Location and Navigation Profile

***Bluetooth*® Profile Specification**

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- **Group Prepared By:** Sports & Fitness Working Group

Abstract:

This profile enables a Collector device to connect and interact with a Location and Navigation Sensor for use in outdoor activity applications.

Revision History

Revision	Date	Comments
V10	2013-04-30	Adopted by the Bluetooth SIG Board of Directors
v1.0.1	2024-10-01	Adopted by the Bluetooth SIG Board of Directors.

Version History

Versions	Changes
v1.0 to v1.0.1	Incorporated errata 15799, 17188, 18752, 22597, 23326.

Acknowledgments

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Robert D. Hughes	Intel Corporation
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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*).

The term *Reserved for Future Use (RFU)* is used to indicate Bluetooth SIG assigned values that are reserved by the Bluetooth SIG and are not otherwise available for use by implementations.

Contents

1 Introduction

The Location and Navigation Profile is used to enable a Collector to interact with a Location and Navigation Sensor (LN Sensor) that exposes the Location and Navigation Service [1] for use in outdoor activity applications.

1.1 Profile Dependencies

This profile requires the Generic Attribute Profile (GATT).

1.2 Conformance

Each capability of this specification shall be supported in the specified manner. This specification may provide options for design flexibility, because, for example, some products do not implement every portion of the specification. For each implementation option that is supported, it shall be supported as specified.

1.3 Bluetooth Specification Release Compatibility

This specification is compatible with any of the following:

- Bluetooth Core Specification 4.2 or later [2]

2 Configuration

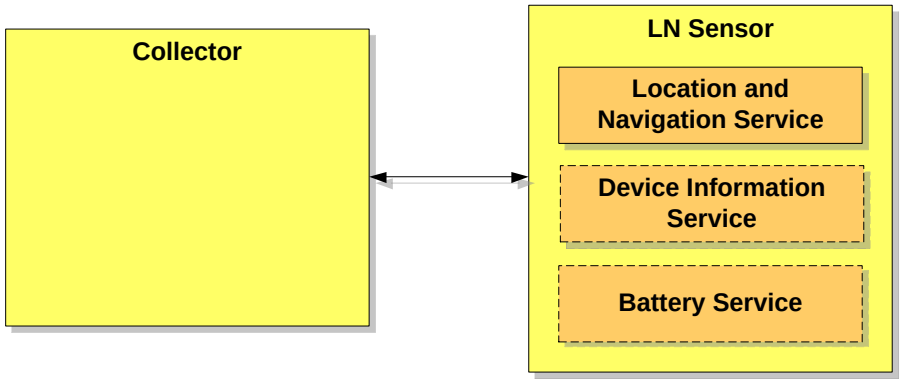
2.1 Roles

The profile defines two roles: LN Sensor and Collector. The LN Sensor is the device that reports speed, distance, location, elevation, and/or navigation data to a Collector. The Collector is the device that receives the data from a LN Sensor while connected to a LN Sensor.

- The LN Sensor shall be a GATT Server.
- The Collector shall be a GATT Client.

2.2 Role/Service Relationships

The following diagram shows the relationships between service and profile roles.



Notes: Profile roles (Collector and LN Sensor) are represented by yellow boxes and services (Location and Navigation service, Device Information Service and Battery Service) are represented by orange boxes.

Dashed box items are optional.

A LN Sensor instantiates the Location and Navigation Service [1] and optionally the Device Information Service [4] and Battery Service [5].

2.3 Concurrency Limitations and Restrictions

There are no concurrency limitations or restrictions for the Collector and LN Sensor roles imposed by this profile.

2.4 Topology Limitations and Restrictions

2.4.1 Topology Restrictions for Low Energy

This section describes topology limitations and restrictions when the profile is used over Low Energy transport.

The LN Sensor shall use the GAP Peripheral role (see Section 5).

The Collector shall use the GAP Central role (see Section 5).

2.4.2 Topology Limitations and Restrictions for BR/EDR

There are no topology limitations or restrictions when the profile is used over BR/EDR transport.

2.5 Transport Dependencies

There are no transport restrictions imposed by this profile specification.

Where the term BR/EDR is used in this document, it also includes the use of AMP.

3 LN Sensor Role Requirements

The LN Sensor shall instantiate one and only one Location and Navigation Service [1]. See specific recommendations in Section 3.1.

The Location and Navigation Service shall be instantiated as a «Primary Service».

The LN Sensor should instantiate the Device Information Service [4]. See specific recommendations in Section 3.2.

The LN Sensor should instantiate the Battery Service [5].

Service	LN Sensor
Location and Navigation Service	M
Device Information Service	O
Battery Service	O

Table 3.1: Location and Navigation Service Requirements

Other than the LN Sensor requirements in this section refer to Sections 5.1 and 6.1 for additional LN Sensor requirements for the LE Transport and Sections 5.3 and 6.3 for the BR/EDR transport.

Refer to Section 5 for connection establishment procedure considerations and refer to Section 6 for security considerations.

3.1 Incremental Location and Navigation Service Requirements

3.1.1 Additional Requirements for Low Energy Transport

This section describes additional LN Sensor requirements beyond those defined in the Location and Navigation Service when using this profile over Low Energy transport.

3.1.1.1 Service UUIDs AD Type

While in a GAP Discoverable Mode for initial connection to a Collector, the LN Sensor should include the Location and Navigation Service UUID defined in [3] in the Service UUIDs AD type field of the advertising data. This enhances the user experience as a LN Sensor may be identified by the Collector before initiating a connection.

3.1.1.2 Local Name AD Type

For enhanced user experience a LN Sensor should include the Local Name (containing either the complete or shortened value of the Device Name characteristic as defined in [2]) in its Advertising Data or Scan Response Data. For privacy reasons, LN Sensors with the Privacy Feature enabled should not include this field in the advertisement.

3.1.1.3 Writable GAP Device Name characteristic

The LN Sensor may support the write property for the Device Name characteristic in order to allow a Collector to write a device name to the LN Sensor.

3.1.1.4 Appearance AD Type

For enhanced user experience a LN Sensor should include the value of the Appearance characteristic defined in [3] in either its Advertising data or Scan Response data.

3.2 Incremental Device Information Service Requirements

In order to allow the user to log the type of equipment used in a training session, the LN Sensor should instantiate the Manufacturer Name String and the Model Number String in the Device Information Service [4].

4 Collector Role Requirements

The Collector shall use the Location and Navigation Service [1].

The Collector may use the Device Information Service [4] as well as the Battery Service [5].

Service	Collector
Location and Navigation Service	M
Device Information Service	O
Battery Service	O

Table 4.1: Collector Service Requirements

This section describes the profile requirements for a Collector.

Profile Requirement	Section	Support in Collector
Service Discovery	4.2	M
Location and Navigation Service Discovery	4.2	M
Device Information Service Discovery	4.2	O
Battery Service Discovery	4.2	O
Characteristic Discovery	4.3	M
Location and Navigation Service Characteristic Discovery	4.3.1	M
Device Information Service Characteristic Discovery	4.3.2	O
Battery Service Characteristic Discovery	4.3.3	O
Location and Navigation Feature	4.4	M
Location and Speed	4.5	M
Position Quality	4.6	O
LN Control Point	4.7	C.1
Navigation	4.8	O

Table 4.2: Profile Requirements for Collector

C.1: Mandatory if at least one LN Control Point procedure is supported, otherwise excluded.
The Collector shall determine the features supported by the LN Sensor by reading the LN Feature characteristic (see Section 4.4). If the Collector discovers the Navigation characteristic, it shall assume that the LN Sensor supports the Navigation feature.

Refer to Section 5 for connection establishment procedure consideration and refer to Section 6 for security considerations.

4.1 GATT Sub-Procedure Requirements

Requirements in this section represent a minimum set of requirements for a Collector. Other GATT sub-procedures may be used if supported by both Client and Server.

The table below summarizes *additional* GATT sub-procedure requirements beyond those required by all GATT Clients.

GATT Sub-Procedure	Collector Requirements
Discover All Primary Services	C.1
Discover Primary Services by Service UUID	C.1
Discover All Characteristics of a Service	C.2
Discover Characteristics by UUID	C.2
Discover All Characteristic Descriptors	M
Read Characteristic Value	M
Write Characteristic Value	C.3
Notification	M
Read Characteristic Descriptors	M
Write Characteristic Descriptors	M

Table 4.3: Additional GATT Sub-Procedure Requirements

C.1: Mandatory to support at least one of these Service Discovery sub-procedures when using the LE transport. Excluded when using the BR/EDR transport since SDP must be used in this case.

C.2: Mandatory to support at least one of these Characteristic Discovery sub-procedures.

C.3: Mandatory if at least one LN Control Point procedure or the writable GAP Device Name is supported (see Section 3.1.1.3).

4.2 Service Discovery

When using the Low Energy transport, the Collector shall perform primary service discovery using either the GATT *Discover All Primary Services* sub-procedure or the GATT *Discover Primary Services by Service UUID* sub-procedure.

When using the BR/EDR transport, the Collector shall perform service discovery by retrieving the SDP record of the Location and Navigation Service as defined in [1].

The Collector shall discover the Location and Navigation Service and may discover the Device Information Service and the Battery Service.

4.3 Characteristic Discovery

As required by GATT, the Collector must be tolerant of additional optional characteristics in the service records of services used with this profile.

4.3.1 Location and Navigation Service Characteristic Discovery

The Collector shall use either the GATT *Discover All Characteristics of a Service* sub-procedure or the GATT *Discover Characteristics by UUID* sub-procedure to discover the characteristics of the service.

The Collector shall use the GATT *Discover All Characteristic Descriptors* sub-procedure to discover the characteristic descriptors.

The discovery requirements for the Collector are shown in Table 4.4 below:

Characteristic	Discovery Requirements for Collector
LN Feature	M
Location and Speed	M
Position Quality	O
LN Control Point	O
Navigation	O

Table 4.4: Discovery Requirements for Collector

Where a characteristic is discovered that can be notified or indicated, the Collector shall also discover the associated *Client Characteristic Configuration* descriptor.

4.3.2 Device Information Service Characteristic Discovery

The Collector may discover the characteristics of the Device Information Service.

In order for the Collector to discover the characteristics of the Device Information Service, it shall use either the GATT *Discover All Characteristics of a Service* sub-procedure or the GATT *Discover Characteristics by UUID* sub-procedure to discover all characteristics of the service.

4.3.3 Battery Service Characteristic Discovery

The Collector may discover the characteristics of the Battery Service.

In order for the Collector to discover the characteristics of the Battery Service, it shall use either the GATT *Discover All Characteristics of a Service* sub-procedure or the GATT *Discover Characteristics by UUID* sub-procedure to discover all characteristics of the service.

4.4 LN Feature

The Collector shall read the LN Feature characteristic to determine the supported features of the LN Sensor in order to understand its capabilities. In many cases this will allow the Collector to operate more efficiently. If one of the feature bits in Table 4.5 is set to 1 (meaning this feature is supported), the Collector shall assume that the related bits of the Flags field are used by the LN Sensor. Otherwise, it is

unnecessary for the Collector to check the value of the related bits in the Flags field for the specified characteristic.

LN Feature Bit(s)	Related Flag(s)
Instantaneous Speed Supported	Instantaneous Speed Present bit and Speed and Distance Format bit of the Location and Speed characteristic
Total Distance Supported	Total Distance Present bit and Speed and Distance Format bit of the Location and Speed characteristic
Location Supported	Location Present bit of the Location and Speed characteristic
Elevation Supported	Elevation Present bit and the Elevation Source bits of the Location and Speed characteristic
Heading Supported	Heading Present bit and the Heading Source bit of the Location and Speed characteristic
Rolling Time Supported	Rolling Time Present bit of the Location and Speed characteristic
UTC Time Supported	UTC Time Present bit of the Location and Speed characteristic
Remaining Distance Supported	Remaining Distance Present bit and Navigation Indicator Type bit of the Navigation characteristic
Remaining Vertical Distance Supported	Remaining Vertical Distance Present bit and Navigation Indicator Type bit of the Navigation characteristic
Estimated Time of Arrival Supported	Estimated Time of Arrival Present bit and Navigation Indicator Type bit of the Navigation characteristic
Number of Beacons in Solution Supported	Number of Beacons in Solution Present bit of the Position Quality characteristic
Number of Beacons in View Supported	Number of Beacons in View Present bit of the Position Quality characteristic
Time to First Fix Supported	Time to First Fix Present bit of the Position Quality characteristic
Estimated Horizontal Position Error Supported	Estimated Horizontal Position Error Present bit of the Position Quality characteristic
Estimated Vertical Position Error Supported	Estimated Vertical Position Error Present bit of the Position Quality characteristic
Horizontal Dilution of Precision Supported	Horizontal Dilution of Position Present bit of the Position Quality characteristic

LN Feature Bit(s)	Related Flag(s)
Vertical Dilution of Precision Supported	Vertical Dilution of Position Present bit of the Position Quality characteristic
Position Status Supported	Position Status bits of the Location and Speed AND Position Quality AND Navigation characteristics

Table 4.5: LN Feature Bit Requirements for Collector - Flags

Similarly, if one of the feature bits in Table 4.6 is set to 1, then the Collector shall assume that the related procedure is supported by the LN Sensor. Otherwise, it is unnecessary for the Collector to attempt to initiate the related procedure.

LN Feature Bit(s)	Related Procedure(s)
Location and Speed Characteristic Content Masking Supported	Mask Location and Speed Characteristic Content (see Section 4.7.2.2)
Fix Rate Setting Supported	Set Fix Rate (see Section 4.7.2.7)
Elevation Setting Supported	Set Elevation (see Section 4.7.2.8)

Table 4.6: LN Feature Bit Requirements for Collector - Procedures

If the Collector receives a LN Feature characteristic with Reserved for Future Use (RFU) bits of the LN Feature field that are non-zero, it shall ignore those bits and any additional data that may be present in the packet and continue to process the LN Feature characteristic in the same way as if all the RFU bits had been zero.

If the Collector reads a LN Feature characteristic with additional unrecognized octets, the Collector behavior shall be identical to the Collector behavior when only recognized octets are received. This is to enable compatibility with future Location and Navigation Service updates for the case where available octets in the characteristic are specified for optional use. What the Collector does with the additional, unrecognized, octets is left to the implementation.

If the LN Sensor supports indication of the LN Feature characteristic, the Collector may configure this characteristic for indications. When the Collector receives an indication of the LN Feature characteristic the Collector shall use the indicated value to determine the supported features again. Alternatively, the Collector may read the LN Feature characteristic each time after connecting with the LN Sensor. A Collector shall enable indications of the LN Feature characteristic, or it shall read the LN Feature characteristic on each connection.

4.5 Location and Speed

The Collector shall control the configuration of notifications (i.e., via the *Client Characteristic Configuration* descriptor) of the Location and Speed characteristic

If the Collector enables notifications of the Location and Speed characteristic, it shall be able to receive the notifications from the LN Sensor at intervals determined by the LN Sensor.

The Collector shall determine the contents of the Location and Speed characteristic structure based on the contents of the Flags field. This allows the Collector to determine whether or not the optional fields are present.

If the Instantaneous Speed field is present, the Collector shall refer to the Speed and Distance format bit of the Location and Speed Characteristic Flags field to determine the format of instantaneous speed (e.g., 2D or 3D).

If the Total Distance field is present, the Collector shall refer to the Speed and Distance format bit of the Location and Speed Characteristic Flags field to determine the format of total distance (e.g., 2D or 3D).

The Total Distance value may occasionally roll over (i.e. approximately after each 1677 km). As such, the Collector shall take into account that the Total Distance value can roll over during use. See Section 4.7.2.1 for information on how to set this value.

If the Elevation field is present, the Collector may refer to Elevation Source bits of the Location and Speed Characteristic Flags field to determine the source of elevation (e.g. Positioning System, Barometric Air Pressure, Database Service or other).

If the Heading field is present, the Collector may refer to the Heading Source bit of the Location and Speed Characteristic Flags field to determine the source of heading (e.g., based on movement or based on magnetic compass).

If the Rolling Time field is present, the Collector shall take into account that, if used, the Rolling Time will roll over every 256 seconds.

If there is a link loss situation during use, the Collector should take that into account when calculating the average values.

The Collector may refer to Position Status bits of the Location and Speed Flags field to determine position status (e.g., no position, position ok, estimated, or last known position) and thus the accuracy of location and speed related data.

If the Collector receives a Location and Speed characteristic with Reserved for Future Use (RFU) bits of the Flags field that are non-zero, it shall ignore those bits and continue to process the Location and Speed characteristic in the same way as if all the RFU bits had been zero.

When the implementation receives a Location and Speed characteristic with additional unrecognized octets, the Collector behavior shall be identical to the Collector behavior when only recognized octets are received. This is to enable compatibility with future Location and Navigation Service updates for the case where available octets in the characteristic are specified for optional use. What the Collector does with the additional, unrecognized, octets is left to the implementation.

4.6 Position Quality

The Collector may read the Position Quality characteristic to receive detailed position quality related information from the Sensor.

The Collector shall determine the contents of the Position Quality characteristic structure based on the contents of the Flags field. This allows the Collector to determine whether or not the optional fields are present.

If the Collector receives a Position Quality characteristic with Reserved for Future Use (RFU) bits of the Flags field that are non-zero, it shall ignore those bits and continue to process the Position Quality characteristic in the same way as if all the RFU bits had been zero.

When the implementation receives a Position Quality characteristic with additional unrecognized octets, the Collector behavior shall be identical to the Collector behavior when only recognized octets are received. This is to enable compatibility with future Location and Navigation Service updates for the case where available octets in the characteristic are specified for optional use. What the Collector does with the additional, unrecognized, octets is left to the implementation.

4.7 LN Control Point

Before performing a LN Control Point procedure, the Collector shall configure the LN Control Point characteristic for indications (i.e., via the *Client Characteristic Configuration* descriptor).

The Collector may perform a write to the LN Control Point to request a desired procedure. A procedure begins when the Collector writes a particular Op Code to the LN Control Point to perform some desired action and ends when the Collector sends a confirmation to acknowledge the LN Control Point indication sent by the LN Sensor at the end of the procedure. This indication includes: the Response Code, the Requested Op Code, and the Response Value and may also include a Response Parameter, as defined in [1].

4.7.1 LN Control Point Procedure Requirements

Table 4.7 shows the requirements for the LN Control Point procedures (Op Codes) in the context of this profile:

Procedure (Op Code)	Requirement
Set Cumulative Value	O
Mask Location and Speed Characteristic Content	O
Navigation Control	C.1
Request Number of Routes	C.1
Request Name of Route	C.1
Select Route	C.1
Set Fix Rate	O
Set Elevation	O

Table 4.7: LN Control Point Procedure Requirements

C.1: Mandatory if Navigation feature is supported by the Collector, otherwise Excluded.

4.7.2 LN Control Point Behavioral Description

The Collector shall write to the LN Control Point characteristic using one of the supported Op Codes in Table 4.7 to request a LN Sensor to perform a procedure. This shall include a Parameter that is valid within the context of that Op Code as defined in [3].

4.7.2.1 Set Cumulative Value Procedure

To request a specific setting of the Total Distance value within the LN Sensor, the Collector shall write the *Set Cumulative Value* Op Code followed by a UINT24 parameter. For example, writing a parameter of 0x000000 will set the Total Distance value to 0 within the Sensor.

In some cases it may be desirable to use this feature to allow a user to transfer the total distance value from their old sensor onto their new sensor (e.g., if they desire to keep track of the total distance they have trained). In this scenario, a Collector that knows the Total Distance value that was reached with the old LN Sensor can use the Set Cumulative Value Procedure to set the Total Distance value within the new LN Sensor to the same value.

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating successful operation as per the request or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.2.2 Mask Location and Speed Characteristic Content Procedure

To set the content of the Location and Speed characteristic within the LN Sensor, the Collector shall write the *Mask Location and Speed Characteristic Content* Op Code with a UINT16 Parameter that represents the content mask of the Location and Speed characteristic (e.g., the fields that are requested to be turned off) as defined in Table 4.8.

Bit Number	Description
0	Instantaneous Speed 0: Leave as default 1: Turn off
1	Total Distance 0: Leave as default 1: Turn off
2	Location 0: Leave as default 1: Turn off
3	Elevation 0: Leave as default 1: Turn off
4	Heading 0: Leave as default 1: Turn off
5	Rolling Time 0: Leave as default 1: Turn off

Bit Number	Description
6	UTC Time 0: Leave as default 1: Turn off
7-15	Reserved for future use

Table 4.8: Mask Location and Speed Characteristic Content Procedure Parameter Requirements

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating success of the operation as per the request or an error response value as described in section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.2.3 Navigation Control Procedure

To control the sending of the Navigation characteristic of LN Sensor and/or to request a specific Navigation action within the LN Sensor, the Collector shall write the *Navigation Control* Op Code with a UINT8 Parameter that represents the control value as defined in Table 4.9.

Parameter value	Navigation Action
0x00	Stop Notification. Stop navigation
0x01	Start Notification. Start navigation to the first waypoint on a route
0x02	Stop Notification. Pause navigation keeping the next waypoint on the route in the memory for continuing the navigation later
0x03	Start Notification. Continue navigation from the point where navigation was paused to the next waypoint on the route
0x04	Notification not affected. Skip waypoint: disregard next waypoint and continue navigation to the next waypoint on the route
0x05	Start Notification. Select nearest waypoint on the route: measure the distance to all waypoints on the route, and start navigation to the closest waypoint on the route and from there to waypoints following that waypoint along the route
0x06-0xFF	Reserved for future use

Table 4.9: Navigation Control Procedure Parameter Requirements

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating successful operation as per the request or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.2.4 Request Number of Routes Procedure

To request the total number of routes stored in the LN Sensor, the Collector shall use the *Request Number of Routes* procedure.

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating success the operation as per the request with a UINT16 Response Parameter value that represent the number of available routes or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

For LE, the Collector should accept a larger MTU than the default (i.e., 23 byte) ATT MTU if requested by the LN Sensor using the GATT Exchange MTU sub procedure in order to allow the LN Sensor to send longer route names.

For BR/EDR, this restriction does not exist due to a larger MTU size.

See Section 4.7.3 for general error handling procedures.

4.7.2.5 Request Name of Route Procedure

To request the name of a route stored in the LN Sensor, the Collector shall write the *Request Name of Route* Op Code with a UINT16 Parameter that represents the sequence number of the route in the LN Sensor.

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating success of the operation as per the request with a UTF-8 string Response Parameter value that represent the name of the route or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.2.6 Select Route Procedure

To select the route for navigation in the LN Sensor, the Collector shall write the *Select Route* Op Code with a UINT16 Parameter that represents the sequence number of the route in the LN Sensor.

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating success of the operation as per the request or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.2.7 Set Fix Rate Procedure

To request a specific setting of the Fix Rate within the LN Sensor, the Collector shall write the *Set Fix Rate* Op Code followed by a UINT8 parameter. Parameter represents the fix rate in seconds. For example, writing a parameter of 0x0A will set the fix rate to 10 seconds. Parameter value 0x00 sets the fix rate to the fastest possible.

If a Collector does not require frequent updates, it can save power in the LN Sensor by setting this value to a less frequent value.

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating successful operation as per the request or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.2.8 Set Elevation Procedure

To set the elevation to a specific value within the LN Sensor, the Collector shall write the *Set Elevation* Op Code followed by a SINT24 parameter. For example, writing a parameter of 0x000000 will set the Elevation value to 0 within the Sensor.

Setting the Elevation is normally used when elevation is based on barometric air pressure.

The Collector shall wait for the *Response Code* LN Control Point Indication with the Response Value set to *Success* indicating successful operation as per the request or an error response value as described in Section 4.7.3 or for the procedure to time out according to the procedure time out operation described in Section 4.7.4.

See Section 4.7.3 for general error handling procedures.

4.7.3 General Error Handling

The Collector shall be tolerant when receiving the following Control Point Error codes defined in [3]:

- Op Code Not Supported
- Invalid Parameter
- Operation Failed

The Collector shall also be tolerant when receiving the following ATT Error Codes defined in CSS Part B, Section 1.2 [6]:

- Procedure Already In Progress
- Client Characteristic Configuration Descriptor Improperly Configured

4.7.4 Procedure Timeout

In the context of the LN Control Point characteristic, a procedure is started when the Collector writes a particular Op Code to the LN Control Point to perform some desired action and ends when the Collector sends a confirmation to acknowledge the LN Control Point indication sent by the LN Sensor at the end of the procedure with the Op Code set to *Response Code*.

In the context of the LN Control Point characteristic, a procedure is not considered started and not queued in the LN Sensor when a write to the LN Control Point results in an ATT Error Response defined in CSS Part B, Section 1.2 [6] or an error response defined in [3].

A procedure is considered to have timed out if an LN Control Point indication is not received within the ATT transaction timeout, defined as 30 seconds in Volume 2 Part F Section 3.3.3 of [2], from the start of the procedure.

If the link is lost while a LN Control Point procedure is in progress then the procedure shall be considered to have timed out. See Section 4.7.4.1 for handling this condition.

Thus a Collector shall start a timer, with the value set to the ATT transaction timeout, after the write response is received from the LN Sensor. The timer shall be stopped when a LN Control Point indication is received and the Op Code is set to *Response Code*. If the timer expires then the procedure shall be considered to have failed.

4.7.4.1 LN Control Point Procedure Timeout Handling

If an LN Control Point procedure times out (see Section 4.7.4 for details of how this may occur) then no new LN Control Point procedure shall be started by the Collector until a new link is established with the LN Sensor. To ensure a good user experience, if a LN Control Point procedure times out, the Collector should disconnect and then reconnect.

4.8 Navigation

Prior to using the Navigation Control procedure to control the sending of Navigation notifications and controlling the navigation (see Section 4.7.2.3), the Collector shall configure for notification the Navigation characteristic (i.e., via the *Client Characteristic Configuration* descriptor) and it shall also configure for indication the LN Control Point characteristic (i.e., via the *Client Characteristic Configuration* descriptor).

By using the appropriate Control Point procedures, the Collector may request a number of routes available in the sensor (see Section 4.7.2.4), request a name of certain route (see Section 4.7.2.5), and select the route to be used in navigation (see Section 4.7.2.6).

If the Collector enables notifications of the Navigation characteristic, it shall be able to receive the notifications from the LN Sensor at intervals determined by the LN Sensor.

The Collector shall determine the contents of the Navigation characteristic structure based on the contents of the Flags field. This allows the Collector to determine whether or not the optional fields are present.

The Collector may refer to the Heading Source bit of the Flags field of the Navigation characteristic to determine the source of heading (e.g. based on movement or based on magnetic compass)

If Remaining Distance data is present, the Collector shall refer to the Navigation Indicator Type bit of the Flags field of the Navigation characteristic to determine if remaining distance refers to waypoint or destination.

If Remaining Vertical Distance data is present, the Collector shall refer to the Navigation Indicator Type bit of the Flags field if the Navigation characteristic to determine if remaining vertical distance refers to waypoint or destination.

If Estimated Time of Arrival data is present, the Collector shall refer to the Navigation Indicator Type bit of the Flags field of the Navigation characteristic to determine if estimated time of arrival refers to waypoint or destination.

During the navigation, the Collector shall refer to the Waypoint Reached bit of the Flags field of the Navigation characteristic to determine if the waypoint has been reached.

During the navigation, the Collector shall refer to Destination Reached bit of the Flags field of the Navigation characteristic to determine if the destination has been reached.

The Collector may refer to Position Status bits of the Flags field of the Navigation characteristic to determine position status (e.g., no position, position ok, estimated, or last known position) and thus the accuracy of all navigation information.

If the Collector receives a Navigation characteristic with Reserved for Future Use (RFU) bits of the Flags field that are non-zero, it shall ignore those bits and continue to process the Navigation characteristic in the same way as if all the RFU bits had been zero.

When the implementation receives a Navigation characteristic with additional unrecognized octets, the Collector behavior shall be identical to the Collector behavior when only recognized octets are received. This is to enable compatibility with future Location and Navigation Service updates for the case where available octets in the characteristic are specified for optional use. What the Collector does with the additional, unrecognized, octets is left to the implementation.

4.9 Device Information Service Characteristics

The Collector may read the value of Device Information Service characteristics.

4.10 Battery Service Characteristics

The Collector may read the value of the Battery Level characteristic exposed in the Battery Service. If the LN Sensor supports the notification of the Battery Level characteristic, the Collector may also configure this characteristic for notification (e.g., via the *Client Characteristic Configuration* descriptor).

5 Connection Establishment Procedures

This section describes the connection establishment and connection termination procedures used by a LN Sensor and Collector in certain scenarios.

The following scenario description is informative for Low Energy Transport:

> Once configured by the Collector, a LN Sensor will typically remain powered off between uses and will only advertise and allow a Collector to connect when it is switched on. In this scenario, the LN Sensor will enter a GAP Connectable Mode and start advertising when it has data to send to a Collector. The Collector will typically execute a GAP connection establishment procedure such that it is scanning for a LN Sensor. When a connection is established and the LN Sensor is configured for notifications and indications by the Collector, the LN Sensor sends notifications to the Collector at regular intervals. When the training session is ended on the Collector, the Collector typically terminates the connection. When the LN Sensor is inactive for a certain period of time, the LN Sensor typically terminates the connection.

5.1 LN Sensor Connection Establishment for Low Energy Transport

This section describes connection procedures a LN Sensor should follow to initiate a connection with a Collector using an LE transport.

- Section 5.1.1 describes the connection procedure when the LN Sensor does not support bonding or if the LN Sensor supports bonding, but is not bonded with any Collectors.
- Section 5.1.2 describes the connection procedure when the LN Sensor is bonded with one or more Collectors.
- Section 5.1.3 is used when the established connection is broken after a link loss.

5.1.1 Connection Procedure for Unbonded Devices

This procedure is used for connection establishment when the LN Sensor is not bonded with any Collectors and ready for connection (e.g. when the LN Sensor detects some activity or when commanded by the user).

The LN Sensor should use the GAP General Discoverable Mode with connectable undirected advertising events when establishing a connection.

If a connection is not established within T_{GAP}(adv_fast_period), the LN Sensor may either continue sending background advertising to reduce power consumption as long as it detects user activity (e.g. significant movement) or stop advertising.

The advertising interval and time to perform advertising should be configured with consideration for user expectations of connection establishment time.

If a connection is not established within a time limit defined by the LN Sensor, the LN Sensor may exit the GAP Connectable Mode.

The LN Sensor should be in the Bondable mode during this procedure to optimize the future connections to the Collector.

If a bond is created, the LN Sensor should write the Bluetooth device address of the Collector in the Filter Accept List of its controller.

When the LN Sensor no longer detects user activity for several seconds (e.g., 10 to 20 seconds), the LN Sensor should perform the GAP *Terminate Connection* procedure.

5.1.2 Connection Procedure for Bonded Devices

This procedure is used after the CP Sensor is bonded with one or more Collectors.

When establishing a connection, the LN Sensor should use the GAP Non-Discoverable Mode with connectable undirected advertising events for the first 10 seconds, with a Filter Accept List containing addresses of bonded devices, to allow only active bonded Collectors to establish a connection. After the 10 second period has expired and in order to allow connection with additional Collectors, the LN Sensor should use the GAP General Discoverable Mode with connectable undirected advertising events and it should be in the GAP Bondable mode

If a connection is not established within T_{GAP}(adv_fast_period), the LN Sensor may either continue sending background advertising to reduce power consumption as long as it detects user activity (e.g. user turns the cranks) or stop advertising.

The advertising interval and time to perform advertising should be configured with consideration for user expectations of connection establishment time.

If a connection is not established within a time limit defined by the LN Sensor, the LN Sensor may exit the GAP Connectable Mode.

If a bond is created, the LN Sensor should write the Bluetooth device address of the Collector in the Filter Accept List of its controller.

When the LN Sensor no longer detects user activity for several seconds (e.g., 10 to 20 seconds), the LN Sensor should perform the GAP *Terminate Connection* procedure.

When the LN Sensor is disconnected and the LN Sensor is ready for reconnection (e.g., when the LN Sensor detects some activity or when commanded by the user), the LN Sensor should reinitiate the connection procedure (e.g. start advertising).

5.1.3 Link Loss Reconnection Procedure

When a connection is terminated due to link loss, a LN Sensor should attempt to reconnect to the Collector by entering a GAP Connectable Mode.

5.2 Collector Connection Establishment for Low Energy Transport

This section describes connection procedures a Collector should follow to initiate a connection with a LN Sensor using an LE transport.

The Collector should use the GAP *General Discovery* procedure to discover a LN Sensor.

A Collector may use one of the GAP connection procedures based on its connectivity requirements as described in Table 5.1:

GAP Connection Procedure	Unbonded Collector	Bonded Collector
General Connection Establishment	Allowed	Allowed
Direct Connection Establishment	Allowed	Allowed
Auto Connection Establishment	Not Allowed	Allowed
Selective Connection Establishment	Not Allowed	Allowed

Table 5.1: Allowed GAP Connection Procedure

If a connection is not established within T_{GAP}(adv_fast_period), (see [2] Volume 3, Part C, Section 9.3.11), the Collector may either continue background scanning to reduce power consumption or stop scanning.

The scan interval, scan window and time to perform scanning should be configured with consideration for user expectations of connection establishment time as defined in [2] Volume 3, Part C, Section 9.3.11.

If a connection is not established within a time limit defined by the Collector, the Collector may exit the connection establishment procedure.

When the connection is established, the Collector should bond with the LN Sensor to optimize the future connections to the device.

If a bond is created, the Collector should write the Bluetooth device address of the LN Sensor in the Filter Accept List of its controller and set its initiator filter policy to 'process connectable advertisement packets'.

Once connected and if not already bonded to the LN Sensor, the Collector shall configure at least one of the Location and Speed or the Navigation characteristic for notification and shall configure the LN Control Point characteristic for indication.

The Collector should terminate the connection when the measurement session is terminated at the Collector by the user. The LN Sensor will typically terminate the connection if the LN Sensor no longer detects user activity for several seconds (e.g., 10 to 20 seconds).

When the Collector is disconnected, the Collector may initiate the new Connection Procedure.

For Collectors that may be used with one or more LN Sensors, refer to Section 5.4.

5.2.1 Link Loss Reconnection Procedure

When a connection is terminated due to link loss, a Collector should attempt to reconnect to the LN Sensor using any of the GAP connection procedures using the connection establishment timing parameters defined in [2] Volume 3, Part C (GAP) section 9.3.11 and the connection interval timing parameters defined in [2] Volume 3, Part C (GAP) section 9.3.12.

5.3 Connection Establishment for BR/EDR

This section describes the connection establishment and connection termination procedures used by a LN Sensor and Collector using a BR/EDR transport. Unlike the LE Connection procedures, which describe specific connection parameters, BR/EDR connection establishment does not state requirements

beyond those described in GAP based on potential interactions with other BR/EDR profiles operating concurrently on the LN Sensor and/or Collector.

When using BR/EDR, devices can utilize sniff mode and sniff subrating to reduce power consumption; however no particular parameters are recommended and the requirements of other profiles may need to be considered.

5.3.1 Connection Procedure

The procedures for establishing a connection between an LN Sensor and Collector that do not have an existing bond and for re-establishing a connection between bonded devices use the inquiry, discovery, paging, pairing and security procedures described in Generic Access Profile of the Core Specification [2] and any additional GAP requirements enumerated in Sections 6 and 7.

5.3.1.1 Connection Procedure for Unbonded Devices

The LN Sensor shall use the GAP General Discoverable Mode when it is not bonded with any Collectors and is ready for a connection (e.g., when the LN Sensor detects movement or when commanded by the user).

The Collector should use the GAP *General Discovery* procedure to discover a LN Sensor to establish a connection to a LN Sensor to which it is not bonded.

Either the LN Sensor or the Collector can establish a BR/EDR link to a remote peer device.

Once a link is established, the Collector shall discover the Location and Navigation Service using SDP procedures prior to establishing a GATT connection.

Once the Location and Navigation Service is discovered and a GATT connection is established, the Collector shall discover the Location and Navigation Service characteristics exposed by this service using GATT Discovery procedures.

Once connected, the Collector shall configure the Location and Speed characteristic for notification. If the LN Sensor exposes the LN Control Point characteristic, the Collector should configure the LN Control Point for indication.

The Collector should terminate the connection when the measurement session is terminated at the Collector by the user. When the LN Sensor no longer detects user activity for several seconds (e.g., 10 to 20 seconds), the LN Sensor may disconnect the link, depending on the use cases of the devices and other profiles connected on either device.

For Collectors that may be used with one or more LN Sensors, refer to Section 5.4.

5.3.1.2 Connection Procedure for Bonded Devices

The LN Sensor shall use the GAP Link Establishment Procedure to connect to any bonded Collectors when it is ready for a connection (e.g., when the LN Sensor detects movement or when commanded by the user).

The Collector shall be Connectable to accept a connection from a LN Sensor to which it is bonded.

Either the LN Sensor or the Collector can establish a BR/EDR link to a remote peer device.

If a higher layer determines the bond no longer exists on the remote device, the local device must reconfigure the remote device after

- user interaction confirms that the user wants to re-pair with the remote device,
- re-bonding has been performed, and
- service discovery has been performed.

If the local device had previously determined that the remote device did not have the «Service Changed» characteristic then service discovery may be skipped.

The Collector should terminate the connection when the measurement session is terminated at the Collector by the user. When the LN Sensor no longer detects user activity for several minutes (e.g., 5 to 30 minutes), the LN Sensor may disconnect the link, depending on the use cases of the devices and other profiles connected on either device. When the LN Sensor is disconnected and it is ready for reconnection (e.g., when the LN Sensor detects movement or when commanded by the user), the LN Sensor should initiate a connection with the Collector.

For Collectors that may be used with one or more LN Sensors, refer to Section 5.4.

5.3.2 Link Loss Reconnection Procedure

When a connection is terminated due to link loss, a LN Sensor should reconnect to the Collector by attempting, for an implementation-specific time, to reestablish an ACL link between the two devices. The Collector should remain Connectable for an implementation-specific time so that a LN Sensor can reestablish an ACL link.

5.4 Multiple LN Sensor Considerations

In the context of this Profile, a Collector may be used with more than one LN Sensor, but not simultaneously. To enhance the user experience, it is recommended that the user interface on the Collector allows the user of the Collector to select the LN Sensor to be used among a list of the user's LN Sensors.

The user interface on the Collector should also provide a mechanism to remove LN Sensors and to add new LN Sensors to enhance the user experience.

6 Security Considerations

This section describes the security considerations for a LN Sensor and Collector.

6.1 LN Sensor Security Considerations for Low Energy

This section describes the security requirements for the LN Sensor for an LE transport.

All supported characteristics specified by the Location and Navigation Service shall be set to LE Security Mode 1 and either Security Level 1, 2, or 3.

The LN Sensor should bond with the Collector.

The LN Sensor should use the SM Peripheral Security Request procedure.

If used, all characteristics exposed by the Device Information Service for use by this profile should be set to the same security mode and level as the characteristics in the Location and Navigation Service.

6.2 Collector Security Considerations for Low Energy

This section describes the security requirements for the Collector for an LE transport.

The Collector should bond with the LN Sensor.

The Collector shall accept any request by the LN Sensor for LE Security Mode 1 and either Security Level 1, 2, or 3.

6.3 Security Considerations for BR/EDR

As required by GAP, Security Mode 4 shall be used for connections by LN Sensor and Collector.

- The Collector and LN Sensor should bond.
- Acceptance of Bonding should be supported by all LN Sensors and Collectors.
- Initiation of Bonding should be supported by Collectors.

7 Generic Access Profile for BR/EDR

This section defines the support requirements for the capabilities as defined in the Generic Access Profile of the Core Specification [2] when BR/EDR is used.

7.1 Modes

The Mode Procedures as defined in GAP describe requirements for both LN Sensor and Collectors involved. This profile further refines the requirements.

- General Discoverable mode or Limited Discovery mode shall be supported by LN Sensors supporting BR/EDR.
- Bondable mode should be supported by LN Sensors and Collectors

Table 7.1 shows the support status for GAP Modes in this profile.

Procedure	Support in LN Sensor	Support in Collector
General Discoverable Mode	M	X

Table 7.1: Modes

7.2 Idle Mode Procedures

The Idle Mode Procedures as defined in GAP describe requirements for both LN Sensor and Collectors involved. This profile further refines the requirements.

- General inquiry shall be supported by all Collectors.
- General bonding should be supported by all LN Sensors and Collectors.

Table 7.2 shows the support status for Idle Mode procedures within this profile.

Procedure	Support in LN Sensor	Support in Collector
General Inquiry	X	M

Table 7.2: Idle mode procedures

8 Acronyms and Abbreviations

Acronyms and Abbreviations	Meaning
ACL	Asynchronous Connection-oriented [logical transport]
AD	Advertising Data
AMP	Alternate MAC/PHY
BR/EDR	Basic Rate / Enhanced Data Rate
EHPE	Estimated Horizontal Position Error
ETA	Estimated Time of Arrival
EVPE	Estimated Vertical Position Error
GAP	Generic Access Profile
GATT	Generic Attribute Profile
HDOP	Horizontal Dilution Of Precision
LE	Low Energy
LN	Location and Navigation
RFU	Reserved for Future Use
SDP	Service Discovery Protocol
SM	Security Manager
UUID	Universally Unique Identifier
VDOP	Vertical Dilution Of Precision

Table 8.1: Acronyms and Abbreviations

9 References

[1] Location and Navigation Service

[2] Bluetooth Core Specification v4.2 or later

[3] Bluetooth Assigned Numbers, https://www.bluetooth.com/specifications/assigned-numbers/

[4] Device Information Service v1.1 or later

[5] Battery Service v1.0 or later

[6] Supplement to the Bluetooth Core Specification, Version 11 or later