zero-length NDEF Message TLV or the complete PHD Message to be sent.

1. Write a zero-length NDEF Message TLV into the first two octets (starting at offset 0) of the data area for dynamic memory structure (cf. [T2TOP] Section 2.2.3).
2. If the PHD Message to send is less than 256 octets, write the PHD Message into the data area for dynamic memory structure starting at offset 2. If the PHD Message to send is more than 256 octets, write the PHD Message into the data area for dynamic memory structure starting at offset 4.
3. Write the length of the PHD Message into the NDEF Message TLV Length field.
4. Wait until a wireless read notification is received. If a wireless read notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2.
5. Wait until a wireless read or write notification is received. If a wireless read or write notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2. If a wireless read notification is received then continue with step 5.

Note that an implementation can omit step 1 and combine steps 2 and 3 if it is able to write the full PHD Message into the data area for dynamic memory structure in a logically single operation that guarantees that the PHDC Manager will not read partially incomplete data.

4.5.1.2. Type 3 Tag PHD Message Send Procedure

The Type 3 Tag PHD Message send procedure is based on the generic interaction model described in Section 4.3 and is not meant to restrict the choice of an implementation to deploy a different

interaction model with optimized procedures. However, when executing the Type 3 Tag PHD Message send procedure, the implementation SHALL ensure that either the value of the Ln field is 000000h, or the NDEF message data area does contain the complete PHD Message to be sent and the Ln field is set to the length of the PHD Message.

1. Write the value 000000h into the attribute information Ln field. The attribute information structure is defined in [T3TOP] Section 6.1.2.
2. Write the PHD Message octets into the NDEF message data area (block 1 to N).
3. Write the length of the PHD Message into the attribute information Ln field.
4. Wait until a wireless read notification is received. If a wireless read notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2.
5. Wait until a wireless read or write notification is received. If a wireless read or write notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2. If a wireless read notification is received then continue with step 5.

Note that an implementation can omit step 1 and combine steps 2 and 3 if it is able to write the full PHD Message into the data area for dynamic memory structure in a logically single operation that guarantees that the PHDC Manager will not read partially incomplete data.

4.5.1.3. Type 4 Tag PHD Message Send Procedure

The Type 4 Tag PHD Message send procedure is based on the generic interaction model described in Section 4.3 and is not meant to restrict the choice of an implementation to deploy a different interaction model with optimized procedures. However, when executing the Type 4 Tag PHD Message send procedure, the implementation SHALL ensure that either the value of the NLEN field is 0000h, or the NDEF message field does contain the complete PHD Message to be sent and the NLEN field is set to the length of the PHD Message.

1. Write the value 0000h into the NLEN field. The NLEN field is the first two octets of the NDEF file.
2. Write the PHD Message into the NDEF message field. The NDEF message field starts at the third octet and ends at the last octet of the NDEF file.
3. Write the length of the PHD Message into the NLEN field.
4. Wait until a wireless read notification is received. If a wireless read notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2.
5. Wait until a wireless read or write notification is received. If a wireless read or write notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2. If a wireless read notification is received then continue with step 5.

Note that an implementation can omit step 1 and combine steps 2 and 3 if it is able to write the full PHD Message into the data area for dynamic memory structure in a logically single operation that guarantees that the PHDC Manager will not read partially incomplete data.

4.5.2. PHD Message Receive Procedure

The PHD Message receive procedure SHALL be executed by the PHDC Agent when a PHDC Message is to be received from the PHDC Manager. The PHD Message receive procedure depends on the tag platform implemented by the Agent device.

- For a Type 2 Tag platform, perform the procedure defined in Section 4.5.2.1 to retrieve a PHD Message from the NDEF message data area.
- For a Type 3 Tag platform, perform the procedure defined in Section 4.5.2.2 to retrieve a PHD Message from the NDEF message data area.
- For a Type 4 Tag platform, perform the procedure defined in Section 4.5.2.3 to retrieve a PHD Message from the NDEF message data area.

If the received PHD Message is not correctly formatted, or the PHD Record payload element LC is not set to 1, or the PHD Record payload element MC is not set to a value that is an increment by one modulo 4 of the MC value transmitted with the most recent Tag Platform PHD message send procedure (defined in Section 4.5.1), the PHDC Agent SHALL enter the activation procedure.

4.5.2.1. Type 2 Tag PHD Message Receive Procedure

The Type 2 Tag PHD Message receive procedure is based on the generic interaction model described in Section 4.3 and is not meant to restrict the choice of an implementation to deploy a different interaction model with optimized procedures. However, for any choice of implementation, execution of the Type 2 Tag PHD Message receive procedure SHALL ensure that a PHD Message is received if and only if the defined acceptance criterias are met.

1. Wait until a wireless write notification is received. If a wireless write notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2.
2. Read sufficient number of octets from the begin of the data area for dynamic memory structure (cf. [T2TOP] Section 2.2.3) to obtain the values of the NDEF Message TLV *Type* and *Length* field and the first 10 octets of the NDEF Message TLV *Value* field.
3. If the value of *Type* is not equal to 03h, or the value of *Lenght* is 0, or the first 10 octets of the NDEF Message TLV *Value* field do not represent a correctly formatted PHD Record header, or the least significant bit of the first PHD Record payload octet is 0, then continue with step 1.
4. Read the remaining octets of the NDEF Message TLV *Value* field.

4.5.2.2. Type 3 Tag PHD Message Receive Procedure

The Type 3 Tag PHD Message receive procedure is based on the generic interaction model described in Section 4.3 and is not meant to restrict the choice of an implementation to deploy a different interaction model with optimized procedures. However, for any choice of implementation, execution of the Type 3 Tag PHD Message receive procedure SHALL ensure that a PHD Message is received if and only if the defined acceptance criterias are met.

1. Wait until a wireless write notification is received. If a wireless write notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2.

2. Read the attribute information block and the first 10 octets of the NDEF storage area to obtain the values of *WriteF* and *Ln* and a potential PHD Record header including the first octet of the PHD Record payload.
3. If the value of *WriteF* is not 0, or the value of Ln is 0, or the first 10 octets of the NDEF storage area do not represent a correctly formatted PHD Record header, or the least significant bit of the first PHD Record payload octet is 0, then continue with step 1.
4. Read the remaining octets of the NDEF message of length *Ln*.

4.5.2.3. Type 4 Tag PHD Message Receive Procedure

The Type 4 Tag PHD Message receive procedure is based on the generic interaction model described in Section 4.3 and is not meant to restrict the choice of an implementation to deploy a different interaction model with optimized procedures. However, for any choice of implementation, execution of the Type 4 Tag PHD Message receive procedure SHALL ensure that a PHD Message is received if and only if the defined acceptance criterias are met.

1. Wait until a wireless write notification is received. If a wireless write notification is not received within 500 milliseconds, enter the PHDC Agent activation procedure defined in Section 4.3.1.2.
2. Read the first 12 octets of the NDEF file to obtain the value of *NLEN* and a potential PHD Record header including the first octet of the PHD Record payload.
3. If the value of *NLEN* is 0, or the octets following NLEN do not represent a correctly formatted PHD Record header, or the least significant bit of the first PHD Record payload octet is 0, then continue with step 1.
4. Read the remaining octets of the NDEF message of length *NLEN*.

4.6. Tag Platform Requirements

A PHDC Tag Agent SHALL be compliant to one of the Type 2, 3, or 4 Tag Platform Requirements sections listed below.

4.6.1. Type 2 Tag Platform Requirements

This section lists conformance requirements for a Type 2 Tag Platform compliant PHDC Agent. The READ command, WRITE command, and SECTOR SELECT command are defined in [T2TOP] Section 5.

1. The PHDC Agent SHALL implement the dynamic memory structure described in [T2TOP] Section 2.2.
2. The PHDC Agent SHALL accept a correctly formatted SECTOR SELECT command that selects a sector within the available memory space.
3. While sector 0 is selected, the PHDC Agent SHALL respond to a correctly formatted READ command where the block number is set to either 0, 1, 2 or 3 by returning 16 octets that include the 4 byte capability container in octets 12-15 if block number 0 was specified, octets

8-11 if block number 1 was specified, octets 4-7 if block number 2 was specified, or octets 0-3 if block number 3 was specified.

   a) The capability container returned SHALL have the value of Byte 0 set to E1h, the value of Byte 1 set corresponding to the version defined in [T2TOP], the value of Byte 2 set to the integral number of octets available as data area for dynamic memory structure (cf. [T2TOP] Section 2.2.3) divided by 8, and the value of Byte 3 set to 00h.

4. While any valid sector is selected, the PHDC Agent SHALL respond to a correctly formatted READ command where the block number addresses a 4-byte data block within the available data area for dynamic memory structure by returning 16 bytes starting with the 4-byte data block stored at the memory position being addressed and the subsequently following 12 bytes.
5. While any valid sector is selected, the PHDC Agent SHALL accept the 4-byte data block provided with a correctly formatted WRITE command where the block number addresses a 4-byte data block within the available data area for dynamic memory structure.

4.6.2. Type 3 Tag Platform Requirements

This section lists conformance requirements for a Type 3 Tag Platform compliant PHDC Agent. The Check command is defined in [T3TOP] Section 5.4. The Update command is defined in [T3TOP] Section 5.5.

1. The PHDC Agent SHALL enable a PHDC Manager compliant to the Type 3 Tag Platform Operation [T3TOP] Specification to read from and write to the Attribute Information block and NDEF data blocks described in [T3TOP] over the wireless interface.
2. The PHDC Agent SHALL respond to a correctly formatted Check command where the number of services is 1, the service code list contains the service code 000Bh or 0009h, the number of blocks is 1 and the block list denotes block number 0 with the attribute information block defined in [T3TOP] Section 6.1.2.

   a) The attribute information block returned SHALL have the value of *Ver* set corresponding to the version defined by [T3TOP], the value of *Nbr* and *Nbw* set according to the capabilities of the Type 3 Tag platform, the value of *Nmaxb* set to the highest block number available for NDEF data, the value of *WriteF* set to the the value received with most recent Update command on block 0, the value of *RWFlag* set to 01h, the value of *Ln* set to the current length of NDEF data available for reading and the *Checksum* set according to the checksum calculation formula defined in [T3TOP] Section 6.1.2.

3. The PHDC Agent SHALL respond to a correctly formatted Check command where the number of services is set to 1, the service code list contains the service code 000Bh or 0009h, the number of blocks is greater 0 but less than or equal to the value of the attribute information *Nbr* field and the block list denotes consecutive blocks between and including 1 and *Nmaxb* with octets from the NDEF message data area as selected by the block list.
4. The PHDC Agent SHALL accept the attribute information block provided with a correctly formatted Update command where the number of services is set to 1, the service code list contains the service code 0009h, the number of blocks is 1 and the block list denotes block number 0.

a) The PHDC Agent SHALL accept the attribute information block only if all values except *WriteF*, *Ln* and *Checksum* are identical to the values returned for a Check command on block 0 and the *Checksum* is set according to the checksum calculation formula defined in [T3TOP] Section 6.1.2.

5. The PHDC Agent SHALL accept the block data provided with a correctly formatted Update command where the number of services is set to 1, the service code list contains the service code 0009h, the number of blocks is greater 0 but less than or equal to the value of the attribute information *Nbw* field and the block list denotes consecutive blocks between and including 1 and *Nmaxb*.

4.6.3. Type 4 Tag Platform Requirements

This section lists conformance requirements for a Type 4 Tag Platform compliant PHDC Agent. The NDEF Tag Application Select command is defined in [T4TOP] Section 5.4.2. The Capability Container (CC) Select command is defined in [T4TOP] Section 5.4.3. The ReadBinary command is defined in [T4TOP] Section 5.4.4. The NDEF Select command is defined in [T4TOP] Section 5.4.5. The NDEF Update command is defined in [T4TOP] Section 5.4.7.

1. The PHDC Agent SHALL respond to a correctly formatted NDEF Tag Application Select command with status “command completed”.
2. The PHDC Agent SHALL respond to a correctly formatted Capability Container (CC) Select command with status “command completed”. The following enclosed requirements SHALL be fulfilled until receipt of a Select command which is not the CC Select command.

    a) The PHDC Agent SHALL respond to any correctly formatted ReadBinary command which addresses all or part of the first 15 octets of the CC file with the octets of the CC file being addressed and status “command completed”.

    b) The data structure of the CC file SHALL comply to the definitions in [T4TOP] Section 5.1.

3. The PHDC Agent SHALL respond to a correctly formatted NDEF Select command where the parameter *File ID* of the Select command is equal to the *File Identifier* of the NDEF File Control TLV contained in the CC file at offset 0007h with status “command completed”. The following enclosed requirements SHALL be fulfilled until receipt of a Select command which is not the NDEF Select command.

    a) The PHDC Agent SHALL respond to a correctly formatted ReadBinary command where *P1* and *Le* identify any range of octets of the NDEF file within the limits expressed in the capability container with the octets of the NDEF file according to the range selected by *P1* and *Le* and status “command completed”.

    b) The PHDC Agent SHALL respond to a correctly formatted NDEF Update command where *P1* and *Lc* identify a valid range of octets of the NDEF file within the limits expressed in the capability container with status “command completed”.

A. Exhibit A

No items have been included in Exhibit A.

B. Example Message Sequence in NFC Forum Peer Mode

This appendix provides an example message exchange between a PHDC Peer Agent and a PHDC Manager in NFC Forum Peer Mode.

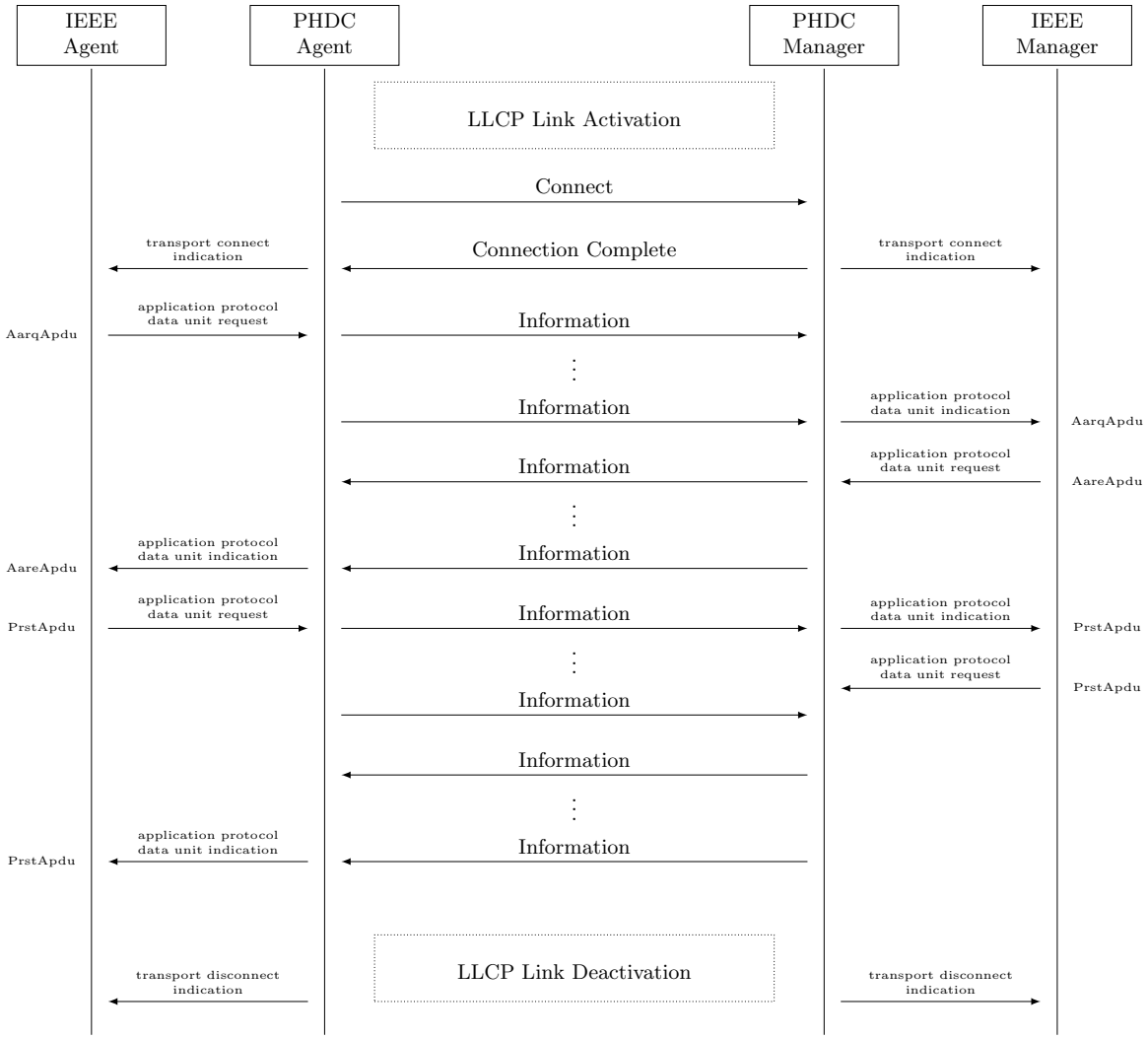

Figure 11: Example Message Sequence in NFC Forum Peer Mode

C. Example Message Sequence in NFC Forum R/W Mode

This appendix provides an example message exchange between a PHDC Tag Agent and a PHDC Manager in NFC Forum Reader/Writer Mode. Note that in this specific example the PHDC Tag Agent does not have an IEEE APDU available immediately after technology selection and tag activation, which results in the initial exchange of two PHD Messages not carrying an APDU payload. However, it is expected that most Agent implementations will be able to transmit the initial IEEE association request APDU (AarqApdu) prior to the logical transport connect indication as result of internal, implementation–specific knowledge.

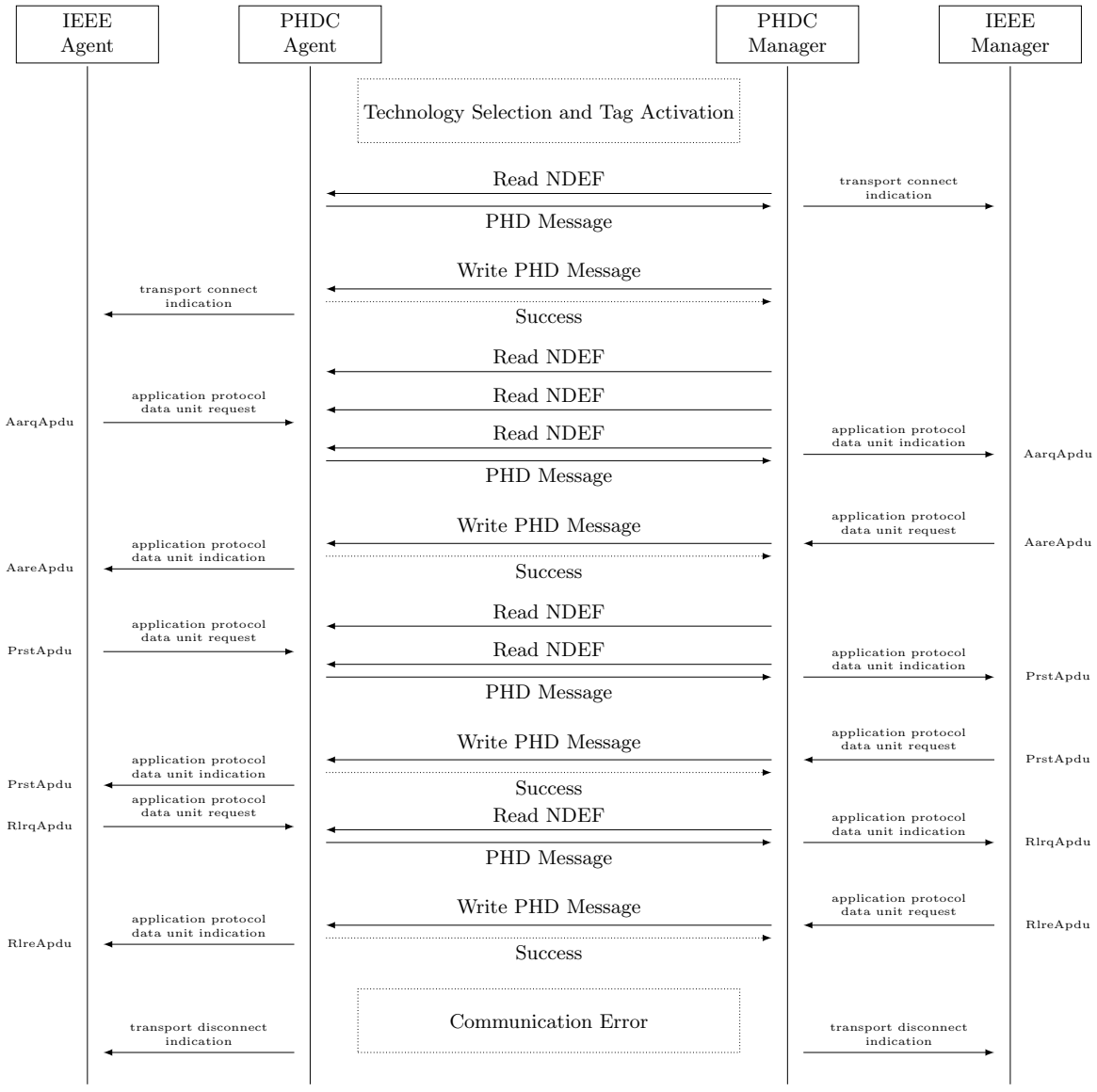

Figure 12: Example Message Sequence in NFC Forum R/W Mode

D. Revision History

The following table outlines the revision history of the Personal Health Device Communication Specification.

Table 2: Revision History

Document Name	Revision and Release Date	Status	Change Notice	Supersedes
Personal Health Device Communication (PHDC) Specification	Version 1, February 2013	Final		None