Japan Electronic-money Promotion Association

Guidelines for implementing e-money payment terminals supporting NFC/FeliCa - Version 1.1 -

March 1st, 2019

Revision history

Ver	Date	Description
1.0	1 June 2016	New creation in Japanese
1.1	1 March 2019	Introduction page was added Bibliography page was modified Contact information page was removed (Opened an inquiry form on web site)

Introduction

- This document includes recommendations to avoid a number of interoperability issues that can potentially occur between FeliCa based e-money payment terminals and NFC mobile devices.

  Additionally the document also includes some recommendations for terminals supporting FeliCa and EMVCo.

FeliCa is a trademark of Sony Corporation. FeliCa is a contactless IC card technology developed by Sony Corporation.

EMV® is a registered trademark in the U.S. and other countries and an unregistered trademark elsewhere. The EMV trademark is owned by EMVCo, LLC.

Categories

- **This guideline classifies issues into the following three categories:**
  - Category A
    - Issues that can occur because of deviations between NFC Forum and FeliCa specifications.
  - Category B
    - Issues that occur because of topics that are not defined in any public specification and therefore left to implementations.
  - Category C
    - Issues that exist because of implementations that do not fully comply with the NFC Forum and/or FeliCa specifications.
    - Issues that relate to terminals supporting multiple technologies and services according to FeliCa and EMVCo specifications.
- **All vendors are encouraged to implement their products according to this guideline.**

Informative: Impact level

- **High**
  - Payment failure (duplicate transactions) may happen.
  - The media may be damaged or destroyed.
- **Medium**
  - A payment with the NFC mobile device in question is not possible.
  - A payment for a specific service is not possible with the NFC mobile device in question.
- **Low**
  - A payment with the NFC mobile device in question is not possible. However the likelihood of the problem to occur is not very high.
  - A payment with the NFC mobile device in question is not possible depending on the surrounding situation.
  - A payment with the NFC mobile device in question is not possible when other terminals are located in close proximity.

Terms and definitions

- **terminal**
  - a payment terminal supporting at least one FeliCa-based payment service.
- **media**
  - a contactless IC card or an NFC mobile device.
- **NFC mobile device**
  - a mobile device compliant to NFC Forum and FeliCa specifications.

- **Mode 0**
  - the state in which a FeliCa media enters after detecting an RF field
- **NFC-A, NFC-B, NFC-F**
  - Different NFC technologies. NFC-F is the NFC technology used by FeliCa.
- **System 0**
  - the first System on a FeliCa media
- **Wild-card polling**
  - a FeliCa Polling command with System Code set to FFFFh and Request Code set to 00h

Category A

No.	Title	FeliCa specs	NFC Forum specs
A-1	NFC-F wild-card Polling	N/A	Yes
A-2	Field reset duration	N/A	Yes 5.1+ ms
A-3	End of frame detection for NFC-F	Yes	Yes
A-4	Maximum field strength	Yes	Yes

Category B

No.	Title	FeliCa Specs	NFC Forum specs
B-1	Rules for RF collision avoidance	N/A	N/A
B-2	Mobile device switches to poll mode	N/A	N/A
B-3	Shutdown time after RF field loss	N/A	N/A
B-4	Accessing multiple FeliCa Systems #1	N/A	N/A
B-5	Accessing multiple FeliCa Systems #2	N/A	N/A
B-6	Presence check interrupts transaction	N/A	N/A

Category C

No.	Title	EMV® Specs	FeliCa specs	NFC Forum specs
C-1	Polling process for multiple RF technologies #1	Yes	N/A	N/A
C-2	Polling process for multiple RF technologies #2	Yes	N/A	N/A
C-3	Invalid Polling commands	-	Yes	Yes
C-4	Guard time	-	Yes	Yes

A-1: NFC-F wild-card Polling

Impact

Host	Payment application	**Terminal software**	Terminal hardware

Level

- Medium

Problem

- The media identified using a FeliCa Polling does not respond to any FeliCa commands.

Root cause

- If the terminal uses a Wild-card Polling, the NFC mobile device sends a response indicating Peer to Peer mode. In Peer to Peer mode, FeliCa commands are not supported, instead the device expects the NFC-DEP protocol to be activated.
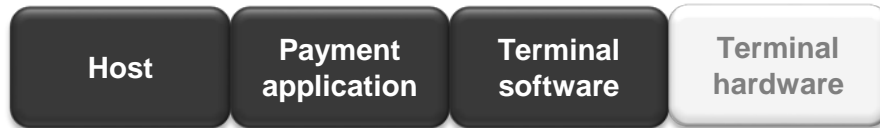
Solution

- The terminal shall use the specific System Code value for the FeliCa-based service it wants to access when sending a FeliCa Polling.

- When sending a Wild-card Polling (System Code set to FFFFh), the Request Code shall be set to 01h.

A-2: Field reset duration

- **Impact**

Host	Payment application	Terminal software	Terminal hardware

- **Level**
  - Medium

- **Problem**
  - An NFC mobile device does not respond to a FeliCa Polling after a field reset, which the terminal performs by switching the RF field off and then on.
  - The field reset can be used for switching between different RF technologies (such as NFC-A, NFC-B and NFC-F) or resetting the media state in case the media has been authentication status.

- **Root cause**
  - The RF field off time during the field reset has been too short. For a field reset, the RF field has to be switched off for a duration of at least 5.1 ms as defined in the NFC Forum specifications.

- **Solution**
  - When performing a field reset, the terminal shall keep the RF field off for at least 5.1 ms.

A-3: End of frame detection for NFC-F

Impact

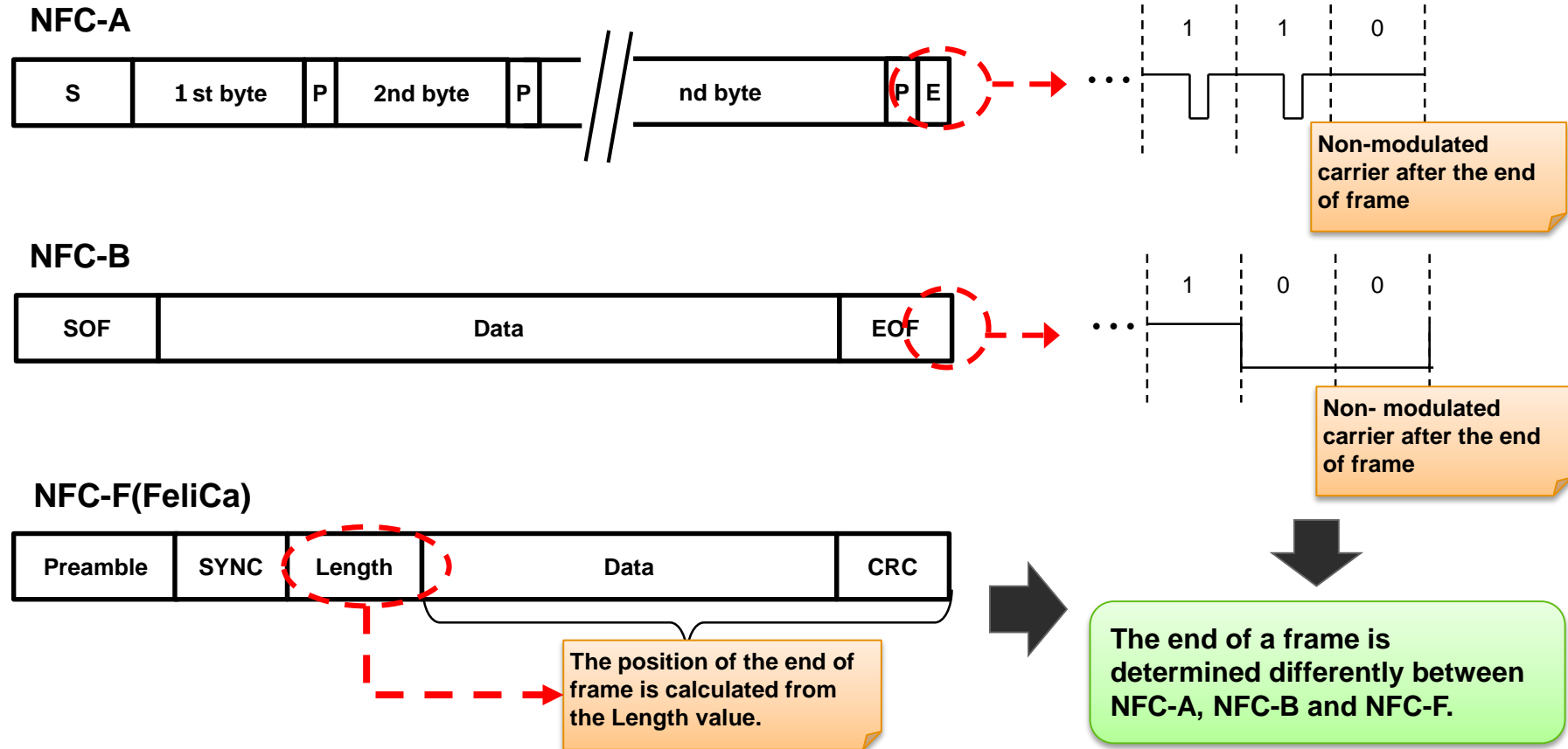| Host	Payment application	Terminal software	**Terminal hardware**

Level

- Low

Problem

- The payment transaction with an NFC mobile device fails because the terminal does not receive the response from the media properly.

Root cause

- If the terminal implementation detects the end of a frame by waiting for a non-modulated carrier, noise that follows the frame might be interpreted as being part of the frame.
  Early versions of the NFC Forum specifications allowed to optionally detect the end of frame based on non-modulated carrier.

A-3: End of frame detection for NFC-F

■ Difference in end of a frame detection between NFC-A, NFC-B and NFC-F

NFC-A

S	1 st byte	P	2nd byte	P		nd byte	P	E

··· 1 1 0

Non-modulated carrier after the end of frame

NFC-B

SOF	Data	EOF

··· 1 0 0

Non- modulated carrier after the end of frame

NFC-F(FeliCa)

Preamble	SYNC	Length	Data	CRC

The position of the end of frame is calculated from the Length value.

The end of a frame is determined differently between NFC-A, NFC-B and NFC-F.

■ **Solution**

■ The terminal shall determine the end of a NFC-F (FeliCa) frame by calculating the frame length using the value of the Length byte.

A-4: Maximum field strength

■ **Impact**

Host	Payment application	Terminal software	**Terminal hardware**

■ **Level**

    ■ High (potential destruction of the media)

■ **Problem**

    ■ An NFC mobile device might be destroyed when tapped on a terminal.

■ **Root cause**

    ■ In the NFC Forum specifications the maximum field strength is defined as 7.5 A/m, while the FeliCa specification defines 11 A/m.

■ **Solution**

    ■ The terminal shall use a maximum field strength of 7.5 A/m as defined in the NFC Forum specifications.

B-1: Rules for RF collision avoidance

Impact

Host	Payment application	Terminal software	Terminal hardware

Level

- Low

Problem

- Some terminals cannot operate when other terminals are located in close proximity.

Root cause

- Using RF Collison Avoidance(RFCA), a terminal can check whether there is an external RF field before switching on its own RF field. If there is an external field, the terminal keeps its RF field off. Therefore the RF field of another terminal located nearby might prevent the operation of the terminal.

Solution

- The terminal shall not keep the RF field ON all the time.

- To avoid interference of RF fields, a terminal implementing RFCA shall not be placed adjacent to another terminal (a minimum distance of approx. 200 mm between the center of the antennas is suggested).

B-2: Mobile device switches to poll mode

Impact
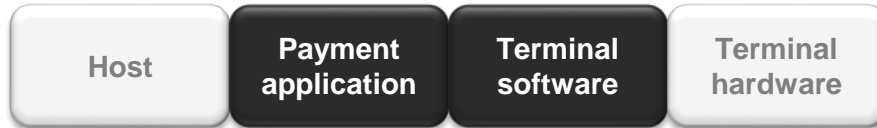
Host	**Payment application**	**Terminal software**	Terminal hardware

Level

- Medium

Problem

- A payment transaction using an NFC mobile device fails when the terminal switches the RF field off after starting the transaction.

Root cause

- The NFC mobile device may switches to poll mode if it detects no external RF field for a certain time.

Solution

- In general the terminal shall not switch RF field off during a transaction.

- If there is a specific need for a field reset during a transaction and a timeout error occurs afterwards, the terminal shall retransmit the command until the NFC mobile device is ready again to receive commands. The period for repeating retransmission is approx. 300 ms, depending on the mobile equipment.

B-3: Shutdown time after RF field loss

Impact
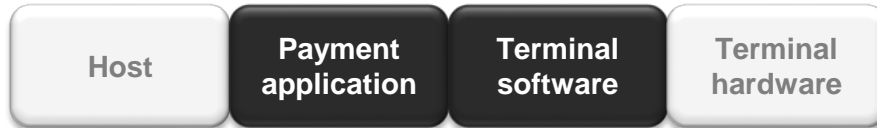
Host	Payment application	Terminal software	Terminal hardware

Level

- Medium

Problem

- A payment transaction using an NFC mobile device fails when the terminal has reset the RF field right before starting the transaction or during the transaction.

Root cause

- Some NFC mobile devices have an IC chip that performs a shutdown process after detecting that an external RF field has been switched off. This shutdown process takes some time during which no communication is possible.

Solution

- In general the terminal shall not switch RF field off during a transaction.

- If there is a specific need for a field reset during a transaction, and a timeout error occurs afterwards, the terminal shall retransmit the command until the NFC mobile device is ready again to receive commands. This is the case latest after 50.4 ms from the time the RF field has been switched off (30 ms for the shutdown process + 20.4 ms for NFC-F guard time).

B-4: Accessing multiple FeliCa Systems #1

Impact

| Host | Payment application | Terminal software | Terminal hardware |
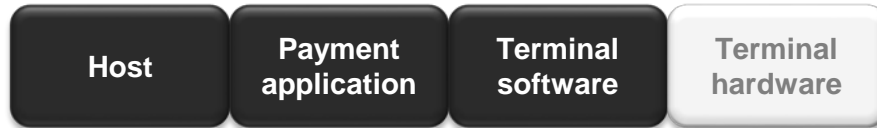
Level

- Medium

Problem

- A payment process using an NFC mobile device fails if the terminal accesses different FeliCa systems sequentially without sending a Polling with the System Code of the next system in-between.
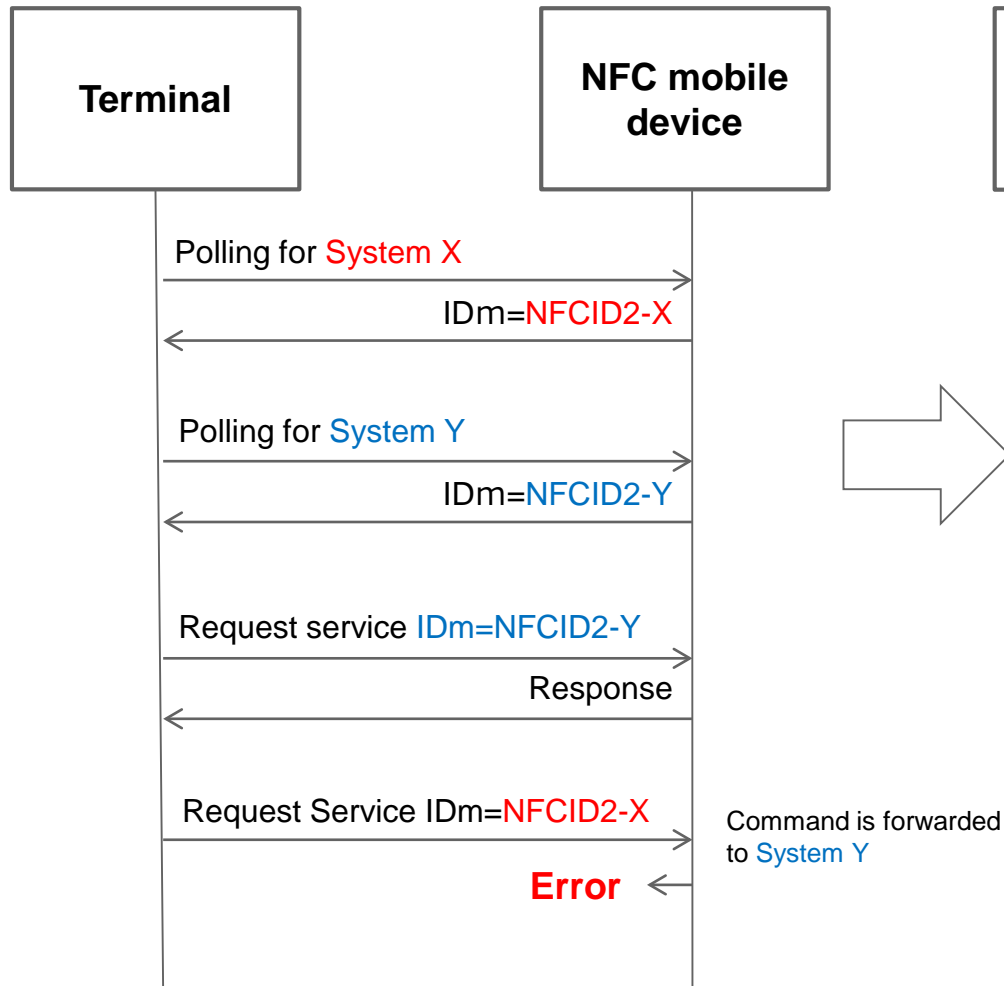
Root cause

- An NFC mobile device is forwarding any commands to the System that has responded to the last Polling.
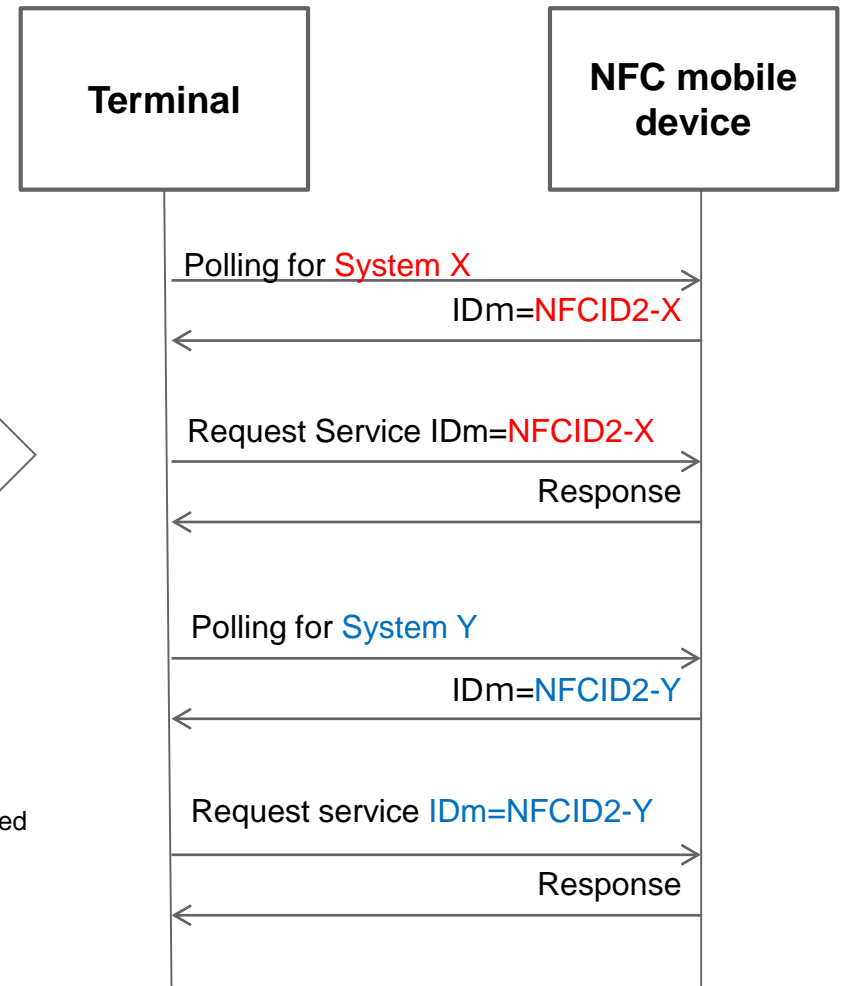
Solution

- Before accessing a different System during a payment process, the terminal shall send a Polling with the System Code of the System. The terminal shall only send commands to the System after it has received a valid Polling response.
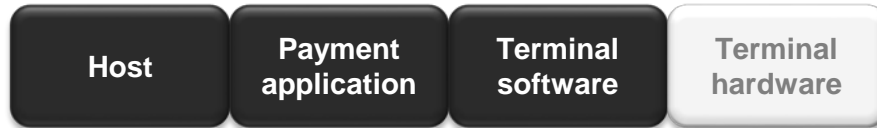
B-4: Examples

Problematic sequence

Recommended solution

Problematic sequence (left diagram):

Terminal → NFC mobile device: Polling for System X
NFC mobile device → Terminal: IDm=NFCID2-X
Terminal → NFC mobile device: Polling for System Y
NFC mobile device → Terminal: IDm=NFCID2-Y
Terminal → NFC mobile device: Request service IDm=NFCID2-Y
NFC mobile device → Terminal: Response
Terminal → NFC mobile device: Request Service IDm=NFCID2-X
Command is forwarded to System Y
Error

Recommended solution (right diagram):

Terminal → NFC mobile device: Polling for System X
NFC mobile device → Terminal: IDm=NFCID2-X
Terminal → NFC mobile device: Request Service IDm=NFCID2-X
NFC mobile device → Terminal: Response
Terminal → NFC mobile device: Polling for System Y
NFC mobile device → Terminal: IDm=NFCID2-Y
Terminal → NFC mobile device: Request service IDm=NFCID2-Y
NFC mobile device → Terminal: Response

B-5: Accessing multiple FeliCa Systems #2

Impact

Host	Payment application	Terminal software	Terminal hardware

Level

- Medium

Problem

- A payment process that uses the Request System Code command without Polling commands fails with an NFC mobile device.

Root cause

- The Request System Code command, which is specified in the FeliCa specification, is not fully supported on NFC mobile devices. The response may not include all System Codes available on the device.

Solution

- In case the terminal intends System Code search with the Request System Code command, the terminal shall use Polling command to check for specific System Codes in advance. The terminal shall use the Request System Code command after receiving a corresponding valid Polling response.

B-6: Presence check interrupts transaction

Impact

Host	Payment application	Terminal software	Terminal hardware
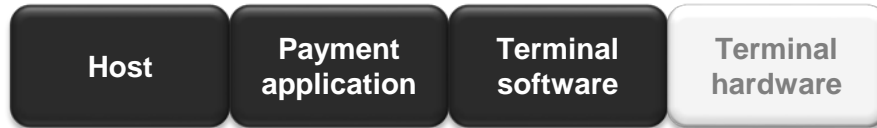
Level

- Medium

Problem

- A payment process on an Android OS-based terminal fails because of the presence check that is triggered by the OS.
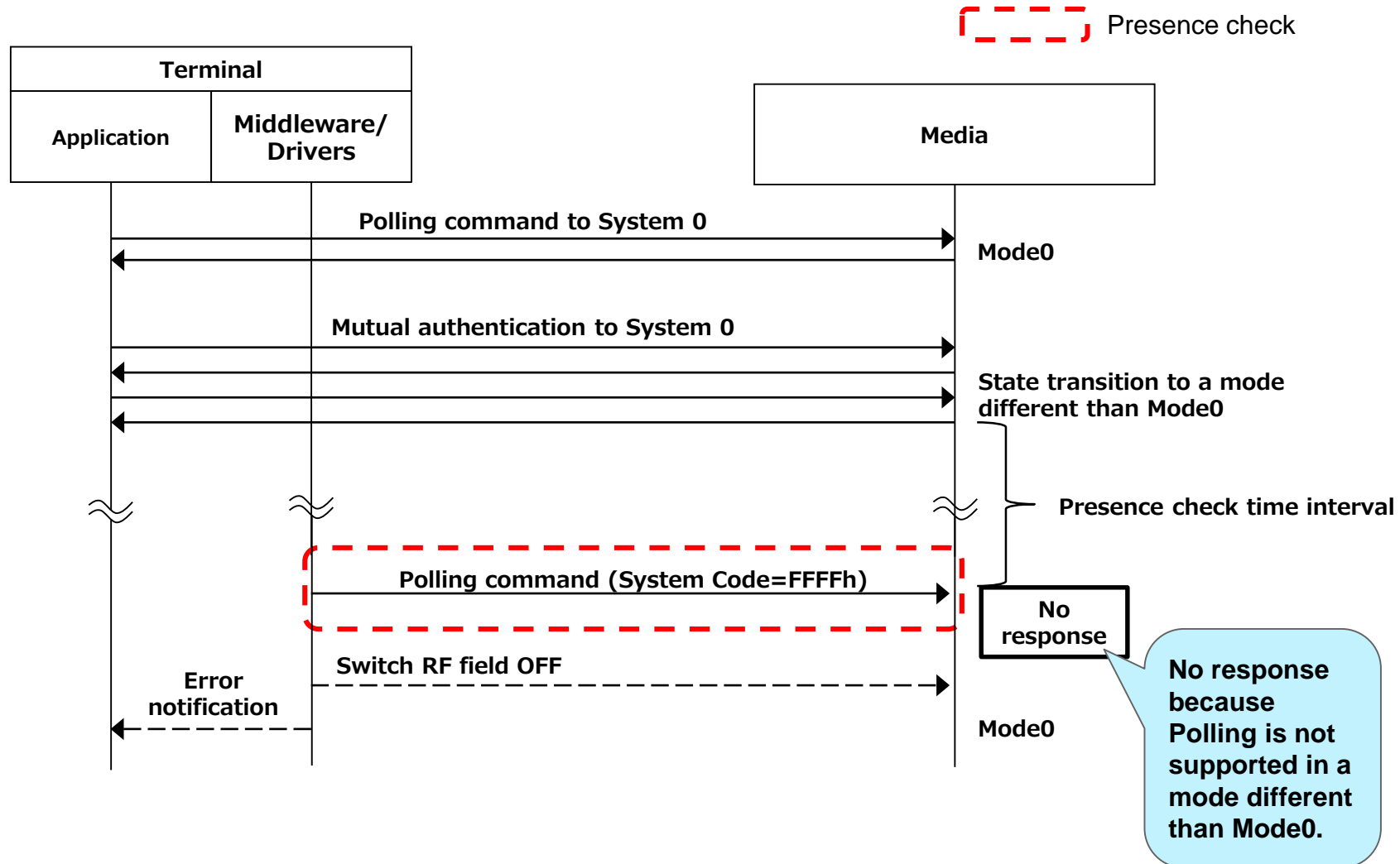
Root cause

- If there is no communication for a specific time, Android performs a presence check by sending a wild-card Polling command. If there is no response to the presence check command, which can be the case for an authenticated System, the Android OS closes the connection as it assumes the media has been removed. Additionally, this command can reset the media state in case the media has been authenticated.

Solution

- Android 4.4 or later allows to configure the time period after which it sends the presence check command. This time shall be configured to a value that is long enough that no presence check is performed during the transaction.
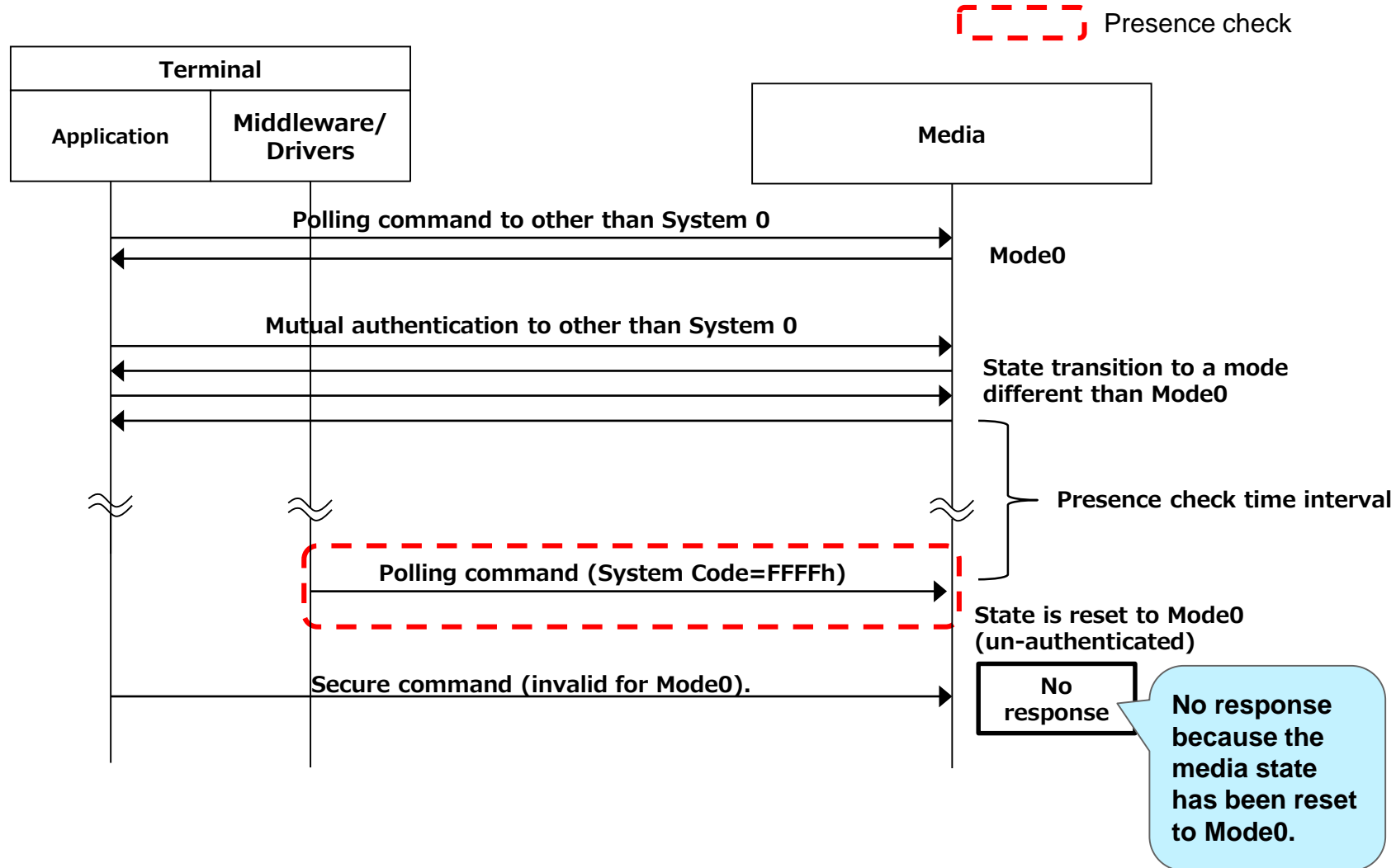
B-6: Presence check interrupts transaction

- The terminal incorrectly recognizes no media in the field.

B-6: Presence check interrupts transaction

- The terminal resets the media state.

Presence check

Terminal		Media
Application	**Middleware/ Drivers**	

Polling command to other than System 0 →

← Mode0

Mutual authentication to other than System 0 →

← State transition to a mode
different than Mode0

Presence check time interval

Polling command (System Code=FFFFh) →

State is reset to Mode0
(un-authenticated)

Secure command (invalid for Mode0). →

No response

No response because the media state has been reset to Mode0.

C-1: Polling process for multiple RF technologies #1

Impact

Host	Payment application	Terminal software	Terminal hardware

Level

- Medium

Problem

- A payment process using NFC-F fails when an NFC mobile device supporting multiple technologies is tapped to a terminal that implements the EMVCo polling procedure.

Root cause

- The EMVCo polling and collision detection procedures are designed to make sure that only a single device is present in the field. If multiple technologies or devices are detected, the process is aborted. If an NFC mobile device supporting multiple technologies is tapped on such a terminal, two problems can occur when targeting an NFC-F payment transaction:
  - Two technologies are detected and the process is aborted.
  - NFC-F is not detected by the terminal.

  A more detailed description can be found on the next slide.

C-1: Polling process for multiple RF technologies #1

Root cause (detailed description)

- The EMVCo polling procedure polls for NFC-A, NFC-B and optionally for additional technologies like NFC-F (in that order). After a technology has been detected, the polling procedure continues to poll for all other supported technologies. The procedure performs an RF reset after polling for additional technologies.

- On the other side the NFC mobile device will respond to the first technology it supports and then won't respond to other technologies until an RF reset.

- The technology that is detected first by the terminal depends on the point in time when the NFC mobile device is tapped on the terminal.

- Assuming that the user intends to use a FeliCa-based payment service with an NFC mobile device that supports NFC-A, NFC-B and NFC-F:

  - if NFC-F is detected first, the polling procedure performs a reset and polls again for NFC-A and NFC-B. This results in detecting two technologies because the NFC mobile device will respond to NFC-A after the reset. In this case the EMVCo collision detection procedure will abort the process.

  - if NFC-B is detected first, the polling procedure polls for NFC-F, resets the RF field and then polls for NFC-A. Again two technologies are detected, as the NFC mobile device responds to NFC-A after the RF reset. The EMVCo collision detection procedure will abort the process.

  - if NFC-A is detected first, the other technologies are polled without an RF reset in-between. Therefore no other technology is detected and the process is not aborted, but NFC-F is not visible to the terminal and the NFC-F based payment transaction cannot be performed.

  In all cases, the user can not use the FeliCa-based payment service.

  Remark: If the terminal additionally uses the optional RF reset before polling for NFC-F, it will always detect multiple technologies.

Japan Electronic-money Promotion Association

C-1: Implementation example

Solution

- The terminal using NFC-F shall differentiate between NFC-F and EMVCo payments and only apply the EMVCo procedures for EMVCo payments as shown below.

Implementation example for co-existence between EMVCo and FeliCa-based services

- The terminal shall be configured before the transaction on whether to perform an EMVCo or FeliCa transaction. This configuration can be triggered by the cashier based on the payment service the payer wants to use.
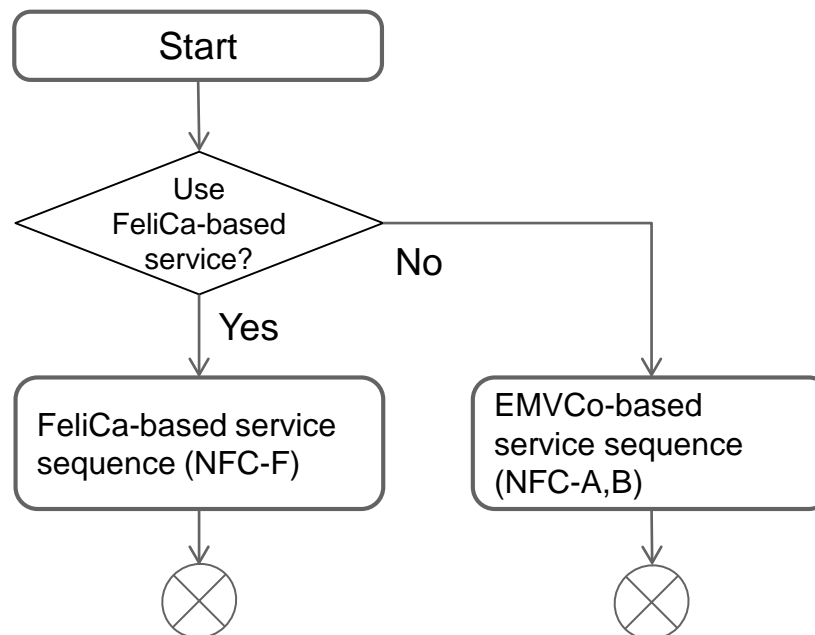
C-2: Polling process for multiple RF technologies #2

■ **Impact**

Host	Payment application	Terminal software	Terminal hardware

■ **Level**

  ■ Medium

■ **Problem**

  ■ A multi-technology terminal might not detect that an NFC mobile device supports NFC-F and therefore can not perform the FeliCa payment transaction.

■ **Root cause**

  ■ An NFC mobile device is locked in the technology it first responds to. Afterwards it will not respond to polling commands of other technologies as long as the RF Field remains ON. To change the technology, the terminal therefore needs to perform an RF reset.
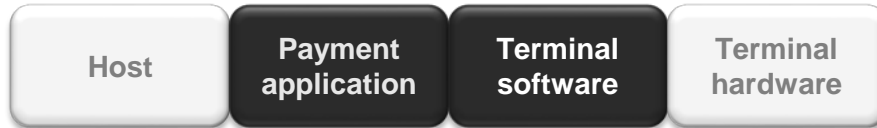
■ **Solution**

  ■ The terminal shall only poll for a technology if it has at least one application that uses the technology.

  ■ When the terminal has received a response to a polling command of a technology, it shall perform an RF reset before polling for another technology.

C-3: Invalid Polling command

Impact

| Host | Payment application | Terminal software | Terminal hardware |

Level

- Medium

Problem

- A payment transaction fails when an NFC mobile device is tapped on a terminal that uses an invalid Polling command.

Root cause

- The terminal uses an invalid Polling command. The length of a Polling command is 6 bytes in NFC Forum and FeliCa specifications. Some existing fare media can also accept Polling commands with an invalid length, nevertheless such invalid Polling commands shall not be used.
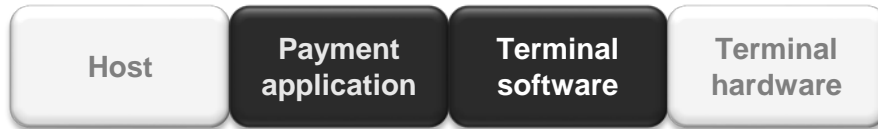
Solution

- The terminal shall format Polling commands as defined in the NFC Forum and FeliCa specifications. A compliant Polling command has a length of 6 bytes.

C-4: Guard time

Impact

Host	Payment application	Terminal software	Terminal hardware

Level

- Low

Problem

- A payment transaction fails when a FeliCa media is tapped on a legacy terminal that does not respect the guard times of the media.

Root cause

- After receiving a response, the terminal does not respect the defined guard time and is sending a new command before the media is ready to receive it (the guard time is required by the media to switch to receive mode after sending a response).

Solution

- The terminal shall respect the defined guard times when transmitting or re-transmitting a command.

C-4: Guard time

■ **NFC Forum and FeliCa specifications define the guard times. The guard time of media is defined as a minimum time the terminal shall wait until it sends the next command.**
Remark: In NFC Forum specifications the corresponding definition is the 'Frame Delay Time Listen→Poll', however the values are different as the NFC Forum specifications include the duration for the 'Preamble' of the NFC-F frame.

■ **The guard time of media is defined in the FeliCa specification as follows:**

■ For normal commands except for the Polling command
  ■ The terminal shall not send any commands during the guard time (approx. 501 µs), which starts at the end of the last response that was received.

Starting point

Preamble	Sync	Response	CRC			Preamble	Sync	Command	CRC	

Time t
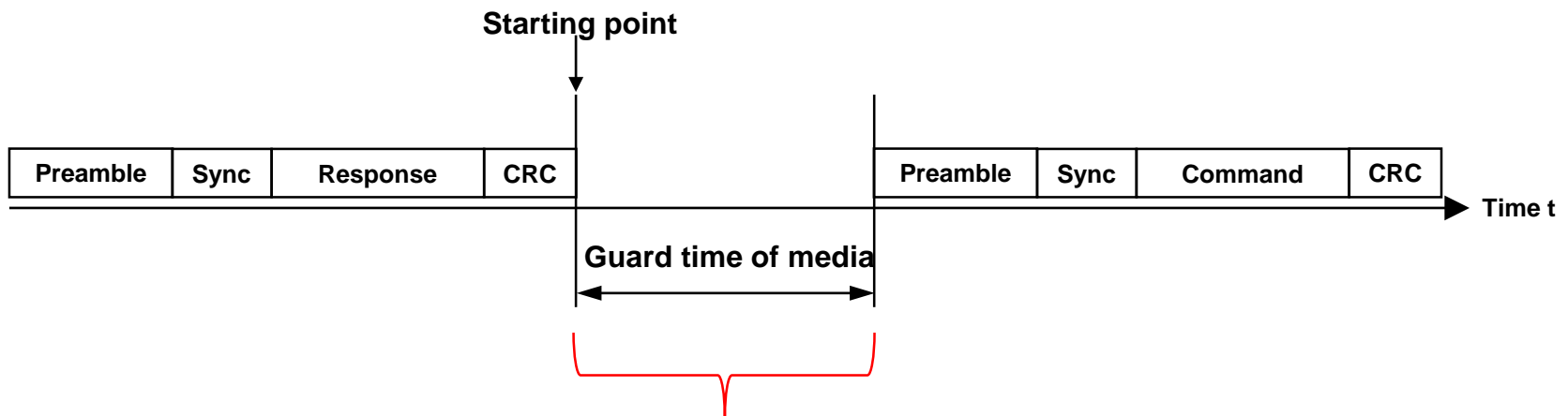
Guard time of media

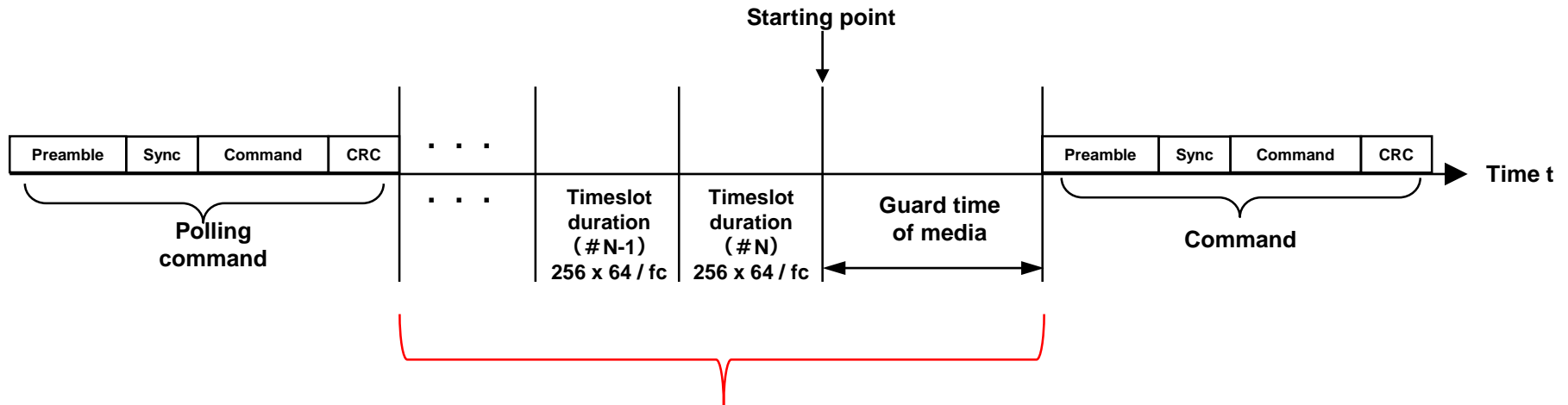Guard time of media = (106 × 64 ＋ 16) / fc = approx. 501µs）

Quoted from FeliCa Card User's Manual Excerpted Edition Ver2.01 P.20

C-4: Guard time (Continued)

The guard time of media is defined in FeliCa specification as follows:

- For Polling
  - The terminal shall not send any command within a maximum response time of a Polling command plus the guard time of media.

Polling maximum response time = Polling response time + num of slots x timeslot duration
  Polling response time = 512 x 64 / fc (approx. 2.417 ms)
  Timeslot duration = 256 x 64 / fc (approx. 1.208 ms)
Guard time of media = (106 x 64 + 16) / fc (approx. 501 µs)

Quoted from FeliCa Card User's Manual Excerpted Edition Ver2.01 P.21

Bibliography

Development Guidelines for NFC/FeliCa-Enabled Devices
https://www.sony.net/Products/felica/business/tech-support/index.html#FeliCa03

Best practice White paper: NFC-F Device Detection
https://www.sony.net/Products/felica/business/tech-support/index.html#NFC03

NFC Forum Specifications
https://nfc-forum.org/our-work/specifications-and-application-documents/specifications/specification-releases/