Indoor Positioning Service

Bluetooth® Service Specification



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Abstract:

This Bluetooth wireless technology Service exposes coordinates and other location related information via an advertisement or indicates that the device address can be used for location look-up, enabling mobile devices to find their position.



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Document Terminology

The Bluetooth SIG has adopted portions 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.

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1 Introduction

The Indoor Positioning Service exposes location information to support mobile devices to position themselves in an environment where GNSS signals are not available, for example in indoor premises. The location information is mainly exposed via advertising and the GATT-based service is primarily intended for configuration.

1.1 Conformance

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

1.2 Service Dependencies

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

1.3 Bluetooth Specification Release Compatibility

This service is compatible with any Bluetooth core specification host that includes the Generic Attribute Profile (GATT) and the broadcast mode in the Generic Access Profile (GAP).

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.

Additional GATT sub-procedures required beyond those required by the GATT are indicated in Table 1.1.

GATT Sub-Procedure		Requirements
Read	Multiple Characteristic Value	М
Read	Long Characteristic Value	C1
Write	Characteristic Value	C2
C1: Mandatory if location name size greater than ATT_MTU-1 is supported by the device		Γ_MTU-1 is supported by
C2:	Mandatory: If characteristic is configurable via an optional	ATT bearer, else

Table 1.1: Table showing additional GATT sub-procedures

1.5 Transport Dependencies

The service may operate over LE and BR/EDR transports. However the broadcasting of the location information will only operate in LE advertising mode.

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

1.6 Application Error Codes

This service defines the following Attribute Protocol Application Error code:

Name	Error Code	Description
Invalid Value	0x80	An attempt was made to write a value to the characteristic that is invalid (e.g. out of range) by this Server.

Table 1.2: Attribute Protocol Application Error code defined by this service

Note: Even if the value of the characteristic being written is acceptable from this specification point of view, the Server may use this error code to indicate that the value is not acceptable from the application point of view.

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 [1].

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2 Service Requirements

2.1 Declaration

The service shall be either a «Primary Service» or «Secondary Service» and the service UUID set to «Indoor Positioning Service» as defined in [2].

2.2 Behaviors

This section describes the service behaviors, including any behaviors associated with each of the characteristics that make up the service.

2.2.1 Service Characteristics and Behaviors

The attribute permissions for the characteristics shall include at least readable and writeable permissions. Additional permission requirements are implementation specific.

Characteristic Name	Status	
Indoor Positioning Configuration	М	
Latitude	М	
Longitude	М	
Local North Coordinate	0	
Local East Coordinate	C1	
Floor Number	0	
Altitude	0	
Uncertainty	0	
Location Name	0	
C1: Mandatory if Local North Coordinate is present else excluded.		

Table 2.1: The Characteristics defined for the Indoor Positioning Service

When a characteristic value is written, the Server may check the validity of the value. If the value is invalid, the Server can reject the write request by sending the error "Invalid Value". The characteristic value will then not be updated.

2.2.1.1 Indoor Positioning Configuration Characteristic Behavior

The Indoor Positioning Configuration Characteristic describes the advertise information data embedded in the Indoor Positioning Service AD type [7] (see Section 2.2.2).

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Reserved for Future Use (RFU) bits in the Indoor Positioning Configuration Characteristic value shall be ignored.

When read, the Indoor Positioning Configuration Characteristic shall return the current value of the characteristic.

When written, the Server shall update the broadcast information associated with the Indoor Positioning Service AD type, according to the new configuration written, and update this characteristic value with the written value.

The configuration of the broadcast information data included in the Indoor Positioning Service AD-type's data is set according to the description in Section 3.1.

2.2.1.2 Latitude Characteristic Behavior

The Latitude Characteristic describes the global WGS84 North coordinate [5] of the device.

When read, the Server shall return the current value of the Latitude Characteristic.

When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.3 Longitude Characteristic Behavior

The Longitude Characteristic describes the global WGS84 East coordinate [5] of the device.

When read, the Server shall return the current value of the Longitude Characteristic.

When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.4 Local North Coordinate Characteristic Behavior

The Local North Coordinate Characteristic describes the North coordinate of the device using a local coordinate system, see Section 3.4.

When read, the Server shall return the current value of the Local North Coordinate Characteristic.

When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.5 Local East Coordinate Characteristic Behavior

The Local East Coordinate Characteristic describes the East coordinate of the device using a local coordinate system, see Section 3.5.

When read, the Server shall return the current value of the Local East Coordinate Characteristic.

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When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.6 Floor Number Characteristic Behavior

The Floor Number Characteristic describes the floor number in which the device is installed.

When read, the Server shall return the current value of the Floor Number Characteristic.

When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.7 Altitude Characteristic Behavior

The Altitude Characteristic describes the altitude of the device above the WGS84 datum.

When read, the Server shall return the current value of the Altitude Characteristic.

When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.8 Uncertainty Characteristic Behavior

The Uncertainty Characteristic describes the uncertainty of the location information the device exposes.

When read, the Server shall return the current value of the Uncertainty Characteristic.

When written, the Server shall update the characteristic value as well as the broadcast information.

2.2.1.9 Location Name Characteristic Behavior

The Location Name Characteristic describes the name of the location in which the device is installed in accordance to the *civicLocation* definition [3].

When read, the Server shall return the current value of the Location Name Characteristic.

When written, the Server shall update the value of the Location Name Characteristic.

2.2.2 Service Behavior

The Server shall broadcast its positioning information according to the information and configuration stored in the service characteristics.

The service can be used by multiple Clients. If a Server can support multiple Clients, the Server shall use the most recent value written by any Client.

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For each update of a characteristic selected to be broadcast (defined in the Indoor Positioning Configuration Characteristic), the Server shall regenerate its broadcast information.

If the flags (defined by the Indoor Positioning Configuration Characteristic), in the broadcast indicate that further information is stored in the GATT database then a minimum of 1 advertisement per second should be connectable. This also applies if the Flags field is excluded, (i.e. all flags are zero) from the advertisement, despite location information being available in the GATT database.

Note: Connectable advertisement without the Flags field does not guarantee that the location information is set in the GATT database.

The connectable advertisements may be less frequent than 1 per second, if the Server's database is only used for configuration (i.e. no additional information is stored in the database compared to the broadcasted data in the advertisement), or another means for making the Server connectable may be provided by the device (e.g. pushing a button to put the Server into configuration mode).

The advertisement interval shall not be longer than 1 second.

The broadcast data associated to the Indoor Positioning Service AD-type is organised using the order described in Table 2.2, according to the Indoor Positioning Configuration Characteristic Value.

Note: The Location Name is not included in the broadcast information of the Indoor Positioning Service.

Location	Order	Name	Property	Length of the field	Reference
LSO	1	Length	M	1 octet	N/A
	2	AD-type: Indoor Positioning Service	M	1 octet	Bluetooth assigned numbers [7]
	3	Flags	C1	1 octet	Table 3.2
	4a	Global Coordinates (Latitude)	C2	4 octets	3.3
	5a	Global Coordinates (Longitude)	C2	4 octets	3.2
	4b	Local Coordinates (North)	C2	2 octets	3.5
	5b	Local Coordinates (East)	C2	2 octets	3.4
	6	Tx Power	C3	1 octet	N/A
	7	Floor Number	C3	1 octet	3.6
	8	Altitude	C3	2 octets	3.7
	9	Uncertainty	C3	1 octet	3.8
		RFU			

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Locatio	n Order	Name	Property	Length of the field	Reference
C1: Included in the advertisement packet if at least one bit of the Flags field is non zero in the Indoor Positioning Characteristic, otherwise excluded				e Indoor	
C2:	Included in the advertisement packet if specified in Flags, otherwise excluded. Bit 1 of the Flags specifies whether the coordination system is using Global or Local Coordinates.				
C3:	Included in the advertisement packet if specified in Flags, otherwise excluded				

Table 2.2: The order of the broadcasting information of the Indoor Positioning Service data.

Flags describe how the broadcasted positioning information is presented using the description in Section 3.1. For example, the length and type of the coordinate fields is set according to the bit 1 of the Flags field indicating the used coordinate system. If all flag values are set to zero, the Server shall omit the Flags field from the advertisement packet.

If only the AD-type is advertised, the device shall use a public device address for its advertisement and will be stationary. This enables a client to use the device address for location estimation based on a database look-up.

Tx Power for advertisement may be included to enable path loss estimation. The configuration of the Tx Power level is not specified in this service specification. It is set by other means (e.g. another service or the device configuration).

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3 Characteristics

The following characteristics are defined for use with the Indoor Positioning Service. The characteristics property requirements are stated in Table 3.1.

Characteristic Name	Broadcast	Read	Write Without Response	Write	Notify	Indicate	Signed Write	Reliable Write	Writable Auxiliaries
Indoor Positioning Configuration	х	М	C2	C1	X	X	х	C2	Х
Latitude	Х	М	C2	C1	Х	Х	Х	C2	Х
Longitude	Х	М	C2	C1	Х	X	Х	C2	Х
Local North Coordinate	Х	М	C2	C1	Х	Х	Х	C2	Х
Local East Coordinate	Х	М	C2	C1	Х	Х	Х	C2	Х
Floor Number	Х	М	C2	C1	Х	Х	Х	C2	Х
Altitude	Х	М	C2	C1	Х	Х	Х	C2	Х
Uncertainty	Х	М	C2	C1	Х	Х	Х	C2	Х
Location Name	Х	М	C2	C1	Х	Х	Х	C2	Х

C1: Mandatory: If Characteristic is configurable via an ATT bearer, else optional

C2: Optional if Write is supported, else excluded

Table 3.1: Characteristics Property Requirements

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

For each characteristic that supports Reliable Write a Characteristic Extended Properties Descriptor shall be present with value 0x0001 (supported).

3.1 Indoor Positioning Configuration Characteristic

The Indoor Positioning Configuration Characteristic is mandatory.

The characteristic property requirements are stated in Table 3.1.

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The attribute permissions for this characteristic declaration shall include at least readable and writeable permissions. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

The Indoor Positioning Configuration Characteristic is a bit field. The meaning of each bit is described in Table 3.2:

Bit	Description
0	Presence of coordinates in advertising packets (0 = coordinates are not present, 1 = coordinates are present)
1	Coordinate system used in advertising packets (0 = WGS84 coordinate system, 1 = Local coordinate system)
2	Presence of Tx Power field in advertising packets (0 = Tx Power is not present, 1 = Tx Power is present)
3	Presence of Altitude field in advertising packets (0 = Altitude is not present, 1 = Altitude is present)
4	Presence of Floor Number in advertising packets (0 = Floor Number is not present, 1 = Floor Number is present)
5	Presence of Uncertainty in advertising packets (0 = Uncertainty is not present, 1 = Uncertainty is present)
6	Location Name available in the GATT database. (0 = Location Name is not present, 1 = Location Name is present)
7	Reserved for Future Use

Table 3.2: Indoor Positioning Configuration bit field

The format of the characteristic is an unsigned integer of size 8 bits.

The characteristic UUID shall be set to « Indoor Positioning Configuration » as defined in [2].

3.2 Latitude Characteristic

The Latitude Characteristic is mandatory.

The characteristic property requirements are stated in Table 3.1.

The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

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Latitude is based on WGS84 [5] datum. The relation between the Latitude X in range [-90°, 90°] and the encoded (transmitted) number N is

$$N = floor\left(\frac{X}{90}2^{31}\right)$$

where N is bounded to the range $-2^{31}+1 \le N \le 2^{31}-1$. If N exceeds the bounds, the closest value within the bounds shall be used.

The floor operation shall be performed according to [4].

The value 0x80000000 in the Latitude Characteristic indicates not configured.

The format of the characteristic is a signed integer of size 32 bits encoded as signed magnitude.

The characteristic UUID shall be set to « Latitude » as defined in [2].

3.3 Longitude Characteristic

The Longitude Characteristic is mandatory.

The characteristic property requirements are stated in Table 3.1.

The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

Longitude is based on WGS84 [5] datum. The relation between the Longitude X in range [-180°, 180°] and the encoded (transmitted) number N is

$$N = floor\left(\frac{X}{180}2^{31}\right)$$

where N is bounded to the range $-2^{31}+1 \le N \le 2^{31}-1$. If N exceeds the bounds, the closest value within the bounds shall be used.

The floor operation shall be performed according to [4].

The value 0x80000000 means the Longitude characteristic is not configured.

The format of the characteristic is a signed integer of size 32 bits encoded as signed magnitude.

The characteristic UUID shall be set to « Longitude » as defined in [2].

3.4 Local North Coordinate Characteristic

The Local North Coordinate Characteristic is optional. If used, the Local North Coordinate shall be present together with Local East Coordinate.

The characteristic property requirements are stated in Table 3.1.

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The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

The Local North Coordinate is relative to the north orientation on a predefined map downloaded prior to using the Indoor Positioning Service at the given location.

The Local North Coordinate value is encoded in decimeters and has a range of -32767 decimeters to 32767 decimeters. The value 0x8000 means the Local North Coordinate information is not configured.

The format of the characteristic is a signed integer of size 16 bits.

The characteristic UUID shall be set to « Local North Coordinate » as defined in [2].

3.5 Local East Coordinate Characteristic

The Local East Coordinate Characteristic is optional. If used, the Local East Coordinate shall be present together with Local North Coordinate.

The characteristic property requirements are stated in Table 3.1.

The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

The Local East Coordinate is relative to the east orientation of a predefined map downloaded prior to using the Indoor Positioning Service at the given location. The Local East Coordinate value is encoded decimeters and it ranges from -32767 decimeters up to 32767 decimeters.

The value 0x8000 means the Local East Coordinate information is not configured.

The format of the characteristic is a signed integer of size 16 bits.

The characteristic UUID shall be set to « Local East Coordinate » as defined in [2].

3.6 Floor Number Characteristic

The Floor Number Characteristic is optional.

The characteristic property requirements are stated in Table 3.1.

The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

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The floor number, N, is encoded as X = N + 20 where X is the encoded floor number. Floor number -20 (X=0), has a special meaning not only indicating the floor -20, but also any floor below that. Floor number = 232 (X = 252) has a special meaning not only indicating the floor 232, but also any floor above that. (X = 253) meaning floor number 0 and ground floor. (X = 254) meaning floor number 1 and ground floor. X = 255 means no floor number is configured.

Note: The reason for having two definitions of ground floor (0 or 1) is to allow for different conventions applicable in different countries.

The format of the characteristic is an unsigned integer of size 8 bits.

The characteristic UUID shall be set to « Floor Number » as defined in [2].

3.7 Altitude Characteristic

The Altitude Characteristic is optional.

The characteristic property requirements are stated in Table 3.1. The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

The Altitude Characteristic expresses the altitude beyond the WGS84 ellipsoid [5] of the device exposing its position.

The characteristic value (x) encodes the altitude (h) in decimeters, x = h + 1000. The valid range of h is from -1000 decimeters to 64534 decimeters. A decoded height of -1000 dm shall be interpreted as -1000 dm or below. A decoded height of 64534 dm shall be interpreted as 64534 dm or above.

The value x=0xFFFF means the altitude information is not configured.

The format of the characteristic is an unsigned integer of size 16 bits.

Characteristic value encoding	Meaning
65535	Altitude is not configured
65534	Altitude is greater than or equal to 64534 decimeters
1 to 65533	Altitude is (characteristic value) -1000 decimeters
0	Altitude is less than or equal to -1000 decimeters

Table 3.3: Altitude bit field encoding

The characteristic UUID shall be set to « Altitude » as defined in [2].

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3.8 Uncertainty Characteristic

The Uncertainty Characteristic is optional.

The characteristic property requirements are stated in Table 3.1.

The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

The Uncertainty Characteristic consists of several values. The meaning of each bit is described in Table 3.4:

Bit	Description
	<stationary></stationary>
0	This bit indicates whether the device broadcasting the location information has a stationary location or is mobile.
	(0 = stationary, 1 = mobile)
1-3	<update time=""></update>
	This value (x) encodes the time (t) elapsed since the last update of the device's position, measured in seconds, where $t = round(e^{1.35^x})$, $x = 0$ indicates 3 seconds or less. $x = 7$ indicates 3541 seconds or more.
	The Server shall ignore any value set by a client and update the value by mapping the elapsed time to the nearest encoded value. Round shall be performed according to [4].
	Note: If stationary is set, a client can ignore this value.

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Bit	D	Description						
	<precision> This value (y) represents a scale, which maps the precision of the location information in the Server. The scale is as follows:</precision>							
4-6		Value	Precision [meters]	Rating				
		0	<0.1m	Ideal				
		1	0.1-1m	Excellent				
		2	1-2m	Good				
		3	2-5m	Moderate				
		4	5-10m	Fair				
		5	10-50m	Poor				
		6	>50m	Very Poor				
		7	N/A	RFU				
7	Reserved for Future Use (RFU)							

Table 3.4: Uncertainty bit field

The format of the characteristic is an unsigned integer of size 8 bits.

The characteristic UUID shall be set to « Uncertainty » as defined in [2].

3.9 Location Name Characteristic

The Location Name Characteristic is optional.

The characteristic property requirements are stated in Table 3.1. The attribute permissions for this characteristic declaration shall include at least readable permission. A higher layer may specify additional permission requirements but it is recommended that only authorized devices are permitted to write.

The Location Name value is a UTF8 string holding the information of the location, for example location name, room name, floor name, etc. The location name shall be formatted according to the *civicLocation* definition [3].

The format of the characteristic is a string of variable size. If unset, the value has zero length.

The characteristic UUID shall be set to « Location Name » as defined in [2].

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4 SDP Interoperability

If this service is exposed over BR/EDR transport, then it shall have the following SDP record, per [1], Volume 3, Part G, Section 9.

Item	Definition	Туре	Value	Status
Service Class ID List				М
Service Class #0		UUID	«Indoor Positioning Service»	М
Protocol Descriptor List				M
Protocol #0		UUID	L2CAP	М
Parameter #0 for Protocol #0	PSM	Uint16	PSM = ATT	М
Protocol #1		UUID	ATT	М
Parameter #0 for Protocol #1	GATT Start Handle	Uint16	First handle of this service in the GATT database	М
Parameter #1 for Protocol #1	GATT End Handle	Uint16	Last handle of this service in the GATT database	M
BrowseGroupList			PublicBrowseRoot*	М

Table 4.1: SDP Record

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



5 Acronyms and Abbreviations

Abbreviation or Acronym	Meaning		
ATT	Attribute Protocol		
BR/EDR	Bluetooth Basic Rate / Bluetooth Enhanced Data Rate		
GATT	Generic Attribute Profile		
GNSS	Global Navigation Satellite System		
LE	Low Energy		
SDP	Service Discovery Protocol		
UTF	Universal Character Set Transformation Format		
UUID	Universally Unique Identifier		
WGS84	World Geodetic System 1984		

Table 5.1: Example Abbreviations and Acronyms

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6 References

- [1] Bluetooth Core Specification, Version 4.0 or later
- [2] Characteristic and Descriptor descriptions are accessible via the <u>Bluetooth SIG Assigned</u> Numbers
- [3] LPP Extensions Specification. Candidate Version 1.0. 08 Jan 2014. Open Mobile Alliance. OMA-TS-LPPe-V1_0-20140108-C
- [4] IEEE Std 754-2008, IEEE Computer Society (August 29, 2008). <u>IEEE Standard for Floating-Point Arithmetic</u>. IEEE. <u>doi:10.1109/IEEESTD.2008.4610935</u>. ISBN 978-0-7381-5753-5.
- [5] NIMA Technical Report TR8350.2, "Department of Defense World Geodetic System 1984, Its Definition and Relationships With Local Geodetic Systems" http://earth-info.nga.mil/GandG/publications/tr8350.2/tr8350 2.html
- [6] Bluetooth Core Specification Supplement, Version 5 or later
- [7] Indoor Positioning AD type in Generic Access Profile assigned numbers

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