Location and Navigation Service

***Bluetooth*® Service Specification**

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

Abstract:

This service exposes location and navigation-related data from a Location and Navigation sensor intended for outdoor activity applications.

Revision History

Revision	Date (yyyy-mm-dd)	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 16267, 16268, 18753, 19074, 23317, 22598.

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 Service (LN Service) exposes location and navigation-related data from a Location and Navigation sensor (Server) intended for outdoor activity applications.

1.1 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.

1.2 Service Dependency

This service is not dependent upon any other services.

1.3 Bluetooth Specification Release Compatibility

This specification is compatible with any of the following:

- Bluetooth Core Specification 4.2 or later [1]

1.4 GATT Sub-Procedure Requirements

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

Table 1.1 summarizes additional GATT sub-procedure requirements beyond those required by all GATT Servers.

GATT Sub-Procedure	Requirements
Write Characteristic Value	C.1
Notifications	M
Indications	C.1
Read Characteristic Descriptors	M
Write Characteristic Descriptors	M

Table 1.1: GATT Sub-procedure Requirements

C.1: Mandatory if the LN Control Point characteristic is supported, otherwise excluded for this service.

1.5 Transport Dependencies

There are no transport restrictions imposed by this service specification.

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

1.6 Error Codes

No Attribute Protocol Application Error Codes are defined by this service.

1.7 Byte 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 **Error! Reference source not found.**.

2 Service Declaration

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

The service UUID shall be set to «Location and Navigation Service» defined in **Error! Reference source not found.**.

3 Service Characteristics

The following characteristics are exposed in the Location and Navigation Service. Only one instance of each characteristic is permitted within this service. The characteristic formats and UUIDs are defined in **Error! Reference source not found.**.

Where a characteristic can be notified or indicated, a Client Characteristic Configuration descriptor shall be included in that characteristic as required by the Core Specification [1].

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
LN Feature	M	Read	Indicate C.1	None.
Location and Speed	M	Notify		None.
Position Quality	O	Read		None.
LN Control Point	O	Write, Indicate		None.
Navigation	O	Notify		None.

Table 3.1: Location and Navigation Service Characteristics

C.1: The Indicate property shall be supported for the LN Feature characteristic if the device supports bonding and the value of the LN Feature characteristic can change over the lifetime of the device, otherwise excluded for this service

Notes:

- Security Permissions of “None” means that this service does not impose any requirements.
- Properties not listed as Mandatory or Optional are Excluded for this version of this service.

3.1 LN Feature

The LN Feature characteristic shall be used to describe the supported features of the Server.

Reserved for Future Use (RFU) bits in the LN Feature characteristic value shall be set to 0.

3.1.1 Characteristic Behavior

When read or indicated, the LN Feature characteristic returns a value that is used by a Client to determine the supported features of the Server.

The bits of the LN Feature characteristic may either be static for the lifetime of the device or guaranteed to be static only during a connection. Although all defined bits (i.e., bits 0 to 20) in this version of the service specification are required to be static during the lifetime of a device, it is possible that some future bits will be defined as being static only during a connection.

When the Server supports a feature, the associated bit of the LN Feature characteristic shall be set to 1 (Feature supported), otherwise, the associated bit shall be set to 0 (Feature not supported). The feature bits are defined in **Error! Reference source not found.**.

When the Client Characteristic Configuration descriptor is configured for indications and the supported features of the Server have changed, the LN Feature characteristic shall be indicated to any bonded Collectors after reconnection.

3.2 Location and Speed

The Location and Speed characteristic is used to send location and speed related data. Included in the characteristic value are a Flags field (for showing the presence of optional fields and the status of different items) and depending upon the contents of the Flags field, may contain one or more optional fields defined in **Error! Reference source not found.**.

The Server calculates location and speed related data from position information received from a positioning system (e.g., satellite, tower-based, or Wi-Fi access point based).

3.2.1 Characteristic Behavior

When the Location and Speed characteristic is configured for notification via the *Client Characteristic Configuration* descriptor and data is available, this characteristic shall be notified while in a connection. The Server should notify this characteristic at a regular interval, typically once per second while in a connection and is not configurable by the Client.

If the Server supports the Location and Speed Characteristic Content Masking feature and if the Client requests to turn off a particular field of the Location and Speed characteristic, the Server shall turn off that particular field of the Location and Speed characteristic as described in Section 3.4.2.2.

For LE, all the fields of this characteristic cannot be notified simultaneously if using a default MTU size. If the required data exceeds the current MTU size, the remaining optional fields shall be sent in the subsequent notification.

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

The Location and Speed characteristic contains time-sensitive data, thus the requirements for time-sensitive data and data storage defined in Section 3.6 apply.

3.2.1.1 Flags Field

The Flags field shall be included in the Location and Speed characteristic.

Reserved for Future Use (RFU) bits in the Flags fields shall be set to 0.

The bits of the Flags field, and their function and relationship to bits in the LN Feature characteristic, are shown in Table 3.2.

Flags Bit Name	**When Set To**		**Corresponding LN Feature support bit (see Section 3.1)**
	0	**Otherwise**	
Instantaneous Speed Present (bit 0), see 3.2.1.2	Corresponding field not present	Corresponding field present	Instantaneous Speed Supported (bit 0)
Total Distance Present (bit 1), see 3.2.1.3	Corresponding field not present	Corresponding field present	Total Distance Supported (bit 1)

Flags Bit Name	When Set To		Corresponding LN Feature support bit (see Section 3.1)
	0	Otherwise	
Location Present (bit 2), see 3.2.1.4	Corresponding field pair not present	Corresponding field pair present	Location Supported (bit 2)
Elevation Present (bit 3), see 3.2.1.5	Corresponding field not present	Corresponding field present	Elevation Supported (bit 3)
Heading Present (bit 4), see 3.2.1.6	Corresponding field not present	Corresponding field present	Heading Supported (bit 4)
Rolling Time Present (bit 5), see 3.2.1.7	Corresponding field not present	Corresponding field present	Rolling Time Supported (bit 5)
UTC Time Present (bit 6), see 3.2.1.8	Corresponding field not present	Corresponding field present	UTC Time Supported (bit 6)
Position Status (bits 7 & 8)	No Position	See definitions in **Error! Reference source not found.**	Position Status Supported (bit 20)
Speed and Distance Format (bit 9)	2D. Elevation changes are not taken into account of speed and distance calculations	3D. Elevation changes are taken into account of speed and distance calculations	Instantaneous Speed Supported (bit 0) and Total Distance Supported (bit 1)
Elevation Source (bits 10 & 11)	Positioning System	See definitions in **Error! Reference source not found.**	Elevation Supported (bit 3)
Heading Source (bit 12)	Movement	Magnetic Compass	Heading Supported (bit 4)

Table 3.2: Bit Definitions for the Location and Speed Characteristic

Each of the Flags bits in the table above may change during a connection if the corresponding support bit in the LN Feature characteristic is set to 1 indicating that the feature is supported. If the corresponding support bit is however set to 0, then the corresponding Flags bit shall also be set to 0 since the feature is not supported.

3.2.1.2 Instantaneous Speed Field

The Instantaneous Speed field may be included in the Location and Speed characteristic if the Server supports the Instantaneous Speed feature (see Table 3.2).

The Instantaneous Speed field represents the instantaneous value of the speed measured by the sensor.

The Speed and Distance Format bit of the Flags Field (bit 9) describes whether the instantaneous speed value is taking elevation changes into account (3D) or not (2D).

3.2.1.3 Total Distance Field

The Total Distance field may be included in the Location and Speed characteristic if the Server supports the Total Distance feature (see Table 3.2).

The Total Distance field represents the cumulative value of the total distance measured by the sensor. After reaching the highest value, the total distance rolls over. To enhance the user experience, the Client should handle the total distance value roll over during the connection transparent to the user.

The Speed and Distance Format bit of the Flags Field (bit 9) describes whether the total distance value is taking elevations changes into account or not.

The total distance value can be set to 0 (or another desired value) as described in Section 3.4.2.1.

3.2.1.4 Location Field Pair (Latitude and Longitude)

The Location field pair including Latitude and Longitude fields may be included in the Location and Speed characteristic if the Server supports the Location feature (see Table 3.2). When present, these fields shall always be present as a pair.

The Latitude value represents a geographic coordinate specifying the north-south position of a point on the Earth's surface in WGS-84 format.

The Longitude value represents a geographic coordinate specifying the east-west position of a point on the Earth's surface in WGS-84 format.

3.2.1.5 Elevation Field

The Elevation field may be included in the Location and Speed characteristic if the Server supports the Elevation feature (see Table 3.2).

The Elevation field represents the value of the elevation measured by the sensor.

The Elevation Source bits of the Flags Field (bit 10 and 11) describe the source of the elevation.

If the Elevation Setting feature is supported, the Elevation value can be set to 0 (or another desired value) as described in Section 3.4.2.8.

3.2.1.6 Heading Field

The Heading field may be included in the Location and Speed characteristic if the Server supports the Heading feature (see Table 3.2).

The Heading field represents the direction the user is heading. The Heading value is represented using the WGS-84 format.

The Heading Source bit of the Flags Field (bit 12) describes the source of the heading.

3.2.1.7 Rolling Time Field

The Rolling Time field may be included in the Location and Speed characteristic if the Server supports the Rolling Time feature (see Table 3.2).

The Rolling Time field represents the time in seconds and rolls over every 256 seconds and it can be used by the Client to keep track of the time elapsed between the position information received by the Server.

3.2.1.8 UTC Time Field

The UTC Time field may be included in the Location and Speed characteristic if the Server supports the UTC Time feature (see Table 3.2).

This field represents the time at the Sensor when the position was received in Coordinated Universal Time format.

3.3 Position Quality

The Position Quality characteristic is used to send position quality-related data. Included in the characteristic value is a Flags field (for showing the presence of optional fields and the status of different items). Depending upon the contents of the Flags field, the characteristic value may contain one or more optional fields defined in **Error! Reference source not found.**.

The Server calculates the estimation of the position quality data using position information received from a positioning system (e.g. satellite, tower-based, or Wi-Fi access point based).

3.3.1 Characteristic Behavior

The Position Quality characteristic can be read at any time when a connection is established. Typically in the beginning of an activity, the Position Quality characteristic is read every 10 seconds until the position quality is good. After this, Position Quality is read less frequently, typically once a minute.

3.3.1.1 Flags Field

The Flags field shall be included in the Position Quality characteristic.

Reserved for Future Use (RFU) bits in the Flags fields shall be set to 0.

The bits of the Flags field, and their function and relationship to bits in the LN Feature characteristic, are shown in Table 3.3 and in the following subsections.

EHPE stands for Estimated Horizontal Position Error, EVPE for Estimated Vertical Position Error, HDOP for Horizontal Dilution Of Precision, and VDOP for Vertical Dilution Of Precision.

Flags Bit Name	**When Set To**		**Corresponding LN Feature support bit (see Section 3.1)**
	0	**Otherwise**	
Number of Beacons in Solution Present (bit 0), see 3.3.1.2	Corresponding field not present	Corresponding field present	Number of Beacons in Solution Supported (bit 10)
Number of Beacons in View Present (bit 1), see 3.3.1.3	Corresponding field not present	Corresponding field present	Number of Beacons in View Supported (bit 11)
Time to First Fix Present (bit 2), see 3.3.1.4	Corresponding field not present	Corresponding field present	Time to First Fix Supported (bit 12)

Flags Bit Name	When Set To		Corresponding LN Feature support bit (see Section 3.1)
	0	Otherwise	
EHPE Present (bit 3), see 3.3.1.5	Corresponding field not present	Corresponding field present	Estimated Horizontal Position Error Supported (bit 13)
EVPE Present (bit 4), see 3.3.1.6	Corresponding field not present	Corresponding field present	Estimated Vertical Position Error Supported (bit 14)
HDOP Present (bit 5), see 3.3.1.7	Corresponding field not present	Corresponding field present	Horizontal Dilution Of Precision Supported (bit 15)
VDOP Present (bit 6), see 3.3.1.8	Corresponding field not present	Corresponding field present	Vertical Dilution Of Precision Supported (bit 16)
Position Status (bits 7 & 8)	No Position	See definitions in **Error! Reference source not found.**	Position Status Supported (bit 20)

Table 3.3: Bit Definitions for the Position Quality Characteristic

Each of the Flags bits in the table above may change during a connection if the corresponding support bit in the LN Feature characteristic is set to 1 indicating that the feature is supported. If the corresponding support bit is however set to 0, then the corresponding Flags bit shall also be set to 0 since the feature is not supported.

3.3.1.2 Number of Beacons in Solution Field

The Number of Beacons in Solution field may be included in the Position Quality characteristic if the Server supports the Number of Beacons in Solution feature (see Table 3.3).

The Number of Beacons in Solution field represents the number of beacons used to calculate the current position. In the case of a satellite-based solution this value represents the number of satellites, for a tower-based solution this value represents the number of towers, and for a Wi-Fi-based solution this represents the number of access points.

3.3.1.3 Number of Beacons in View Field

The Number of Beacons in View field may be included in the Position Quality characteristic if the Server supports the Number of Beacons in View feature (see Table 3.3).

The Number of Beacons in View field represents the number of beacons from which the Server is receiving data. In the case of a satellite-based solution this value represents the number of satellites, for a tower-based solution this value represents the number of towers, and for a Wi-Fi-based solution this represents the number of access points.

3.3.1.4 Time to First Fix Field

The Time to First Fix field may be included in the Position Quality characteristic if the Server supports the Time to First Fix feature (see Table 3.3).

The Time to First Fix field represents the time used to receive data and calculate the initial position after the device was switched on.

3.3.1.5 EHPE Field

The EHPE field may be included in the Position Quality characteristic if the Server supports the EHPE feature (see Table 3.3).

The EHPE field represents the Estimated Horizontal Position Error, i.e., a measure of the error in a position in the horizontal plane.

3.3.1.6 EVPE Field

The EVPE field may be included in the Position Quality characteristic if the Server supports the EVPE feature (see Table 3.3).

The EVPE field represents the Estimated Vertical Position Error, i.e., a measure of the error in a position in the vertical plane.

3.3.1.7 HDOP Field

The HDOP field may be included in the Position Quality characteristic if the Server supports the HDOP feature (see Table 3.3).

The HDOP field represents the Horizontal Dilution of Precision, a factor that influences the error in a position fix in the horizontal plane. It is a measure of the geometric quality of a positioning configuration.

3.3.1.8 VDOP Field

The VDOP field may be included in the Position Quality characteristic if the Server supports the VDOP feature (see Table 3.3).

The VDOP field represents the Vertical Dilution of Precision, a factor that influences the error in a position fix in the vertical plane. It is a measure of the geometric quality of a positioning configuration.

3.4 LN Control Point

If the LN Control Point is supported, profiles utilizing this service are required to ensure that the Client configures the LN Control Point characteristic for indications (i.e., via the *Client Characteristic Configuration* descriptor) at the first connection.

Support for this characteristic is mandatory if the Server supports any of the features requiring control point procedures.

3.4.1 Procedure Requirements

Table 3.4 shows the requirements for the LN Control Point characteristic in the context of this service.

A Client shall use the *Write Characteristic Value* procedure to initiate a procedure defined in the Table 3.4.

Procedure	Requirement	Parameter Description	Applicable Response Value	Response Parameter
Set Cumulative Value	C.1	Cumulative Value	Success, Op Code Not Supported,	None

Procedure	Requirement	Parameter Description	Applicable Response Value	Response Parameter
			Invalid Parameter, Operation Failed	
Mask Location and Speed Characteristic Content	C.2	Content Mask	Success, Op Code Not Supported, Invalid Parameter, Operation Failed	None
Navigation Control	C.3	Control Value	Success, Op Code Not Supported, Invalid Parameter, Operation Failed	None
Request Number of Routes	C.3	None	Success	Number of Routes
			Op Code Not Supported, Invalid Parameter, Operation Failed	None
Request Name of Route	C.3	Route Number	Success	Name of Route
			Op Code Not Supported, Invalid Parameter, Operation Failed	None
Select Route	C.3	Route Number	Success, Op Code Not Supported, Invalid Parameter, Operation Failed	None
Set Fix Rate	C.4	Fix Rate	Success, Op Code Not Supported, Invalid Parameter, Operation Failed	None
Set Elevation	C.5	Elevation	Success, Op Code Not Supported, Invalid Parameter, Operation Failed	None

Table 3.4: LN Control Point Procedure Requirements

C.1: Mandatory if Total Distance feature is supported, otherwise excluded from this version of this Service.

C.2: Mandatory if Location and Speed Characteristic Content Masking feature is supported, otherwise excluded from this version of this Service.

C.3: Mandatory if Navigation feature is supported, otherwise excluded from this version of this Service.

C.4: Mandatory if Fix Rate Setting feature is supported, otherwise excluded from this version of this Service.

C.5: Mandatory if Elevation Setting feature is supported, otherwise excluded from this version of this Service.

3.4.2 Behavioral Description

The LN Control Point is used by a Client to control certain behaviors of the Server. Procedures are triggered by a Write to this characteristic value that includes an Op Code specifying the operation (see Table 3.4), which may be followed by a Parameter that is valid within the context of that Op Code.

3.4.2.1 Set Cumulative Value Procedure

When the *Set Cumulative Value* Op Code is written to the LN Control Point (along with the desired parameter value) and if the Total Distance feature is supported by the Server, the Server shall set the Total Distance value to the desired cumulative total distance value transmitted as a Parameter of the LN Control Point. The format of the Parameter Value of this Control Point is UINT24 and represents the cumulative total distance value in meters with a resolution of 0.1 meters. The response shall be indicated when the Total Distance value is applied using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

If the operation results in an error condition, or if the Total Distance feature is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.2 Mask Location and Speed Characteristic Content Procedure

When the *Mask Location and Speed Characteristic Content* Op Code is written to the LN Control Point (along with the desired parameter value that represents the mask) and if the Location and Speed Characteristic Content Masking feature is supported by the Server, the Server shall disable (i.e., turn off) fields of the Location and Speed characteristic based on the transmitted Parameter of the LN Control Point. The format of the Parameter Value of this Control Point is UINT16 and represents the fields of the Location and Speed characteristic to turn off as described in Table 3.5.

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

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

Table 3.5: Mask Location and Speed Characteristic Content Procedure Parameter Requirements

This Control Point procedure is typically used to save power in the Server. When the Client does not need a particular field of the Location and Speed characteristic, the Client may turn off that particular field of the Location and Speed characteristic. The response shall be indicated when the Location and Speed characteristic content is updated in the Server using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

The Server shall not cache the most recent value of the field configuration of the Location and Speed characteristic and each time a connection is established, it shall use its default configuration (e.g., all supported fields of the Location and Speed characteristic are enabled).

If the operation results in an error condition, or if the Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.3 Navigation Control Procedure

When the *Navigation Control* Op Code is written to the LN Control Point (along with the desired parameter value that represents the action) and if the Navigation feature is supported by the Server and the Navigation characteristic is configured for notifications, the Server shall perform the desired action, based on the Parameter of the LN Control Point, as defined in Table 3.6. The format of the Parameter Value of this Control Point is UINT8.

Parameter Value	Action Description
0x00	Stop Notification of the Navigation characteristic. Stop Navigation
0x01	Start Notification of the Navigation characteristic. Start Navigation to the first waypoint on a route
0x02	Stop Notification of the Navigation characteristic. Pause Navigation keeping the next waypoint on the route in the memory for continuing the navigation later
0x03	Start Notification of the Navigation characteristic. Continue Navigation from the point where navigation was paused to the next waypoint on the route

Parameter Value	Action Description
0x04	Notification of the Navigation characteristic not affected. Skip Waypoint: disregard next waypoint and continue navigation to the waypoint following next waypoint on the route
0x05	Start Notification of the Navigation characteristic. Select Nearest Waypoint on a Route: measure the distance to all waypoints on the route, and start navigation to the closest or optimal waypoint on the route (left to the implementation) and from there to waypoints following next waypoint along the route
0x06-0xFF	Reserved for future use

Table 3.6: Navigation Control Procedure Parameter Requirements

The response shall be indicated when the Navigation Control action is performed using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

If the operation results in an error condition, if the Navigation feature is not supported by the Server, or if the Navigation characteristic is not configured for notifications, see Section 3.4.3 for details on handling this condition.

3.4.2.4 Request Number of Routes Procedure

When the *Request Number of Routes* Op Code is written to the LN Control Point and if the Navigation feature is supported by the Server, the Server shall respond with the current number of routes stored in the Server in its Response Parameter. The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, and the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the number of routes in the Response Parameter. The format of the Response Parameter, in response to this Control Point, is UINT16 and represents the number of routes stored in the Server.

If the operation results in an error condition, or if the Navigation feature is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.5 Request Name of Route Procedure

When the *Request Name of Route* Op Code is written to the LN Control Point (along with a parameter value that represents the route) and if the Navigation feature is supported by the Server, the Server shall respond with the corresponding route name in its Response Parameter. The format of the Parameter Value of this Control Point is UINT16 and represents the number of the desired route. The valid route number values are sequenced from 0 to the number of routes -1. (See Section 3.4.2.4 on how to request the number of routes available in the Server.) The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, and the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the name of the route in the Response Parameter. The format of the Response Parameter, in response to this Control Point, is UTF-8 string and represents the name of the selected route stored in the Server.

For LE, if the length of the route name exceeds the current MTU size -5, the Server should negotiate a larger MTU to enhance the user experience. Otherwise, the route name will be truncated.

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

If the operation results in an error condition, or if the Navigation feature is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.6 Select Route Procedure

When the *Select Route* Op Code is written to the LN Control Point (along with a parameter value that represents the route) and if the Navigation feature is supported by the Server, the Server shall use the route designated in the Parameter Value field for navigation. The format of the Parameter Value of this Control Point is UINT16 and represents the desired route number as described in Section 3.4.2.5. The response shall be indicated when the route has been selected using the *Response Code* Op Code, the *Request* Op Code along with "Success" or other appropriate *Response Value*.

If the operation results in an error condition, or if the Navigation feature is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.7 Set Fix Rate Procedure

When the *Set Fix Rate* Op Code is written to the LN Control Point (along with the desired parameter value that represents the rate) and if the Fix Rate Setting feature is supported by the Server, the Server shall set the Fix Rate value, i.e., a value specifying how often the position is acquired, to the desired value transmitted as a Parameter of the LN Control Point. The format of the Parameter Value of this Control Point is UINT8 and represents the fix rate value with a resolution of 1 second. The response shall be indicated when the Fix Rate value is applied using the *Response Code* Op Code, the *Request* Op Code along with "Success" or other appropriate *Response Value*.

If the operation results in an error condition, or if the Fix Rate Setting feature is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.8 Set Elevation Procedure

When the *Set Elevation* Op Code is written to the LN Control Point (along with the desired parameter value that represents the elevation) and if the Elevation and Elevation Setting features are supported by the Server, the Server shall set the Elevation value to the desired elevation value transmitted as a Parameter of the LN Control Point. The format of the Parameter Value of this Control Point is SINT24 and represents the elevation value in meters with a resolution of 0.01 meters. The response shall be indicated when the Elevation value is applied using the *Response Code* Op Code, the *Request* Op Code along with "Success" or other appropriate *Response Value*. This procedure is typically used to calibrate devices based on a barometric elevation sensor. The Client sets the elevation value of the Server to a known elevation.

If the operation results in an error condition, or if the Elevation Setting feature is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.3 General Error Handling procedures

Other than error handling procedures that are specific to certain Op Codes, the following apply:

If an Op Code is written to the LN Control Point characteristic that is unsupported by the Server, the Server, after sending a Write Response, shall indicate the LN Control Point with a *Response Code* Op Code, the *Request* Op Code and *Response Value* set to *Op Code Not Supported*.

If a Parameter is written to the LN Control Point characteristic that is invalid (e.g., the Client writes the *Mask Location and Speed Characteristic Content* Op Code with a mask that is not valid in the context of the Server, or out of the supported range of the Server), the Server, after sending a Write Response, shall

indicate the LN Control Point with a *Response Code* Op Code, the *Request* Op Code and *Response Value* set to *Invalid Parameter*.

If an Op Code is written to the LN Control Point characteristic while the Server is performing a previously triggered LN Control Point operation (i.e., resulting from invalid Client behavior), the Server shall return an error response with the Attribute Protocol error code set to *Procedure Already In Progress* as defined in CSS Part B, Section 1.2 [3].

If an Op Code is written to the LN Control Point characteristic and the *Client Characteristic Configuration* descriptor of the LN Control Point is not configured for indications, the Server shall return an error response with the Attribute Protocol Application error code set to *Client Characteristic Configuration Descriptor Improperly Configured* as defined in CSS Part B, Section 1.2 [3].

If the *Navigation Control* Op Code is written to the LN Control Point characteristic and the *Client Characteristic Configuration* descriptor of the Navigation characteristic is not configured for notification, the Server shall return an error response with the Attribute Protocol error code set to *Client Characteristic Configuration Descriptor Improperly Configured* as defined in CSS Part B, Section 1.2 [3].

3.4.4 Procedure Timeout

In the context of the LN Control Point characteristic, a procedure is started when a write to the LN Control Point characteristic is successfully completed (i.e., the Server sends a Write Response). When a procedure is complete, the Server shall indicate the LN Control Point 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 Server when a write to the LN Control Point results in an error response with the Attribute Protocol error code defined in CSS Part B, Section 1.2 [3], or with the error code defined in **Error! Reference source not found.**.

3.5 Navigation

The Navigation characteristic is used to send navigation-related data. Included in the characteristic value are a Flags field (for showing the presence of optional fields and the status of different items), a Bearing field and a Heading field. Depending upon the contents of the Flags field, the characteristic value may contain one or more optional fields defined in **Error! Reference source not found.**.

If the Server supports Navigation characteristic, it calculates navigation data using position related data received from a positioning system and the stored route information.

3.5.1 Characteristic Behavior

Notification can only occur when enabled by the Client using the Navigation Control Procedure described in Section 3.4.2.3. When enabled, the Navigation characteristic is typically notified once per second and is not configurable by the Client.

The Navigation characteristic contains time-sensitive data, thus the requirements for time-sensitive data and data storage defined in Section 3.6 apply.

3.5.1.1 Flags Field

The Flags field shall be included in the Navigation characteristic.

Reserved for Future Use (RFU) bits in the Flags fields shall be set to a default value of 0.

The bits of the Flags field, their function and relationship to bits in the LN Feature characteristic are shown in Table 3.7 and in the following subsections.

Flags Bit Name	When Set To		Corresponding LN Feature support bit (see Section 3.1)
	0	Otherwise	
Remaining Distance Present (bit 0), see 3.5.1.4	Corresponding field not present	Corresponding field present	Remaining Distance Supported (bit 7)
Remaining Vertical Distance Present (bit 1), see 3.5.1.5	Corresponding field not present	Corresponding field present	Remaining Vertical Distance Supported (bit 8)
Estimated Time of Arrival Present (bit 2), see 3.5.1.6	Corresponding field not present	Corresponding field present	Estimated Time of Arrival Supported (bit 9)
Position Status (bits 3 & 4)	No Position	See definitions in **Error! Reference source not found.**	Position Status Supported (bit 20)
Heading Source (bit 5)	Movement	Magnetic Compass	None
Navigation Indicator Type (bit 6)	Remaining Distance is relative to the Waypoint	Remaining Distance is relative to the Destination	Remaining Distance Supported (bit 7)
	Remaining Vertical Distance is relative to the Waypoint	Remaining Vertical Distance is relative to the Destination	Remaining Vertical Distance Supported (bit 8)
	Estimated Time of Arrival is relative to the Waypoint	Estimated Time of Arrival is relative to the Destination	Estimated Time of Arrival Supported (bit 9)
Waypoint Reached (bit 7), see 3.5.1.1.1	Waypoint is not reached	Waypoint is reached.	None
Destination Reached (bit 8), see 3.5.1.1.2	Destination is not reached	Destination is reached	None

Table 3.7: Bit Definitions for the Navigation Characteristic

Each of the Flags bits in the table above may change during a connection if the corresponding support bit in the LN Feature characteristic is set to 1 indicating that the feature is supported. If the corresponding support bit is however set to 0, then the corresponding Flags bit shall also be set to a default value of 0 since the feature is not supported.

3.5.1.1.1 Waypoint Reached bit

The Waypoint Reached bit (bit 7 of the Flags field) indicates if the waypoint has been reached or not.

During navigation, the Server shall keep the Waypoint Reached bit value at 0 as long as a waypoint has not been reached. When the waypoint is reached, the Server shall set the Waypoint Reached bit value to 1.

An artificial radius around a waypoint is typically used to determine when the waypoint is reached. The radius should be implemented according to the positioning system in use. For satellite positioning and Wi-Fi based systems, a typical radius used is 20 meters and for tower based systems some hundreds of meters. Once the waypoint is reached, a new waypoint is loaded as a target and the Waypoint Reached bit is set to 0.

3.5.1.1.2 Destination Reached bit

The Destination Reached bit (bit 8 of the Flags field) indicates if the final destination (i.e., the last waypoint in the route) has been reached or not.

During navigation, the Server shall keep the Destination Reached bit value at 0 as long as final destination has not been reached. When the final destination is reached, the Server shall set the Destination Reached bit value to 1.

An artificial radius around final destination point is typically used to determine when the final destination is reached. The radius should be implemented according to the positioning system in use. For satellite positioning and Wi-Fi based systems, a typical radius used is 20 meters and for tower based systems some hundreds of meters.

3.5.1.2 Bearing Field

The Bearing field shall be included in the Navigation characteristic.

The Bearing field represents the direction where the user should be heading to reach the next waypoint or final destination. The Bearing follows the Great Circle path (orthodrome) and is represented using the WGS-84 format.

3.5.1.3 Heading Field

The Heading field shall be included in the Navigation characteristic.

The Heading field represents the direction where the user is heading to. The Heading value is represented using the WGS-84 format.

The Heading Source bit of the Flags Field (bit 5) describes the source of the heading.

3.5.1.4 Remaining Distance Field

The Remaining Distance field may be included in the Navigation characteristic if the Server supports the Remaining Distance feature (see Table 3.7).

The Remaining Distance field represents the distance from the current position to the next waypoint or final destination. The Remaining Distance is based on the Great Circle distance between two points.

The Navigation Indicator Type bit (see Table 3.7) is used to specify if the remaining distance is relative to the next waypoint or to the final destination.

3.5.1.5 Remaining Vertical Distance Field

The Remaining Vertical Distance field may be included in the Navigation characteristic if the Server supports the Remaining Vertical Distance feature (see Table 3.7).

The Remaining Vertical Distance field represents the vertical distance from the current position to the next waypoint or final destination.

The Navigation Indicator Type bit (see Table 3.7) is used to specify if the remaining vertical distance is relative to the next waypoint or to the final destination.

3.5.1.6 Estimated Time of Arrival Field

The Estimated Time of Arrival field may be included in the Navigation characteristic if the Server supports the Estimated Time of Arrival feature (see Table 3.7).

The Estimated Time of Arrival field represents the remaining time from the current position to reach the next waypoint or final destination.

The Navigation Indicator Type bit (see Table 3.7) is used to specify if the estimated time of arrival is relative to the next waypoint or to the final destination.

3.6 Requirements for Time-Sensitive Data

The Location and Speed characteristic and Navigation characteristic contain time sensitive data and are considered time-sensitive characteristics, thus the following requirements apply:

The Location and Speed characteristic and Navigation characteristic shall be discarded if either the connection does not get established or if the notification is not successfully transmitted (e.g., due to link loss).

4 SDP Interoperability

If this service is exposed over BR/EDR then it shall have the following SDP record.

Item	Definition	Type	Value	Status
Service Class ID List				M
Service Class #0		UUID	«Location and Navigation»	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
BrowseGroupList			PublicBrowseRoot*	M

Table 4.1: SDP Record

* PublicBrowseRoot shall be present; however, other browse UUIDs may also be included in the list.

5 Acronyms and Abbreviations

Acronyms and Abbreviations	Meaning
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
UTC	Coordinated Universal Time
UUID	Universally Unique Identifier
VDOP	Vertical Dilution Of Precision

Table 5.1: Acronyms and Abbreviations

6 References

[1] Bluetooth Core Specification v4.2 or later

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

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