
Communication Protocol Between Pedelec Station and Central Management System

Authors:
RWTH - i5

Version:
0.0.20

Date:
21.07.2015

Version History

| Version | Date | Description |
|---------|------------|---|
| 0.0.1 | 01.07.2014 | Initial draft |
| 0.0.2 | 03.07.2014 | Added Update Firmware (by CMS) and Firmware Status Notification (by PS) Added Change & Get Pedelec Configuration (by CMS) |
| 0.0.3 | 08.07.2014 | Deleted maxBatteryRange from Charging Status Notification (by PS) |
| 0.0.4 | 10.07.2014 | Added Upload Logs (by CMS) and Logs Status Notification (by PS) Added more parameters to Charging Status Notification (by CMS) |
| 0.0.5 | 18.08.2014 | Updated station pedelec URLs in section 3 |
| 0.0.6 | 25.08.2014 | Added ChangeState Type |
| 0.0.7 | 06.10.2014 | Added the operations Reserve Now and Cancel Reservation |
| 0.0.8 | 15.10.2014 | Changed in "Start Transaction" parameter from 'userId' to 'cardId' |
| 0.0.9 | 24.10.2014 | Send 'cardId' instead of 'userId' after Authorize Request |
| 0.0.10 | 03.11.2014 | Add Card Activation API |
| 0.0.11 | 27.11.2014 | Add "Get Available Pedelecs" API and update "Card Activation" API |
| 0.0.12 | 12.01.2015 | Change request param in "Remote Authorize"; replacing "remainingTrials" in "Authorize" with error 403 |
| 0.0.14 | 04.03.2015 | In 2.7 & 2.8 renamed to "cardPin", added types-column, changed "userId" to "cardId" in 3.14; "pedelecManufacturerId" in 2.1 and "error-code"/"errorinfo" in 2.2/2.3 are now optional; removed "slotManufacturerId" in 2.4 |
| 0.0.15 | 06.03.2015 | Added EncryptionKeys in 2.1 BootNotification and checksum in 3.12 Update Firmware |
| 0.0.16 | 10.03.2015 | Renamed values in chapter 4 - Types and errorCode + errorInfo are optional |
| 0.0.17 | 24.04.2015 | Added stationURL in BootNotification and accountState in Authorize (Chapter 2) |
| 0.0.18 | 24.06.2015 | Simplified return object of get available pedelecs |
| 0.0.19 | 02.07.2015 | Added CardId Param to 2.11 Get Available Pedelecs for filtering user-reservations |
| 0.0.20 | 21.07.2015 | Added charging state NOT_CHARGING |

Contents

| | | |
|----------|--|-----------|
| 1 | Introduction | 6 |
| 1.1 | Use Cases | 6 |
| 1.2 | Technology | 8 |
| 2 | Operations Initiated by Pedelec Station | 9 |
| 2.1 | Boot Notification | 9 |
| 2.2 | Station Status Notification | 9 |
| 2.3 | Pedelec Status Notification | 10 |
| 2.4 | Charging Status Notification | 10 |
| 2.5 | Firmware Status Notification | 11 |
| 2.6 | Logs Status Notification | 11 |
| 2.7 | Authorize | 11 |
| 2.8 | Activate Card | 12 |
| 2.9 | Start Transaction | 13 |
| 2.10 | Stop Transaction | 13 |
| 2.11 | Get Available Pedelecs | 13 |
| 2.12 | Heartbeat | 14 |
| 3 | Operations Initiated by Central Management System | 15 |
| 3.1 | Change Station Operation State | 15 |
| 3.2 | Change Pedelec Operation State | 15 |
| 3.3 | Change Pedelec Configuration | 15 |
| 3.4 | Change Station Configuration | 16 |
| 3.5 | Get Station Configuration | 16 |
| 3.6 | Get Charging Status | 17 |
| 3.7 | Get Pedelec Configuration | 17 |
| 3.8 | Remote Authorize | 17 |
| 3.9 | Cancel Authorize | 18 |
| 3.10 | Reboot | 18 |
| 3.11 | Unlock Slot | 18 |
| 3.12 | Update Firmware | 18 |
| 3.13 | Upload Logs | 19 |
| 3.14 | Reserve Now | 19 |
| 3.15 | Cancel Reservation | 20 |

| | | |
|----------|--------------------------------------|-----------|
| 4 | Types | 21 |
| 4.1 | Error Message Template | 21 |
| 4.2 | Operation State | 21 |
| 4.3 | Charging State | 21 |
| 4.4 | Firmware Update State | 21 |
| 4.5 | Logs Update State | 21 |
| 4.6 | Account State | 21 |
| 4.7 | Configuration Error Reason | 22 |

Acronyms

PS Pedelec Station

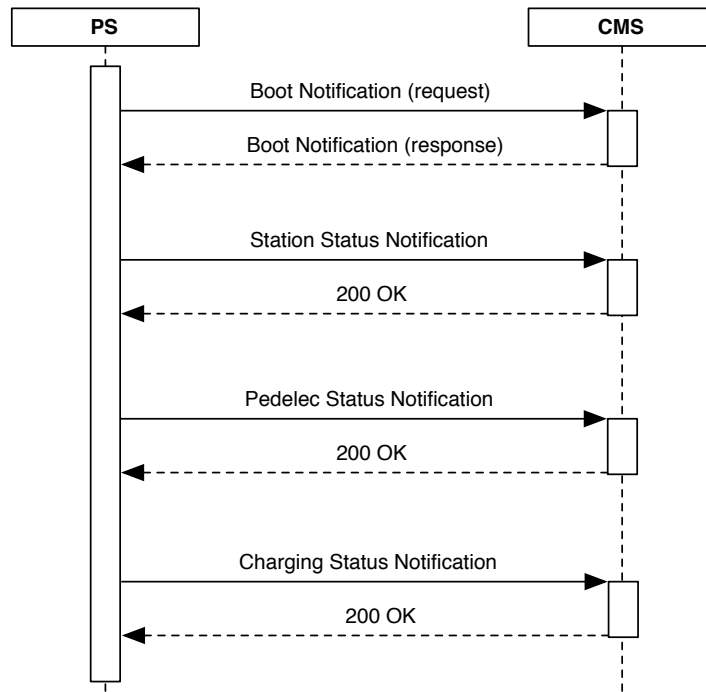
CMS Central Management System

1 Introduction

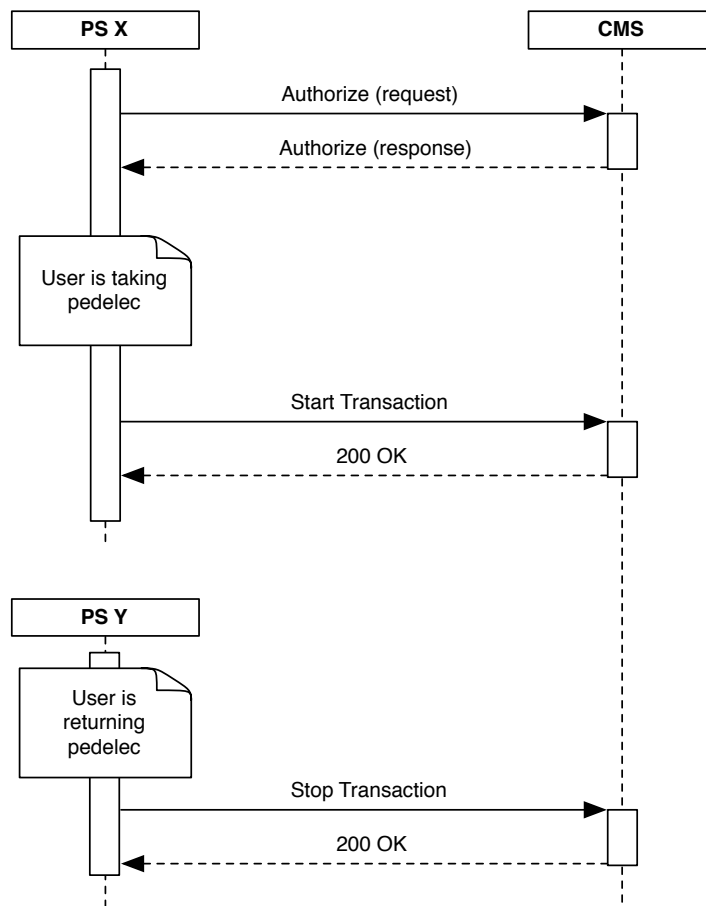
// TODO

1.1 Use Cases

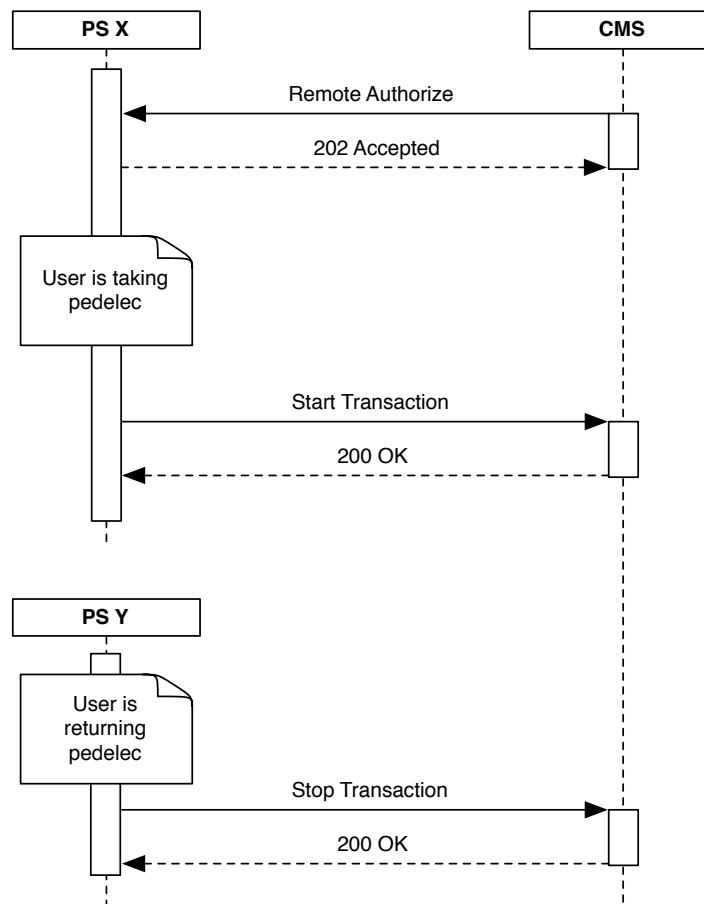
1.1.1 Station Boot



1.1.2 Rent Bike with Card



1.1.3 Rent Bike with App



1.2 Technology

The protocol is designed to be implemented as a RESTful Webservice with HTTP as the underlying data transfer protocol. The resources are represented in JSON data format.

We require that all communications are done encrypted, e.g. using SSL/TLS or VPN.

2 Operations Initiated by Pedelec Station

2.1 Boot Notification

Description: After start-up of a PS, the PS sends a notification to the CMS with information about its configuration (e.g., manufacturer id, connected station slots and pedelecs). CMS will accept only registered stations.

After each reboot, the Boot Notification is sent.

The CMS sends a response with the acceptable status, including current time and heartbeat interval if accepted.

The PS repeats the Boot Notification (in an appropriated interval) until the CMS accepts the PS. The PS requests nothing else, until CMS accepts it.

URL: [BASE_CMS_URI]/boot

Method: POST

Request:

| Field | Type | Description |
|-----------------------------|-------------------|---|
| stationManufacturerId | String | This value identifies the PS by its hardware serial |
| firmwareVersion | String | Firmware version of PS |
| slots/slotManufacturerId | String | This value identifies the slot by its hardware serial |
| slots/slotPosition | Integer | The sequence position of the connected slot |
| slots/pedelecManufacturerId | String (optional) | This value identifies the locked pedelec by its hardware serial related to the slot |
| stationURL | String | URL to communicate with PS initiated by CMS |

Response: **200 OK**

| Field | Type | Description |
|-------------------|---------|--|
| timestamp | Long | Unix timestamp (seconds since epoch) |
| heartbeatInterval | Integer | In seconds |
| cardReadEncrKey | String | Encryption key to read out user's cardId |
| cardWriteEncrKey | String | Encryption key to write user's cardId |

Errors: **406 Not Acceptable** (If the station is not registered)

5xx Server Error

2.2 Station Status Notification

Description: A PS sends a notification to the CMS to inform the CMS about its status or error condition within the PS including the connected station slots. A PS shall send a Station Status Notification when it becomes unavailable as a result of an error condition or other external events.

URL: [BASE_CMS_URI]/status/station

Method: POST

| Request: | Field | Type | Description |
|----------|--------------------------|--------|---|
| | stationManufacturerId | String | This value identifies the PS by its hardware serial |
| | stationErrorCode | String | Required when stationState is INOPERATIVE |
| | stationErrorInfo | String | Required when stationState is INOPERATIVE |
| | stationState | String | See Section 4.2 |
| | timestamp | Long | Unix timestamp (seconds since epoch) |
| | slots/slotManufacturerId | String | This value identifies the slot by its hardware serial |
| | slots/slotErrorCode | String | Required when slotState is INOPERATIVE |
| | slots/slotErrorInfo | String | Required when slotState is INOPERATIVE |
| | slots/slotState | String | See Section 4.2 |

Response: **200 OK**

Errors: **5xx Server Error**

2.3 Pedelec Status Notification

Description: A PS sends a notification to the CMS to inform the CMS about the status or error condition of connected pedelecs. A PS shall send an Pedelec Status Notification when a pedelec becomes unavailable as a result of an error condition or other external events.

URL: [BASE_CMS_URI]/status/pedelec

Method: POST

| Request: | Field | Type | Description |
|----------|-----------------------|--------|--|
| | pedelecManufacturerId | String | This value identifies the Pedelec by its hardware serial |
| | pedelecErrorCode | String | Required when pedelecState is INOPERATIVE |
| | pedelecErrorInfo | String | Required when pedelecState is INOPERATIVE |
| | pedelecState | String | See Section 4.2 |
| | timestamp | Long | Unix timestamp (seconds since epoch) |

Response: **200 OK**

Errors: **5xx Server Error**

2.4 Charging Status Notification

Description: The PS informs the CMS at regular intervals about the charging status (in

time intervals or when fully charged) of all connected pedelecs of the PS.

The message contains the current timestamp, the meter value (Wh), the charging state (e.g., charging, completed), the and PedelecID.

URL: [BASE_CMS_URI]/status/charging

Method: POST

| Request: | Field | Type | Description |
|----------|-----------------------|---------|--------------------------------------|
| | pedelecManufacturerId | String | |
| | timestamp | Long | Unix timestamp (seconds since epoch) |
| | chargingState | String | See Section 4.3 |
| | meterValue | Double | |
| | battery/soc | Double | percentage points |
| | battery/temperature | Double | |
| | battery/cycleCount | Integer | |
| | battery/voltage | Double | |
| | battery/current | Double | |

Response: **200 OK**

Errors: **5xx Server Error**

2.5 Firmware Status Notification

Description: A PS notifies CMS about the success/failure of the firmware update.

URL: [BASE_CMS_URI]/status/firmware

Method: POST

| Request: | Field | Type | Description |
|----------|--------|--------|---|
| | status | String | Progress status of the firmware update; see Section 4.4 |

Response: **200 OK**

Errors: **5xx Server Error**

2.6 Logs Status Notification

Description: The PS informs the CMS about the status of requested uploading of logs.

URL: [BASE_CMS_URI]/status/logs

Method: POST

| Request: | Field | Type | Description |
|----------|--------|--------|--|
| | status | String | Upload status of the logs; see Section 4.5 |

Response: **200 OK**

Errors: **5xx Server Error**

2.7 Authorize

Description: Before a user can choose and unlock a pedelec with his CustomerCard (e.g., Bluecard), the PS needs to be able to authorize the operation. Only after

authorization the PS will be able to unlock the pedelec. For this purpose the PS needs user's Card-ID and PIN for authorization.

The response shall indicate, whether or not the Card-ID and PIN combination is accepted by the CMS.

URL: [BASE_CMS_URI]/authorize

Method: POST

| Request: | Field | Type | Description |
|----------|---------|--------|----------------------|
| | cardId | String | Card specific number |
| | cardPin | String | User's secret PIN |

Response: **202 Accepted** (If credentials are accepted)

| Field | Type | Description |
|--------------|---------------|----------------------|
| cardId | String | Card specific number |
| accountState | Account State | See Section 4.6 |

Errors: **403 Forbidden - no trials remaining and account gets disabled**

403 Forbidden - card account is unknown

403 Forbidden - card account is disabled

403 Forbidden - wrong pin

406 Not Acceptable

5xx Server Error

2.8 Activate Card

Description: Before a user can use his card (e.g., Bluecard) to rent a bike, he has to activate it on the PS terminal. For this purpose, the PS sends Activation-Key and PIN to the CMS.

The response shall indicate, whether or not the Activation-Key and PIN are accepted by the CMS and responses with the CardId.

URL: [BASE_CMS_URI]/activate-card

Method: POST

| Request: | Field | Type | Description |
|----------|---------------|--------|--|
| | activationKey | String | Key to start activation process to initial user's card |
| | cardPin | String | PIN for customer's card |

Response: **202 Accepted** (If credentials are accepted)

| Field | Type | Description |
|--------|--------|----------------------|
| cardId | String | Card specific number |

Errors: **406 Not Acceptable**

5xx Server Error

2.9 Start Transaction

Description: When the rental is authenticated, the station slot is unlocked and the user took the pedelec out of the slot, the PS needs to inform the CMS about this.

As response the CMS sends an acknowledgment.

URL: [BASE_CMS_URI]/transaction/start

Method: POST

| Request: | Field | Type | Description |
|----------|-----------------------|--------|--------------------------------------|
| | cardId | String | |
| | pedelecManufacturerId | String | |
| | stationManufacturerId | String | |
| | slotManufacturerId | String | |
| | timestamp | Long | Unix timestamp (seconds since epoch) |

Response: **200 OK**

Errors: **5xx Server Error**

2.10 Stop Transaction

Description: After the PS recognizes the return of a pedelec at a station slot, it needs to inform the CMS about this.

As response the CMS sends an acknowledgment.

URL: [BASE_CMS_URI]/transaction/stop

Method: POST

| Request: | Field | Type | Description |
|----------|-----------------------|--------|--------------------------------------|
| | pedelecManufacturerId | String | |
| | stationManufacturerId | String | |
| | slotManufacturerId | String | |
| | timestamp | Long | Unix timestamp (seconds since epoch) |

Response: **200 OK**

Errors: **5xx Server Error**

2.11 Get Available Pedelecs

Description: PS can retrieve a list of available pedelecs ordered by a predefined priority or a specific pedelec for a user's reservation when available for this moment.

URL: [BASE_CMS_URI]/available-pedelecs?cardId=ab34-cd56

Method: GET

| Request: | Field | Type | Description |
|----------|--------|--------|----------------|
| | cardId | String | User's card ID |

Response: **200 OK**

| Type | Description |
|----------|---|
| String[] | List of manufacturer Ids for available pedelecs |

Errors: **5xx Server Error**

2.12 Heartbeat

Description: To let the CMS know that a station is still connected, a PS sends heartbeats regularly in configurable time intervals.

The CMS sends a response with the current time of the CMS, which could be used to synchronize the time of the PS with the time of the CMS.

URL: `[BASE_CMS_URI]/heartbeat`

Method: GET

Request: -

Response: **200 OK**

| Field | Type | Description |
|-----------|------|--------------------------------------|
| timestamp | Long | Unix timestamp (seconds since epoch) |

Errors: **5xx Server Error**

3 Operations Initiated by Central Management System

3.1 Change Station Operation State

Description: CMS can request to change the operation state of a PS or its slots. The PS can accept or reject the process the request. When rejected, the PS must include a reason.

URL: [BASE_PS_URI]/state

Method: POST

| Request: | Field | Type | Description |
|----------|-------------------------|-----------------|--|
| | slotPosition (optional) | Integer | When present, the state of the slot with the given position will be changed. When absent, the state of whole PS will be changed. |
| | state | See Section 4.2 | |

Response: **202 Accepted**

Errors: **406 Not Acceptable**

5xx Server Error

3.2 Change Pedelec Operation State

Description: CMS can request to change the operation state of a pedelec located at a slot of a PS. The PS can accept or reject the process the request. When rejected, the PS must include a reason.

URL: [BASE_PS_URI]/pedelecs/<pedelecManufacturerId>/state

Method: POST

| Request: | Field | Type | Description |
|----------|--------------|---------|--|
| | slotPosition | Integer | The position of the slot where the pedelec is located. |
| | pedelecState | String | See Section 4.2 |

Response: **202 Accepted**

Errors: **406 Not Acceptable**

5xx Server Error

3.3 Change Pedelec Configuration

Description: CMS can request a PS to change specific Pedelec configuration parameters. This request contains a list of key-value pairs, where "key" is the name of the configuration setting to change and "value" contains the new setting for the configuration setting.

URL: [BASE_PS_URI]/pedelecs/<pedelecManufacturerId>/config

Method: POST

| Request: | Field | Type | Description |
|----------|-----------------|--------|-------------|
| | maxCurrentValue | Double | .. |
| | maxBatteryLevel | Double | .. |

Response: **202 Accepted** (If all the parameter changes are accepted and done)

Errors: **400 Bad Request**

| Field | Type | Description |
|--------|--------|---|
| failed | ... | List of parameters that PS failed to set a new value for. |
| reason | String | See Section 4.7 |

5xx Server Error

3.4 Change Station Configuration

Description: CMS can request a PS to change configuration parameters. This request contains a list of key-value pairs, where "key" is the name of the configuration setting to change and "value" contains the new setting for the configuration setting.

URL: [BASE_PS_URI]/config

Method: POST

| Request: | Field | Type | Description |
|----------|------------------------------|---------|---|
| | cmsURI | String | New value for the CMS Webser-vice URI |
| | heartBeatInterval | Integer | In seconds |
| | openSlotTimeout | Integer | In seconds. How long should PS wait after unlocking a slot before locking it again. |
| | rebootRetries | Integer | How many times should PS try to reboot before giving up. |
| | chargingStatusInformInterval | Integer | In seconds |

Response: **202 Accepted** (If all the parameter changes are accepted and done)

Errors: **400 Bad Request**

| Field | Type | Description |
|--------|--------|---|
| failed | .. | List of parameters that PS failed to set a new value for. |
| reason | String | See Section 4.7 |

5xx Server Error

3.5 Get Station Configuration

Description: CMS can retrieve the values of configuration settings. This operation requires no parameters, and PS returns all values.

URL: [BASE_PS_URI]/config

Method: GET

Request: -

Response: **200 OK**

JSON object with return values for elements defined in Section 3.4/Request

Errors: **5xx Server Error**

3.6 Get Charging Status

Description: Even though a PS informs the CMS about the charging status of pedelecs regularly, it is desirable to get the latest information in various cases.

URL: [BASE_PS_URI]/charging-status

Method: GET

Request: -

Response: **200 OK**

JSON object with return values for elements defined in Section 2.4/Request

Errors: **5xx Server Error**

3.7 Get Pedelec Configuration

Description: CMS can retrieve the values of configuration settings. This operation requires no parameters, and PS returns all values.

URL: [BASE_PS_URI]/pedelecs/<pedelecManufacturerId>/config

Method: GET

Request: -

Response: **200 OK**

JSON object with return values for elements defined in Section 3.3/Request

Errors: **5xx Server Error**

3.8 Remote Authorize

Description: When using the mobile app for renting a pedelec the user does not require a card to authenticate against the PS, but uses the app to authenticate directly against the CMS. In this case, CMS sends a Remote Authorize message to the PS to unlock the slot(s) for the user to take the pedelec.

After a timeout period PS checks the existence of a pedelec at the slot(s) and sends a Start Transaction message to CMS, namely the rental process proceeds usual.

URL: [BASE_PS_URI]/authorize/remote

Method: POST

Request:

| Field | Type | Description |
|--------------|---------|-------------|
| slotPosition | Integer | |
| cardId | String | |

Response: **202 Accepted**

Errors: **406 Not Acceptable**

5xx Server Error

3.9 Cancel Authorize

Description: When using the mobile app for renting a pedelec the user can wish to cancel the rental process after Remote Authorize is initiated. In this case, CMS sends a Cancel Authorize message to PS to lock the slot(s) again.

URL: [BASE_PS_URI]/authorize/cancel/<slotPosition>

Method: POST

Request: -

Response: **202 Accepted**

Errors: **406 Not Acceptable**

5xx Server Error

3.10 Reboot

Description: CMS can request a PS to reboot. When accepted, the PS reboots after gracefully terminating running software. When rejected, the PS must include a reason.

URL: [BASE_PS_URI]/reboot

Method: POST

Request: -

Response: **202 Accepted**

Errors: **406 Not Acceptable**

5xx Server Error

3.11 Unlock Slot

Description: In cases of maintenance or technical problems CMS can request a PS to unlock a slot or all slots in order to access a pedelec.

URL: [BASE_PS_URI]/unlock/<slotPosition>
slotPosition is optional. When absent, the PS unlocks all slots.

Method: POST

Request: -

Response: **202 Accepted**

Errors: **406 Not Acceptable**

5xx Server Error

3.12 Update Firmware

Description: The CMS can send the PS a firmware update command. With a firmware update request, the CMS informs the PS about a new firmware, including the location of the firmware and the date & time when the update shall be executed.

The PS should start as soon as possible the firmware after retrieving the retrieve-update.

URL: [BASE_PS_URI]/update-firmware

Method: POST

| Request: | Field | Type | Description |
|----------|-------------------|--------|---|
| | firmwareUpdateUrl | String | Location of the firmware update |
| | executionDateTime | Long | Date and time when the PS should execute update, UNIX timestamp |
| | checksum | String | |

Response: **200 OK**

Errors: **5xx Server Error**

3.13 Upload Logs

Description: In order to diagnose errors, the CMS can request the PS to upload its locally stored log files to a remote directory. The fields oldestLogTimestamp and latestLogTimestamp define a date/time range for the requested logs. When both absent, PS uploads all logs.

URL: [BASE_PS_URI]/upload-logs

Method: POST

| Request: | Field | Type | Description |
|----------|-------------------------------|--------|--|
| | logDirectoryUrl | String | Directory for the logs to be uploaded to |
| | oldestLogTimestamp (optional) | Long | UNIX timestamp |
| | latestLogTimestamp (optional) | Long | UNIX timestamp |

Response: **200 OK**

A JSON array with the file names of the logs to be uploaded.

Errors: **404 Not Found**

When logs for the requested time window do not exist.

5xx Server Error

3.14 Reserve Now

Description: A customer can reserve a pedelec for a specific time. For this purpose, the CMS sends a reservation message with an expiry date to the PS. The message does not include a specific pedelec, it reminds the PS to keep free one bike for one reservation.

URL: [BASE_PS_URI]/reserve-now

Method: POST

| Request: | Field | Type | Description |
|----------|---------------|------|--|
| | reservationId | .. | Id to identify reservation on CMS and PS side |
| | cardId | .. | Customer identification |
| | expiryDate | Long | UNIX timestamp which identifies the end of the reservation |

Response: **200 OK**

A reservation was successfully added to the PS

Errors:

403 Forbidden

When no pedelecs are available.

5xx Server Error

3.15 Cancel Reservation

Description: A customer or the CMS can cancel a reservation. For this purpose, the CMS sends a cancel reservation message with the reservationId to the PS which holds the reservation.

URL: [BASE_PS_URI]/cancel-reservation

Method: POST

| Request: | Field | Type | Description |
|----------|---------------|------|---|
| | reservationId | .. | Id to identify reservation on CMS and PS side |

Response: **200 OK**

A reservation was successfully removed.

Errors:

404 Not Found

When the reservation was not found.

5xx Server Error

4 Types

4.1 Error Message Template

In case an error occurs, regardless of the HTTP code that is returned the implementation *always* responses with a JSON object containing following fields:

| Field | Description |
|-----------|---|
| timestamp | Unix timestamp (seconds since epoch) |
| code | Internal, application-specific error code |
| message | Additional explanation |

4.2 Operation State

| Value | Description |
|-------------|--|
| OPERATIVE | When the item is functional and working and ready to serve |
| INOPERATIVE | When the item is faulted and cannot be used |

4.3 Charging State

| Value | Description |
|--------------|--|
| CHARGING | When the battery is charging |
| COMPLETED | When the charging process is completed |
| NOT_CHARGING | Neither charging nor completed |

4.4 Firmware Update State

| Value | Description |
|---------------------|--|
| DOWNLOAD_FAILED | PS failed to load firmware |
| INSTALLATION_FAILED | Installation of firmware failed |
| INSTALLED | Firmware is successfully installed in PS |

4.5 Logs Update State

| Value | Description |
|---------------|-------------|
| UPLOADED | |
| UPLOAD_FAILED | |

4.6 Account State

| Value | Description |
|-----------------|---|
| HAS_PEEDELEC | When customer occupies at least one pedelec |
| HAS_NO_PEEDELEC | When customer has no pedelec |

4.7 Configuration Error Reason

| Value | Description |
|---------------|---|
| NotAcceptable | If the request for some keys could not be processed. The server returns a JSON array of keys that are rejected (in this case other parameters are set) |
| NotFound | If some of the keys are not found/supported. The server returns a JSON array of keys that are not found as configuration parameters (in this case other parameters are set) |