

# Battery Service ~~Specification~~

## Bluetooth® Service Specification

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- Prepared By: ~~GPA~~HID Working Group

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### Abstract:

The Battery Service exposes the ~~state of~~battery level and other information for a battery within a device.



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## Document Terminology

The Bluetooth SIG has adopted Section 13.1 of the IEEE Standards Style Manual, which dictates use of the words “shall”, “should”, “may”, and “can” in the development of documentation, as follows:

The word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).

The use of the word *must* is deprecated and shall not be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

The use of the word *will* is deprecated and shall not be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is deprecated but not prohibited (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).



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# 1 Introduction

~~The Battery Service exposes the Battery Level of a single battery or set of batteries in a device.~~

The Battery Service exposes the Battery Level and other information for a battery (which may be composed of one or more cells) in the context of the battery's electrical connection to a device. If a device has several batteries to be monitored, then multiple instances of the Battery Service should be declared. The following examples show various ways of using the Battery Service. In each case, it is possible that the batteries are removable.

Figure 1.1 shows an example of a basic device with a single battery and Battery Service instance.

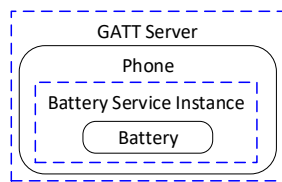


Figure 1.1: Example of Battery Service use in a basic device

Figure 1.2 and Figure 1.3 show examples of one system made up of two devices that can operate independently. In the example of Figure 1.2, these devices are physically separate, while in the example of Figure 1.3, these devices are attachable. Each device has a single battery, Battery Service instance, and Generic Attribute Profile (GATT) Server whether the devices are attached or not.

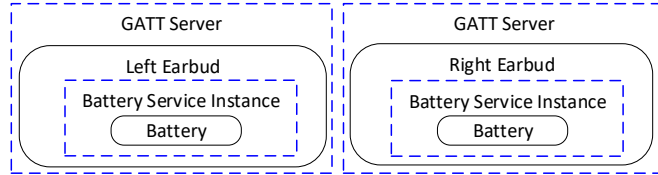


Figure 1.2: Example of Battery Service use in two physically separate devices

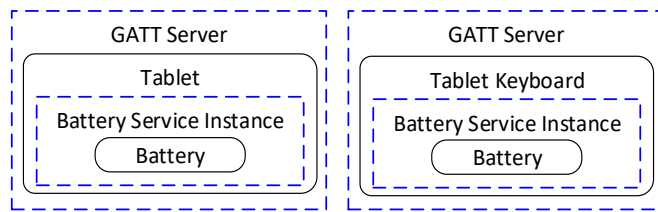


Figure 1.3: Example of Battery Service use in two attachable devices

Figure 1.4 shows an example of a distributed device (i.e., two physical ear buds that present as a single headset), where each device has a single battery and Battery Service instance, but the devices share a GATT Server.

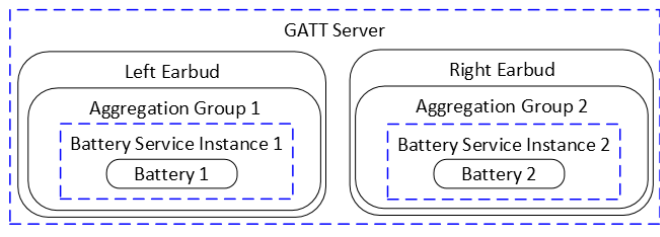


Figure 1.4: Alternate example of Battery Service use in a distributed device

Figure 1.5 shows an example of a detachable and distributed device. The display has a single non-removable battery with its Battery Service instance. The base has two batteries, each with a Battery Service instance. The entire device shares a GATT Server. In this example, only the display has a Bluetooth radio and can expose the Battery Service instances for the batteries in the base. When the base is detached, the services and characteristics for those batteries remain in the GATT database but their values will show the batteries as being removed. See Appendix A for an example message sequence illustrating the removal and insertion of a battery.

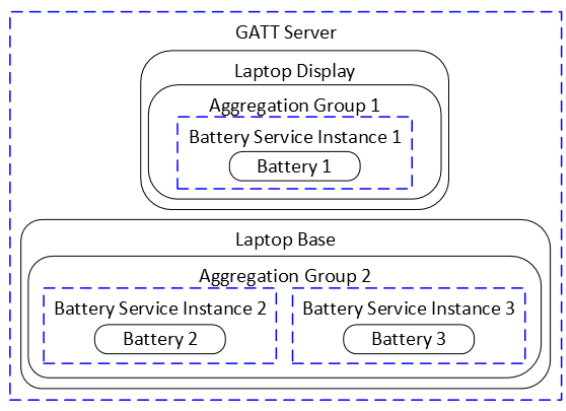


Figure 1.5: Alternate example of Battery Service use in a detachable and distributed device

Figure 1.6 shows an example of a phone with a primary non-removable battery and a phone battery sleeve that was purchased later. The phone starts with a single instance of the Battery Service; however, when the phone battery sleeve is attached, the phone recognizes it and supports sending detailed battery status over a link providing battery information. The phone chooses to start a new instance of the Battery Service to represent the state of the phone battery sleeve.

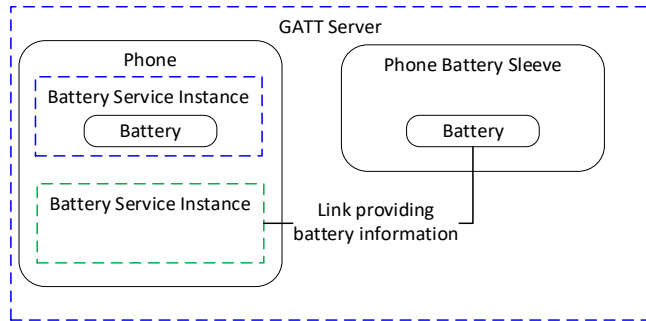


Figure 1.6: Alternate example of Battery Service use in a phone with an extra battery purchased later

## 1.1 Language

### 1.1.1 Language conventions

The Bluetooth SIG has established the following conventions for use of the words **shall**, **must**, **will**, **should**, **may**, **can**, and **note** in the development of specifications:

<u>shall</u>	<u>is required to – used to define requirements.</u>
<u>must</u>	<u>is used to express:</u> <u>a natural consequence of a previously stated mandatory requirement.</u> <u>OR</u> <u>an indisputable statement of fact (one that is always true regardless of the circumstances).</u>
<u>will</u>	<u>it is true that – only used in statements of fact.</u>
<u>should</u>	<u>is recommended that – used to indicate that among several possibilities one is recommended as particularly suitable, but not required.</u>
<u>may</u>	<u>is permitted to – used to allow options.</u>
<u>can</u>	<u>is able to – used to relate statements in a causal manner.</u>
<u>note</u>	<u>Text that calls attention to a particular point, requirement, or implication or reminds the reader of a previously mentioned point. It is useful for clarifying text to which the reader ought to pay special attention. It shall not include requirements. A note begins with “Note:” and is set off in a separate paragraph. When interpreting the text, the relevant requirement shall take precedence over the clarification.</u>

If there is a discrepancy between the information in a figure and the information in other text of the specification, the text prevails. Figures are visual aids including diagrams, message sequence charts (MSCs), tables, examples, sample data, and images. When specification content shows one of many alternatives to satisfy specification requirements, the alternative shown is not intended to limit implementation options. Other acceptable alternatives to satisfy specification requirements may also be possible.



### 1.1.2 Reserved for Future Use

Where a field in a packet, Protocol Data Unit (PDU), or other data structure is described as "Reserved for Future Use" (irrespective of whether in uppercase or lowercase), the device creating the structure shall set its value to zero unless otherwise specified. Any device receiving or interpreting the structure shall ignore that field; in particular, it shall not reject the structure because of the value of the field.

Where a field, parameter, or other variable object can take a range of values, and some values are described as "Reserved for Future Use," a device sending the object shall not set the object to those values. A device receiving an object with such a value should reject it, and any data structure containing it, as being erroneous; however, this does not apply in a context where the object is described as being ignored or it is specified to ignore unrecognized values.

When a field value is a bit field, unassigned bits can be marked as Reserved for Future Use and shall be set to 0. Implementations that receive a message that contains a Reserved for Future Use bit that is set to 1 shall process the message as if that bit was set to 0, except where specified otherwise.

The acronym RFU is equivalent to Reserved for Future Use.

### 1.1.3 Prohibited

When a field value is an enumeration, unassigned values can be marked as "Prohibited." These values shall never be used by an implementation, and any message received that includes a Prohibited value shall be ignored and shall not be processed and shall not be responded to.

Where a field, parameter, or other variable object can take a range of values, and some values are described as "Prohibited," devices shall not set the object to any of those Prohibited values. A device receiving an object with such a value should reject it, and any data structure containing it, as being erroneous.

"Prohibited" is never abbreviated.

## 1.2 Table requirements

Requirements are defined as "Mandatory" (M), "Optional" (O), "Excluded" (X), "Not Applicable" (N/A), or "Conditional" (C.n). Conditional statements (C.n) are listed directly below the table in which they appear.

### ~~4.1.1.3~~ Conformance

If ~~a device claims~~ conformance to this ~~service specification~~ is ~~claimed~~, all capabilities indicated as mandatory for this ~~service specification~~ shall be supported in the specified manner (process-mandatory). This also applies for all optional and conditional capabilities for which support is indicated. ~~All mandatory capabilities, and optional and conditional capabilities for which support is indicated, are subject to verification as part of the Bluetooth qualification program.~~

## ~~1.2~~ Service Dependency

~~This service has no dependencies on other GATT-based services.~~

## ~~1.3~~ Bluetooth Specification Release Compatibility

~~This service is compatible with any Bluetooth core specification host [1] that includes the Generic Attribute Profile (GATT).~~



## 1.4 ~~GATT Sub-Procedure Requirements~~

Additional GATT Sub-Procedures requirements beyond those required by GATT are indicated in Table 1.1.

GATT Sub-Procedure	Requirements
Read Characteristic Descriptors	M
Notifications	C1
Write Characteristic Descriptors	C1

Table 1.1: GATT Sub-Procedure Requirements

C1: Mandatory if the Battery Level characteristic properties supports notification, otherwise excluded.

## 1.5 ~~Transport Dependencies~~

This service may operate over LE and BR/EDR transports.

## 1.6 ~~Error Codes~~

This service does not define any application error codes that are used in Attribute Protocol.

### 1.7.1.4 ~~Byte Transmission Order~~ transmission order

All characteristics used with this service shall be transmitted with the least significant octet first (i.e., little endian). The least significant octet is identified in the characteristic definitions in [2].

## 1.5 ~~Service Definitions~~

For the purposes of this specification, the following definitions apply.

### 1.5.1 ~~Low~~

Low represents the battery condition in which the device will still function normally, but immediate recharge or replacement of the battery is recommended.

### 1.5.2 ~~Critical~~

Critical represents the battery condition in which a load powered by the battery might not function fully or correctly.

### 1.5.3 ~~Battery Aggregation Group~~

A Battery Aggregation Group represents a collection of one or more batteries that provide power to a device concurrently and in parallel. The capacity and level information of the batteries in the group, as provided by the Battery Service instances, can be aggregated for presentation to the user.

An example usage of a Battery Aggregation Group would be to sum the Available Energy field of the Battery Energy Status characteristic and sum the Available Battery Capacity field from two instances of Battery Service that share a Battery Aggregation Group as depicted in Figure 1.5. An application could choose to visually represent the percent of remaining energy for the Aggregation Group by calculating the sum of available energy divided by the sum of available battery capacity.



Another example of a Battery Aggregation Group would be to select the maximum value of the Time Until Discharged fields of the Battery Time Status characteristics from two instances of Battery Service that share a Battery Aggregation Group as depicted in Figure 1.5. An application could choose to represent this value as the estimated remaining time on the battery.



## 2 Service ~~Declaration~~

~~The service UUID shall be set to «Battery Service». The UUID value assigned to «Battery Service» is defined in [2].~~

### 2.1 Service dependencies

The Battery Service has no dependencies on other GATT-based services.

### 2.2 Bluetooth Core Specification release compatibility

The Battery Service is compatible with any version of the Bluetooth Core Specification [1] that includes GATT.

### 2.3 Transport dependencies

The Battery Service may operate over Low Energy (LE) and Basic Rate/Enhanced Data Rate (BR/EDR) transports. Except for the optional use of the LE broadcast feature for some characteristics, there are no transport restrictions imposed by this service specification.

### 2.4 Attribute Protocol Application error codes

This service does not define or reference any Attribute Protocol (ATT) Application error codes.

### 2.5 GATT sub-procedure requirements

Additional GATT sub-procedures requirements beyond those required by GATT are indicated in Table 2.1.

<u>GATT Sub-Procedure</u>	<u>Requirements</u>
<u>Notifications</u>	<u>C.1</u>
<u>Indications</u>	<u>C.2</u>
<u>Read Characteristic Descriptors</u>	<u>M</u>
<u>Write Characteristic Descriptors</u>	<u>C.3</u>

*Table 2.1: GATT sub-procedure requirements*

C.1: Mandatory if any characteristic properties in this service allow notification; otherwise excluded.

C.2: Mandatory if any characteristic properties in this service allow indication; otherwise excluded.

C.3: Mandatory if any characteristic properties in this service allow notification, indication, or broadcast; otherwise excluded.

### 2.6 Declaration

The service UUID shall be set to «Battery Service» as defined in [2].

This service should be instantiated as a primary service if it represents the battery status for the device even if the instance is included in another service.



### 3 ~~Service~~ ~~Characteristics~~ characteristics

Characteristic	Ref.	Mandatory / Optional
Battery-Level	3.1	M

Table 3.1: ~~Service~~ Characteristics

In Table 3.1, characteristics that are mandatory or characteristics that are optional that are implemented shall comply with the properties in Table 3.2:

	Broadcast	Read	Write without Response	Write	Notify	Indicate	Signed Write	Reliable Write	Writable Auxiliaries
Battery-Level	X	M	X	X	O	X	X	X	X

Table 3.2: Characteristic properties

Requirements marked with 'M' are mandatory, 'O' are optional and 'X' are excluded (not permitted).

This service defines no security requirements for these characteristics.

The characteristics listed in Table 3.1 are exposed in the Battery Service. Only one instance of each characteristic is permitted within this service. The service, characteristic, and descriptor UUIDs are defined in [2] and the characteristic formats are defined in the GATT Specification Supplement (GSS) [3].

Where a characteristic's properties allow it to be notified or indicated, a Client Characteristic Configuration descriptor must be included in the characteristic definition as required in Volume 3, Part G, Section 3.3.3.3 in [1].

Where a characteristic's properties allow it to be broadcast, a Server Characteristic Configuration descriptor must be included in the characteristic definition as required in Volume 3, Part G, Section 3.3.3.4 in [1].

For many devices, the values of characteristics.

#### 2.1 ~~Battery Level~~

##### 2.1.1 ~~Characteristic Behavior~~

The ~~exposed by the~~ Battery Level characteristic is read using the GATT ~~Read Characteristic Value~~ sub-procedure and returns the current battery level as a percentage from 0% to 100%; 0% represents a battery that is fully discharged, 100% represents a battery that is fully charged.

For many devices, the battery level value ~~Service~~ will not change frequently; therefore it is ~~recommended devices should not to poll this~~ for the characteristic value at a high frequency. For example, if the expected battery life is in the order of years, reading ~~the battery level~~ ~~any characteristic~~ value more frequently than once a week is ~~not recommended unnecessary~~.





This characteristic can be configured for notification using the GATT *Write Characteristic Descriptors* sub-procedure on the *Client Characteristic Configuration* descriptor. When configured for notification, this characteristic can be notified while in a connection; see section 4.1.1.

The value of the *Client Characteristic Configuration* descriptor is persistent for bonded devices when not in a connection.

## 2.1.2 Characteristic Descriptors

### 2.1.2.1 Characteristic Presentation Format

When a device has more than one instance of the Battery service, each Battery Level characteristic shall include a Characteristic Presentation Format descriptor that has a namespace/description value that is unique for that instance of the Battery service.

This descriptor shall be readable.

This descriptor shall be read using the GATT *Read Characteristic Descriptors* sub-procedure.

### 2.1.2.2 Client Characteristic Configuration Descriptor

If the characteristic properties of this characteristic allow notification, then the *Client Characteristic Configuration* descriptor shall be included in this characteristic; otherwise, this descriptor shall not be included.

If included, this descriptor shall be readable and writable.

This descriptor can be read using the GATT *Read Characteristic Descriptors* sub-procedure.

This descriptor can be written using the GATT *Write Characteristic Descriptors* sub-procedure.

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
Battery Level	<u>M</u>	<u>Read</u>	<u>Notify</u>	<u>None</u>
Battery Level descriptor: Characteristic Presentation Format descriptor	<u>C.1</u>	<u>Read</u>	<u>None</u>	<u>None</u>
Battery Level Status	<u>O</u>	<u>Read, Notify</u>	<u>LE: Broadcast ***</u> , <u>Indicate *</u> <u>BR/EDR: Indicate *</u>	<u>None</u>
Estimated Service Date	<u>C.2</u>	<u>Read, Notify</u>	<u>Indicate *</u>	<u>None</u>
Battery Critical Status	<u>C.2</u>	<u>Read</u> , <u>Indicate</u>	<u>None</u>	<u>None</u>
Battery Energy Status	<u>C.2</u>	<u>Read, Notify</u>	<u>Indicate *</u>	<u>None</u>
Battery Time Status	<u>C.2</u>	<u>Read, Notify</u>	<u>Indicate *</u>	<u>None</u>
Battery Health Status	<u>C.2</u>	<u>Read, Notify</u>	<u>Indicate *</u>	<u>None</u>



<u>Characteristic Name</u>	<u>Requirement</u>	<u>Mandatory Properties</u>	<u>Optional Properties</u>	<u>Security Permissions</u>
Battery Health Information	<u>C.3</u>	<u>Read, Indicate</u>	<u>None</u>	<u>None</u>
Battery Information	<u>C.2</u>	<u>Read, Indicate</u>	<u>None</u>	<u>None</u>
Manufacturer Name String	<u>O</u>	<u>Read, Indicate</u>	<u>None</u>	<u>None</u>
Model Number String	<u>O</u>	<u>Read, Indicate</u>	<u>None</u>	<u>None</u>
Serial Number String	<u>C.2</u>	<u>Read, Indicate</u>	<u>None</u>	<u>None**</u>
<p>* Recommended for life-critical or other critical applications that require reliable delivery.</p> <p>** The connection should be authenticated if the Serial Number String can contain personally identifiable information for a device.</p> <p>*** Broadcasting relatively static data without encryption may constitute personally identifiable information.</p>				

Table 3.1: Service characteristics and properties

C.1: Mandatory if a device has more than one instance of Battery Service; otherwise optional.

C.2: Optional if the Battery Level Status characteristic is exposed; otherwise excluded.

C.3: Optional if the Battery Health Status characteristic is exposed; otherwise excluded.

Security permissions of None mean that the Battery Service does not impose any specific security requirements; however, a higher level profile can specify stronger requirements.

Properties not listed as Mandatory or Optional are excluded for this version of the Battery Service.

Most characteristics have optional fields. The following requirements apply to the usage of fields:

- A server is said to support the field if it is capable of setting the field to a value conformant with the specification.
- All fields that have an associated flag bit are optional to support.
- At least one field shall be supported for any exposed characteristic.
- Transmission of any given field that has an associated flag bit is optional for the server.
- When a characteristic is read, notified, or indicated, all supported fields that have a value different from what was last transmitted during the current connection shall be included.

Note: Later revisions of this specification can append additional optional fields to any characteristic with a Flags field.



## 3.1 Battery Level

This characteristic is used to describe the level of the battery represented by this instance of the Battery Service.

### 3.1.1 Characteristic behavior

When read, the Battery Level characteristic returns the current battery level.

The value of the battery level is represented as a percentage from 0 to 100, where 0 percent represents a battery that is fully discharged, and 100 percent represents a battery that is fully charged.

If the Battery Energy Status characteristic is not exposed, then the Battery Level value should represent the linear range of its expected lifetime, where 0 percent represents the battery that is unable to power the device and 100 percent represents full capacity.

If the Battery Energy Status characteristic is exposed, then the Battery Level value shall be calculated using the following equation:

$$\frac{\text{Available Energy}}{\text{Available Battery Capacity}} \cdot 100$$

Where the Available Energy is the value of the Available Energy field of the Battery Energy Status characteristic, and Available Battery Capacity is the value of the Available Battery Capacity field of the Battery Energy Status characteristic (see Section 3.4).

If the battery is not present, then the value of the Battery Level characteristic should be set to zero.

Upon reconnection with a bonded GATT Client, if the Battery Level characteristic is configured for notifications and the value of the Battery Level characteristic has changed while the device was disconnected, then the Battery Level characteristic shall be notified.

If the Battery Level characteristic is configured for notifications and the Battery Level characteristic value changes while in a connection, then the characteristic shall be notified.

### 3.1.2 Characteristic descriptors

#### 3.1.2.1 Characteristic Presentation Format descriptor

When a device has more than one instance of the Battery Service, each Battery Level characteristic shall include a *Characteristic Presentation Format* descriptor (Volume 3, Part G, Section 3.3.3.5 in [1]) that has the Name Space field set to "Bluetooth SIG" and the Description field set to a valid value from the GATT Namespace Descriptors [4] and that is unique among all instances of the Battery Service exposed by the GATT Server.

If the service that instantiates the Battery Level characteristic represents the battery status for the device, the Description field should be set to "main".

## 3.2 Battery Level Status

This characteristic may be used to describe the battery level and power state of the battery represented by this instance of the Battery Service. Fields included in the characteristic value are a Flags field, a Power State field, and, depending upon the contents of the Flags field, one or more optional fields defined in [3].



### 3.2.1 Characteristic behavior

When read, the Battery Level Status characteristic returns summary information related to the battery status.

While the Battery Level Status characteristic is configured for indication or notification, the following requirements apply:

- The characteristic may be indicated or notified if the value of the Battery Level field changed by at least 1 percent of the expected range since the last transmission of this field in this connection.
- The characteristic shall be indicated or notified if the value of the Power State field or the value of the Service Required bit of the Additional Status field changed since the last transmission of these fields in this connection.
- The characteristic may be indicated or notified upon reconnection with a bonded Client.

Note: This option is necessary for an implementation that does not save the state per bonded GATT Client (for example, because of nonvolatile memory limitations).

- The characteristic shall also be notified or indicated if the Battery Level field is supported, and the Battery Level characteristic is notified.
- The characteristic shall not be indicated or notified under any other condition.

When the Battery Level Status characteristic is configured for broadcast, the advertising interval recommendations given for Peripheral devices in Volume 3, Part C, Section 9.3.11.2 in [1] should be used.

When the Battery Level Status characteristic is configured for broadcast, a <Service Data> AD Type must be used and the additional service data (after the Service UUID) must be the characteristic's value as mandated in Volume 3, Part G, Section 2.7 in [1]; see also Part A, Section 1.11 in the Bluetooth Core Specification Supplement [Error! Reference source not found.](#)

If a device needs to broadcast more than one instance of the Battery Level Status characteristic from different instances of the Battery Service, then each characteristic value must be broadcast in a separate AD structure following the format in Volume 3, Part C, Section 11 in [1].

#### 3.2.1.1 Flags field

The Flags field shall be included in the Battery Level Status characteristic.

The bits of this field represent the presence of optional fields.

#### 3.2.1.2 Power State field

The Power State field shall be included in the Battery Level Status characteristic.

This field represents the battery power status including the presence of the battery, whether it is connected to an external power source, and whether it is charging or discharging.



#### **3.2.1.2.1 Battery Present bit**

If the battery is not present, then the Battery Present bit shall be set to the value No.

If the battery is present, then the Battery Present bit shall be set to the value Yes.

#### **3.2.1.2.2 Wired External Power Source Connected bits**

If the battery is not connected to a wired external power source, then the Wired External Power Source Connected bits shall be set to the value No.

If the battery is connected to a wired external power source, then the Wired External Power Source Connected bits shall be set to the value Yes.

If it is not known if the battery is connected to a wired external power source, then the Wired External Power Source Connected bits shall be set to the value Unknown.

#### **3.2.1.2.3 Wireless External Power Source Connected bits**

If the battery is not connected to a wireless external power source, then the Wireless External Power Source Connected bits shall be set to the value No.

If the battery is currently connected to a wireless external power source, then the Wireless External Power Source Connected bits shall be set to the value Yes.

If it is not known if the battery is connected to a wireless external power source, then Wireless External Power Source Connected bits shall be set to the value Unknown.

#### **3.2.1.2.4 Battery Charge State bits**

If the battery is not present or the charging state of the battery is unknown, then the Battery Charge State bits shall be set to the value Unknown.

If the battery is present and charging, the Battery Charge State bits shall be set to the value Charging.

If the battery is present and discharging through a load, the Battery Charge State bits shall be set to the value Discharging: Active.

If the battery is present and self-discharging, or discharging only because of leakage, the Battery Charge State bits shall be set to the value Discharging: Inactive. This also applies when self-discharging or leakage is being compensated (i.e., in the case of a battery that stopped charging because it is full, but the charger remained present).

#### **3.2.1.2.5 Battery Charge Level bits**

If the battery is not present or if the monitoring of low and critical battery levels is not supported, then the Battery Charge Level bits shall be set to the value Unknown.

If the battery is present and is currently at a low battery level as defined in Section 1.5.1, then the Battery Charge Level bits shall be set to the value Low.

If the battery is present and is currently at a critical battery level as defined in Section 1.5.2, then the Battery Charge Level bits shall be set to the value Critical.



If the battery is present and if the battery level is not at a low or critical battery level, then the Battery Charge Level bits shall be set to the value Good.

#### **3.2.1.2.6 Charging Type bits**

If the battery is not present or if the monitoring of charging type is not supported, then the value of the Charging Type bits shall be set to the value Unknown or Not Charging.

If the battery is present and using a constant current charging type, then the Charging Type bits shall be set to the value Constant Current.

If the battery is present and using a constant voltage charging type, then the Charging Type bits shall be set to the value Constant Voltage.

If the battery is present and using a trickle charging type, then the Charging Type bits shall be set to the value Trickle.

If the battery is present and using a float charging type, then the Charging Type bits shall be set to the value Float.

#### **3.2.1.2.7 Charging Fault Reason bitfield**

If charging malfunctions (e.g., underperforms or entirely fails to charge), then this bitfield gives the reason(s) why.

If charging malfunctions because the battery's state prevents it from being charged properly (e.g., battery is under or over temperature), then the "Battery" bit shall be set.

If charging malfunctions because of the external power source (e.g., source not providing enough power), then the "External Power Source" bit shall be set.

If charging malfunctions because of any other issue in the device, then the "Other" bit shall be set.

#### **3.2.1.3 Identifier field**

This field is used as a service identifier and shall be included in the Battery Level Status characteristic when multiple instances of the Battery Service are present on a GATT Server and the characteristic is broadcast. This field is optional otherwise.

When the Characteristic Presentation Format descriptor of the Battery Level characteristic (see Section 3.1.2.1) is present, the value of this field shall be identical to the Description field of that descriptor. When the descriptor is not present, then this field shall have the value representing "main".

#### **3.2.1.4 Battery Level field**

The Battery Level field may be included in the Battery Level Status characteristic if the battery is present; otherwise it shall not be included.

The value of this field shall be identical to the Battery Level characteristic (see Section 3.1).

#### **3.2.1.5 Additional Status field**

The Additional Status field may be included in the Battery Level Status characteristic. It contains additional status information such as whether or not service is required. If the battery needs servicing for any reason, then the value of the Service Required bits shall be set to the value True. Otherwise, the



value of the Service Required bits shall be set to the value False or the value Unknown. The type of servicing is battery- and product-dependent, but might include replacing or reconditioning the battery.

If the battery is currently in a bad state but could recover without servicing (e.g., over or under temperature) then the value of the Battery Fault bit shall be set to the value True. Otherwise, the value of the bit shall be set to the value False or Unknown.

### **3.3 Estimated Service Date**

This characteristic may be used to describe the estimated service or replacement date of the battery represented by this instance of the Battery Service.

#### **3.3.1 Characteristic behavior**

When read, the Estimated Service Date characteristic returns the current estimated date when the battery is likely to require service or replacement.

The estimated service date may change over time. When configured for notification or indication, then the characteristic may be notified or indicated whenever the value of the characteristic changes, but this should not be notified or indicated more than once a day; otherwise, it shall not be notified or indicated.

If the battery is not present, then the value has no meaning, and this characteristic shall not be notified or indicated.

### **3.4 Battery Critical Status**

This characteristic aggregates state information indicating that the device may no longer function as expected due to low energy or service required.

#### **3.4.1 Characteristic behavior**

When read, the Battery Critical Status characteristic returns status bits related to potential battery malfunction.

When configured for indication, then the characteristic may be indicated whenever the value of the characteristic changes; otherwise, it shall not be indicated. If the battery is not present, then the value has no meaning and this characteristic shall not be indicated.

##### **3.4.1.1 Battery Critical Status field**

The Battery Critical Status field shall be included in the Battery Critical Status characteristic.

The value of the Critical Power State bit shall be set to True if the value of the Battery Charge Level bits is set to Critical in the Power State field of the Battery Level Status characteristic if implemented. Otherwise, the Critical Power State bit shall be set to False.

The value of the Immediate Service Required bit shall be set to True if the value of the Service Required bits is set to True in the Additional Status field of the Battery Level Status characteristic if implemented. Otherwise, the Immediate Service Required bit shall be set to False.

### **3.5 Battery Energy Status**

This characteristic may be used to describe quantitative information of the battery (e.g., capacity in kilowatt-hour) represented by this instance of the Battery Service. Included in the characteristic value are



a Flags field and, depending upon the contents of the Flags field, one or more optional fields defined in [3].

### 3.5.1 Characteristic behavior

When read, the Battery Energy Status characteristic returns the current energy status details of the battery.

When the Battery Energy Status characteristic is configured for indication or notification, the following requirements apply:

- The characteristic may be indicated or notified if the value of the Available Energy field changed by at least 1 percent of the expected range since the last transmission of the field in this connection.
- The characteristic may be indicated or notified if the value of the Available Battery Capacity field changed by at least 1 percent of the expected range since the last transmission of the field in this connection.
- The characteristic shall be indicated or notified if the value of the Power State field of the Battery Level Status characteristic changed since the last transmission of the field in this connection.
- The characteristic may be indicated or notified upon reconnection with a bonded Client.

Note: This option is necessary for an implementation that does not save the state per bonded GATT Client (for example, because of nonvolatile memory limitations).

- The characteristic shall not be indicated or notified under any other condition.

If the battery is not present, then the Present Voltage, Available Energy, Available Battery Capacity, Charge Rate, and Available Energy at Last Change fields have no meaning and shall not be present.

#### 3.5.1.1 Flags field

The Flags field shall be included in the Energy Status characteristic.

The bits of this field represent the presence of optional fields.

#### 3.5.1.2 External Source Power field

The External Source Power field may be included in the Battery Energy Status characteristic.

This field represents the total power being consumed from an external power source. If this instance of Battery Service is in a Battery Aggregation Group (see Section 1.5.3), then the value of this field is an aggregate value and shall be the same across all instances within the same Aggregation Group. Otherwise, this field represents the total power being consumed for this instance of Battery Service.

If there is no external power source connected, this field shall not be present.

#### 3.5.1.3 Present Voltage field

The Present Voltage field may be included in the Battery Energy Status characteristic.

This field represents the present terminal voltage of the battery.

If the battery is not present, this field shall not be present.





#### **3.5.1.4 Available Energy field**

The Available Energy field may be included in the Battery Energy Status characteristic.

This field represents the available energy of the battery in its current charge state. The field value is generally less than or equal to the value of the Available Battery Capacity field.

If the battery is not present, this field shall not be present.

#### **3.5.1.5 Available Battery Capacity field**

The Available Battery Capacity field may be included in the Battery Energy Status characteristic.

This field represents the capacity of the battery at full charge in its current (not new) condition. The field value is generally less than or equal to the value of the Battery Designed Capacity field of the Battery Information characteristic (see Section 3.9.1.5).

If the battery is not present, this field shall not be present.

#### **3.5.1.6 Charge Rate field**

The Charge Rate field may be included in the Battery Energy Status characteristic.

This field represents the energy flowing into the battery. Positive values indicate charging, and negative values indicate discharging.

If the battery is not present, this field shall not be present.

#### **3.5.1.7 Available Energy at Last Charge field**

The Available Energy at Last Charge field may be included in the Battery Energy Status characteristic.

This field represents the available energy of the battery in its last charge state.

If the battery is not present, this field shall not be present.

### **3.6 Battery Time Status**

This characteristic may be used to describe the charge and discharge time status of the battery represented by this instance of the Battery Service. The characteristic value includes a Flags field, a Time until Discharged field and, depending upon the contents of the Flags field, may include one or more optional fields defined in [3].

#### **3.6.1 Characteristic behavior**

When read, the Battery Time Status characteristic returns the current estimates on times for discharging and charging.

If the device is not currently charging, then the Time until Recharged field shall not be present. If the device is not on standby, then the Time until Discharged on Standby field is optional.



When the Battery Time Status characteristic is configured for indication or notification, the following requirements apply:

- The characteristic may be indicated or notified if the value of at least one of the fields changed by at least 1 percent of their expected range since the last transmission of the field in this connection.
- The characteristic may be indicated or notified upon reconnection with a bonded Client.

Note: This option is necessary for an implementation that does not save the state per bonded GATT Client (for example, because of nonvolatile memory limitations).

- The characteristic shall not be indicated or notified under any other condition.

If the battery is not present, then the value has no meaning and this characteristic shall not be notified or indicated.

#### **3.6.1.1 Flags field**

The Flags field shall be included in the Battery Time Status characteristic. The bits of the Flags field represent the presence of optional fields.

#### **3.6.1.2 Time until Discharged field**

The Time until Discharged field shall be included in the Battery Time Status characteristic. The field represents the estimated time in minutes before the battery is fully discharged.

#### **3.6.1.3 Time until Discharged on Standby field**

The Time until Discharged in Standby field may be included in the Battery Time Status characteristic. The field represents the estimated time in minutes before the battery is fully discharged if it were in a Standby mode of operation.

#### **3.6.1.4 Time until Recharged field**

This field represents the estimated time in minutes until the battery is fully charged.

The Time until Recharged field may be included in the Battery Time Status characteristic unless the Battery Information characteristic is exposed and the Battery Rechargeable bits of the Battery Features field indicate that the battery is not chargeable.

### **3.7 Battery Health Status**

This characteristic may be used to describe several dynamic aspects of battery health for this instance of the Battery Service.

The characteristic value includes a Flags field and, depending upon the contents of the Flags field, may include one or more optional fields defined in [3].

#### **3.7.1 Characteristic behavior**

When read, the Battery Health Status characteristic returns aspects of battery health.

When configured for notification or indication, this characteristic may be notified or indicated whenever the value of the characteristic changes; otherwise, it shall not be notified or indicated. If the battery is not present, then the value has no meaning and this characteristic shall not be notified or indicated.



#### **3.7.1.1 Flags field**

The Flags field shall be included in the Battery Health Status characteristic. The bits of the Flags field represent the presence of optional fields.

#### **3.7.1.2 Battery Health Summary field**

The Battery Health Summary field may be included in the Battery Health Status characteristic. The field represents the aggregation of the overall health of the battery, where 100 percent represents new working condition and 0 percent represents the end of its expected lifetime when replacement is required. The value within this range is determined by the implementation.

#### **3.7.1.3 Cycle Count field**

The Cycle Count field may be included in the Battery Health Status characteristic. The field represents the count value of charge cycles where one charge cycle is a discharge equivalent to the capacity of the battery at full charge in its current condition.

#### **3.7.1.4 Current Temperature field**

The Current Temperature field may be included in the Battery Health Status characteristic. The field represents the current temperature of the battery. If the value of the Current Temperature field is:

- Less than the Min Designed Operating Temperature value specified in the Battery Health Information characteristic, then the Battery Charge State of the Power State field of the Battery Level Status characteristic should be set to "Not Charging: Under Temperature."
- Greater than the Max Designed Operating Temperature value specified in the Battery Health Information characteristic, then the Battery Charge State of the Power State field of the Battery Level Status characteristic should be set to "Not Charging: Over Temperature."

#### **3.7.1.5 Deep Discharge Count field**

The Deep Discharge Count field may be included in the Battery Health Status characteristic. The field represents the number of times the battery was completely discharged.

### **3.8 Battery Health Information**

This characteristic may be used to describe static aspects of battery health for this instance of the Battery Service.

The characteristic value includes a Flags field and, depending upon the contents of the Flags field, may include one or more optional fields defined in [3].

#### **3.8.1 Characteristic behavior**

When read, the Battery Health Information characteristic returns static aspects of battery health.

When configured for indications, this characteristic shall be indicated while in a connection whenever the value of any field changes (e.g., the battery is replaced as shown in the example in Appendix A) and may be indicated once at the start of a reconnection irrespective of the value change; otherwise, it shall not be indicated.

If the battery is not present, then the value of the characteristic has no meaning and this characteristic shall not be indicated.



#### **3.8.1.1 Flags field**

The Flags field shall be included in the Battery Health Information characteristic. The bits of the Flags field represent the presence of optional fields.

#### **3.8.1.2 Cycle Count Designed Lifetime field**

The Cycle Count Designed Lifetime field may be included in the Battery Health Information characteristic. The field represents the designed number of charge cycles supported by the device where one charge cycle is a discharge equivalent to the capacity of the battery at full charge in its current condition.

#### **3.8.1.3 Min Designed Operating Temperature and Max Designed Operating Temperature fields**

The Min Designed Operating Temperature and Max Designed Operating Temperature fields may be included in the Battery Health Information characteristic. Together, the fields represent the designed operating temperature range of the battery.

### **3.9 Battery Information**

This characteristic may be used to describe static information about the battery represented by this instance of the Battery Service.

The characteristic value includes a Flags field, a Battery Features field and, depending upon the contents of the Flags field, may include one or more optional fields defined in [3].

#### **3.9.1 Characteristic behavior**

When read, the Battery Information characteristic returns the physical characteristics of the battery.

When configured for indications, this characteristic shall be indicated while in a connection whenever the value of any field changes (e.g., the battery is replaced as shown in the example in [Appendix A](#)) and may be indicated once at the start of a reconnection irrespective of the value change; otherwise, it shall not be indicated.

If the battery is not present, then the value has no meaning and this characteristic shall not be indicated.

##### **3.9.1.1 Flags field**

The Flags field shall be included in the Battery Information characteristic. The bits of the Flags field represent the presence of optional fields.

##### **3.9.1.2 Battery Features field**

The Battery Features field shall be included in the Battery Information characteristic. The field represents the supported features of the battery.

##### **3.9.1.3 Battery Manufacture Date field**

The Battery Manufacture Date field may be included in the Battery Information characteristic. The field represents the date of manufacture of the battery.

##### **3.9.1.4 Battery Expiration Date field**

The Battery Expiration Date field may be included in the Battery Information characteristic. The field represents the manufacturer-provided expiration date for the battery. The date, determined at the time of



manufacture, typically represents the date after which the battery's usable capacity has decreased because of self-discharge by 20 percent from its nominal capacity.

#### **3.9.1.5 Battery Designed Capacity field**

The Battery Designed Capacity field may be included in the Battery Information characteristic. The field represents the designed capacity of the battery when new.

#### **3.9.1.6 Battery Low Energy field**

The Battery Low Energy field may be included in the Battery Information characteristic.

The field represents the battery energy value when the battery is low as defined in Section 1.5.1.

If the Battery Energy Status characteristic is exposed and the value of the Available Energy field is less than or equal to this field, but greater than the Battery Critical Energy field, then the value of the Battery Charge Level bit (see Section 3.2.1.2.5) shall be Low.

#### **3.9.1.7 Battery Critical Energy field**

The Battery Critical Energy field may be included in the Battery Information characteristic.

The field represents the battery energy value when the battery is critical as defined in Section 1.5.2.

If the Battery Energy Status characteristic is exposed and the value of the Available Energy field is less than or equal to this field, then the value of the Battery Charge Level bit (see Section 3.2.1.2.5) shall be Critical.

#### **3.9.1.8 Battery Chemistry field**

The Battery Chemistry field may be included in the Battery Information characteristic. The field represents the chemical composition of the battery.

#### **3.9.1.9 Nominal Voltage field**

The Nominal Voltage field may be included in the Battery Information characteristic. The field represents the nominal voltage of the battery as specified by the manufacturer.

#### **3.9.1.10 Battery Aggregation Group field**

The Battery Aggregation Group field may be included in the Battery Information characteristic.

The field represents the Battery Aggregation Group to which this instance of Battery Service is associated (see Section 1.5.3).

### **3.10 Manufacturer Name String**

This characteristic may be used to name the manufacturer of the battery represented by this instance of the Battery Service.

#### **3.10.1 Characteristic behavior**

When read, the Manufacturer Name String characteristic returns the manufacturer name of the battery.



When configured for indications, this characteristic shall be indicated while in a connection whenever the value changes, or may be indicated once at the start of a reconnection irrespective of the value change; otherwise, it shall not be indicated.

If the battery is not present, then the value of the characteristic shall be empty and shall not be indicated.

### **3.11 Model Number String**

This characteristic may be used to describe the model number of the battery represented by this instance of the Battery Service.

#### **3.11.1 Characteristic behavior**

When read, the Model Number String characteristic returns the model number of the battery.

When configured for indications, this characteristic shall be indicated while in a connection whenever the value changes, or may be indicated once at the start of a reconnection irrespective of the value change; otherwise, it shall not be indicated.

If the battery is not present, then the value of the characteristic shall remain unchanged from the previous battery and shall not be indicated.

### **3.12 Serial Number String**

This characteristic may be used to describe the serial number of the battery represented by this instance of the Battery Service.

#### **3.12.1 Characteristic behavior**

When read, the Serial Number String characteristic returns the serial number of the battery.

When configured for indications, this characteristic shall be indicated while in a connection whenever the value changes, or may be indicated once at the start of a reconnection irrespective of the value change; otherwise, it shall not be indicated.

If the battery is not present, then the value shall be empty and shall not be indicated.



## 3—Service Behaviors

### 3.1—Notification Behavior

If a client has configured notification on the Battery Level characteristic, no notifications of this characteristic shall be sent when disconnected. The Battery service shall not initiate a connection if a notification would have been sent when connected.

Upon reconnection, the server shall send a notification if the value of the Battery Level characteristic has changed while the service has been disconnected from a bonded client.

If a client has configured notification on the Battery Level characteristic and the Battery Level characteristic value changes while in a connection, then the characteristic shall be notified.



## 4 SDP Interoperability

If this service is exposed over BR/EDR<sub>1</sub> then it shall have the following Service Discovery Protocol (SDP) record:

Item	Definition	Type	Value	Status
Service Class ID List	⋮	⋮	⋮	M
Service Class #0	⋮	UUID	«Battery Service»	M
Protocol Descriptor List	⋮	⋮	⋮	M
Protocol #0	⋮	UUID	L2CAP	M
Parameter #0 for Protocol #0	PSM	Uint16	PSM = ATT	M
Protocol #1	⋮	UUID	ATT	M
Parameter #0 for Protocol #1	GATT Start Handle	Uint16		M
Parameter #1 for Protocol #1	GATT End Handle	Uint16		M
BrowseGroupList	⋮	⋮	PublicBrowseRoot	M

Commented [SIG Staff]: E16258

Table 4.1: SDP records





## 5 Acronyms and ~~A~~bbreviations

Acronym and <del>Abbreviations</del> <u>Abbreviation</u>	Meaning
<del>AD</del> -ATT	<del>Advertising Data</del> -Attribute Protocol
BR/EDR	Basic Rate- <del>/</del> Enhanced Data Rate
GATT	Generic Attribute Profile
<u>GSS</u>	<u>GATT Specification Supplement</u>
LE	Low Energy
<del>UUID</del>	<del>Universally Unique Identifier</del>
L2CAP	Logical Link Control and Adaption Protocol
<u>MSC</u>	<u>Message Sequence Chart</u>
<u>PDU</u>	<u>Protocol Data Unit</u>
PSM	Protocol- <del>/</del> Service Multiplex- <del>er</del>
<del>ATT</del> -RFU	<del>Attribute Protocol</del> -Reserved for Future Use
SDP	Service Discovery Protocol
<u>UUID</u>	<u>Universally Unique Identifier</u>

Table 5.1: Acronyms and ~~A~~bbreviations

## 6 References

- [1] Bluetooth ~~v4.0~~ Core Specification, Version 5.3 or later
- [2] ~~Characteristic and Descriptor descriptions are accessible via the Bluetooth SIG Assigned Numbers.~~ Bluetooth SIG Assigned Numbers, <https://www.bluetooth.com/specifications/assigned-numbers>
- [3] GATT Specification Supplement, Version 8 or later
- [4] GATT Namespace Descriptors (in Bluetooth SIG Assigned Numbers)
- [5] Bluetooth Core Specification Supplement, Version 10 or later



## Appendix A Message sequences for battery removal and insertion

Figure A.1 and Figure A.2 illustrate example message sequences associated with removal and insertion of batteries when using indications; the characteristics remain in the GATT database but their values tell if the battery is present or not.

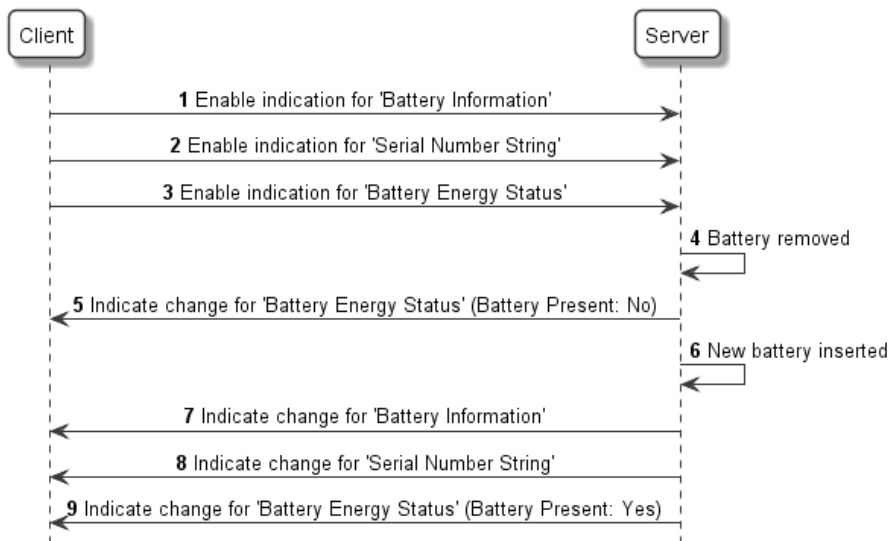


Figure A.1: Example message sequence for battery removal and insertion of a different battery

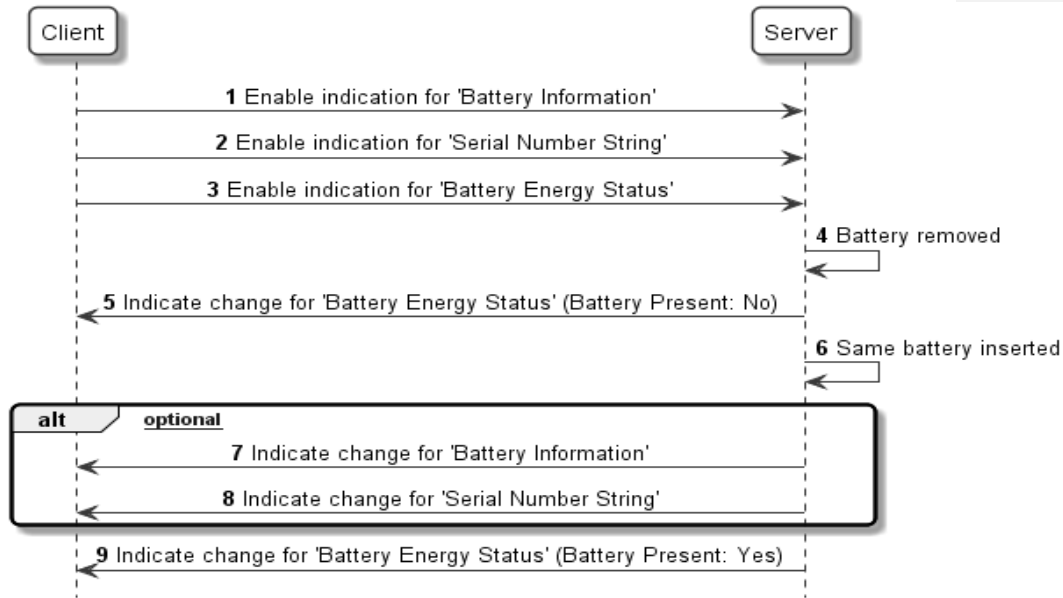


Figure A.2: Example message sequence for battery removal and insertion of the same battery