

Environmental Sensing Service

Bluetooth® Service Specification

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Abstract:

This service exposes measurement data from an environmental sensor. A wide range of environmental parameters is supported.



Revision History

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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.



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1 Introduction

The Environmental Sensing Service (ESS) exposes measurement data from an environmental sensor. A wide range of environmental parameters is supported.

The ESS uses a family of characteristics, one characteristic for each type of environmental measurement. The UUID of the characteristic identifies the environmental parameter that is being measured, as described in Section 3.1. The service may expose one or more such Environmental Sensing Service characteristics, referred to generically from now on as “ESS Characteristics”.

Optionally, additional information describing the measurement contained in each ESS Characteristic is made available to the Client through one or more additional characteristic descriptors:

- I. an Environmental Sensing (ES) Measurement descriptor ;
- II. one or more ES Trigger Setting descriptors;
- III. an ES Configuration descriptor;
- IV. a Characteristic User Description descriptor;
- V. a Valid Range descriptor.

The behavior of these characteristic descriptors is described in Section 3.1.2.

The full set of ESS Characteristics that may be discovered is listed in the Environmental Sensing Service Characteristics table for this specification [2]. The list may be updated whenever support for additional environmental parameters is required by adding further ESS Characteristics to those defined there. To request ESS Characteristics to be added to this table to support new or future ESS applications, please contact the Sports and Fitness WG (sf-main@bluetooth.org). Since all ESS Characteristics are required to have identical behavioral options, extending the types of environmental parameters in this way does not require any change to be made to this service specification.

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 Dependencies

This service is not dependent upon any other services.

1.3 Bluetooth Core 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
Notifications	C.1
Indications	C.2
Read Characteristic Descriptors	M
Read Long Characteristic Descriptors	C.3
Write Characteristic Descriptors	C.4
Write Long Characteristic Descriptors	C.5

Table 1.1: GATT Sub-procedure Requirements

- C.1: Mandatory if the Server supports the ES Trigger Setting descriptor; excluded otherwise.
- C.2: Mandatory if the Descriptor Value Changed characteristic is supported; optional otherwise.
- C.3: Mandatory if the Server supports reading a Characteristic User Description descriptor string length that exceeds the capacity of the default ATT_MTU; optional otherwise.
- C.4: Mandatory if the Server supports the Descriptor Value Changed characteristic or notification of the ESS Characteristic or writing to the Characteristic User Description descriptor, ES Trigger Setting descriptor or ES Configuration descriptor; optional otherwise.
- C.5: Mandatory if the Server supports writing a Characteristic User Description descriptor string length that exceeds the capacity of the default ATT_MTU; optional otherwise.

1.5 Transport Dependencies

There are no transport restrictions imposed by this service specification.

The term BR/EDR used throughout this document 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
Write Request Rejected	0x80	An attempt was made to write a value to the descriptor that is invalid or not supported by this Server.
Condition not supported	0x81	An attempt was made to write a value to the Condition field of the ES Trigger Setting descriptor that is invalid or not supported by this Server.

Table 1.2: Attribute Protocol Application Error code 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 [5].



2 Service Declaration

The Environmental Sensing Service is recommended to be instantiated as a «Primary Service».

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

3 Service Characteristics

The characteristics that may be exposed in the Environmental Sensing Service comprise a family of characteristics all having the same general structure, each of which shall meet the description of “ESS Characteristic” given in [Table 3.1](#).

The generic term “ESS Characteristic” means any of the characteristics that are listed in the Environmental Sensing Service Characteristics table published in [\[2\]](#).

Each type of environmental measurement supported has a characteristic assigned to it. The service may expose more than one instance of the same ESS Characteristic subject to compliance with the conditions specified in [Section 3.1](#).

Where a characteristic can be notified, a Client Characteristic Configuration descriptor shall be included in that characteristic as required by the Bluetooth Core Specification [\[1\]](#).

Characteristic	Requirement	Mandatory Properties	Optional Properties	Security Permissions
ESS Characteristic	C.1	Read	Notify, Extended Properties	None
Descriptor Value Changed	C.2, C.3	Indicate		None

Table 3.1: Requirements for each ESS Characteristic

C.1: At least one ESS Characteristic shall be exposed.

C.2: Mandatory if at least one of the following descriptors can be changed by the Server for at least one ESS Characteristic: ES Measurement, ES Trigger Setting, ES Configuration, Characteristic User Description.

C.3: Mandatory if the Write property is supported for the Characteristic User Description descriptor.

Notes:

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

An example illustrating a typical use of the characteristics and the optional characteristic descriptors used by this service has been included in [Appendix 1](#).

3.1 ESS Characteristics

The Server shall expose at least one ESS Characteristic.

Each ESS Characteristic is defined in the Environmental Sensing Service Characteristics table in [\[5\]](#).

The Server may expose multiple instances of the same ESS Characteristic (i.e., characteristics with the same UUID) provided that each instance has an ES Measurement descriptor (see [Section 3.1.2.1](#)) and each ES Measurement descriptor has a unique value to allow the instances to be differentiated by the Client. This allows a sensor to report its readings in more than one way. For example, a temperature sensor may provide both instantaneous and daily average readings. In this example, the instantaneous

and average measurements are identified by the ES Measurement descriptor associated with each instance of the ESS Characteristic so the Client can discriminate between the characteristic for average temperature and instantaneous temperature.

3.1.1 ESS Characteristic Behavior

All ESS Characteristics have identical behavioral options as described in this sub-section.

If notification is supported and the ESS Characteristic is configured for notification via the Client Characteristic Configuration descriptor and a measurement is available, the characteristic may be notified while in a connection.

However, if the Server supports notifications and they have been enabled, notifications shall be sent only in accordance with the trigger conditions specified by the value of the ES Trigger Setting descriptor(s) for the associated ESS Characteristic as described in Section 3.1.2.2.

The ESS Characteristic contains time-sensitive data, thus the requirements for time-sensitive data and data storage defined in Section 3.3 apply. The Server may attempt to notify a triggered ESS Characteristic multiple times and at a period that it defines, as long as the requirements in Section 3.3 are met.

3.1.2 Characteristic Descriptors

With the exception of the ES Trigger Setting descriptor, there shall be no more than one instance of each descriptor associated with each instance of an ESS Characteristic.

All descriptor values shall be persistent for bonded Clients, however, if an ESS-related descriptor value (i.e., a descriptor other than the Client Characteristic Configuration descriptor) is changed by a device other than the Client itself, the Descriptor Value Changed characteristic shall be used to alert all affected Client(s). See Section 3.2 for requirements related to this characteristic.

The service has the characteristic descriptor requirements defined in the following table.

Characteristic Descriptor	Requirement	Mandatory Permissions (Note 1)	Optional Permissions (Note 1)	Security Permissions (Note 2)
ES Measurement (See 3.1.2.1)	C.1	Read	None	None
ES Trigger Setting (See 3.1.2.2)	C.2	Read	Write (C.4) (Note 3)	Write: with Authorization
ES Configuration (See 3.1.2.3)	C.3	Read	Write (C.4) (Note 3)	Write: with Authorization
Characteristic User Description (See 3.1.2.4)	O	Read	Write (Note 4)	Read: None Write: with Authentication
Valid Range (See 3.1.2.5)	O	Read	None	None

Table 3.2: Environmental Sensing Service Characteristic Descriptors



- C.1: Mandatory if multiple instances of an ESS Characteristic with same UUID are supported; optional otherwise.
- C.2: Mandatory if notifications are supported; excluded otherwise.
- C.3: Mandatory if multiple ES Trigger Setting descriptors are supported; excluded otherwise.
- C.4: If the Write permission is supported, it shall be supported for all ES Trigger Setting descriptors and the ES Configuration descriptor (if present).

Notes:

1. Permissions not listed as Mandatory or Optional are excluded for this service.
2. Security Permissions of “None” means that this service does not impose any requirement.
3. If Write is supported, bonding is mandatory as described in Section 3.1.2.3.1.
4. Refer to Section 3.1.2.4.1 for details on the use of this descriptor.

3.1.2.1 ES Measurement Descriptor

This optional characteristic descriptor describes the associated ESS Characteristic by providing additional information pertaining to the value.

The descriptor UUID shall be set to «ES Measurement» as defined in [2].

The definition of the ES Measurement descriptor is shown in Table 3.3.

Field Name	Format	Octets	Exponent Base	Exponent	Unit	Resolution	Field Requirement
Flags	16bit	2	N/A	N/A	unitless	Bitfield	M
Sampling Function	UINT8	1	N/A	N/A	unitless	Enumeration (refer to listing below)	M
Measurement Period	UINT24	3	10	0	second	1 second	M
Update Interval	UINT24	3	10	0	second	1 second	M
Application	UINT8	1	N/A	N/A	unitless	Enumeration (refer to listing below)	M
Measurement Uncertainty	UINT8	1	2	-1	percentage	0.5 percent	M

Table 3.3: ES Measurement Descriptor - Structure

The fields in Table 3.3, reading from top to bottom, are shown in the order of LSO to MSO, where LSO = Least Significant Octet and MSO = Most Significant Octet. For the case of the 16bit bit field, the Least Significant Octet represents the eight bits numbered 0 to 7.

3.1.2.1.1 Fields

The ES Measurement descriptor contains the following fields.



3.1.2.1.1.1 Flags

This is a bit field. The flags have been included to support future extensions. In the current version of this specification, all of the bits are reserved for future use.

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

Bit	Definition
0-15	Reserved for Future Use

Table 3.4: ES Measurement Descriptor – Flags

3.1.2.1.1.2 Sampling Function

This field specifies the averaging operation or type of sampling function applying to the value of the ESS characteristic. For example, this field of the descriptor can identify whether the measurement provided by the Server is an arithmetic mean value or an instantaneous value. The assigned numbers for this field are enumerated in Table 3.5.

For cases in which the sampling function is not made available, a special number has been assigned indicating 'Unspecified'.

Value and Description
0x00: Unspecified
0x01: Instantaneous
0x02: Arithmetic Mean
0x03: RMS
0x04: Maximum
0x05: Minimum
0x06: Accumulated
0x07: Count
0x08-0xFF: Reserved for future use

Table 3.5: ES Measurement Descriptor – Sampling Functions

3.1.2.1.1.3 Measurement Period

This field specifies the averaging time span, accumulation time, or measurement period in seconds over which the measurement is taken. For example, it can specify the length of the period used to obtain an average reading.

For those cases where a value for the measurement period is not available or not applicable, a special number has been assigned indicating 'Not in use'.

Value and Description
0x000000: Not in use.
0x000001-0xFFFFFFFF: Time period in seconds

Table 3.6: ES Measurement Descriptor – Measurement Period



3.1.2.1.1.4 Internal Update Interval

The value of the ESS characteristic shall be internally refreshed by the Server at the frequency indicated in the Internal Update Interval field; for example, a temperature value that is internally updated every 15 minutes. This field allows the Client to determine the interval (in seconds) between updates.

For those cases where a value for the Internal Update Interval is not available or not applicable, a special number has been assigned indicating 'Not in use'.

Value and Description
0x000000: Not in use.
0x000001-0xFFFFFFFF: Time period in seconds

Table 3.7: ES Measurement Descriptor – Internal Update Interval

Note that this interval may be shorter than the Measurement Period if, for example, multiple averaging periods are overlapped providing a rolling average. This is illustrated in [Figure 3.1](#). A practical example is described below:

A true wind speed sensor constantly tracks the average wind speed. The sensor makes a new average available to the client every 15 minutes (i.e., the Internal Update Interval is 900 seconds). However, the sensor uses an entire hour's worth of wind speed measurement data to calculate the average value so the Measurement Period is 3600 seconds. This is a rolling average with the averaging window moving forward by 900 seconds at each update.

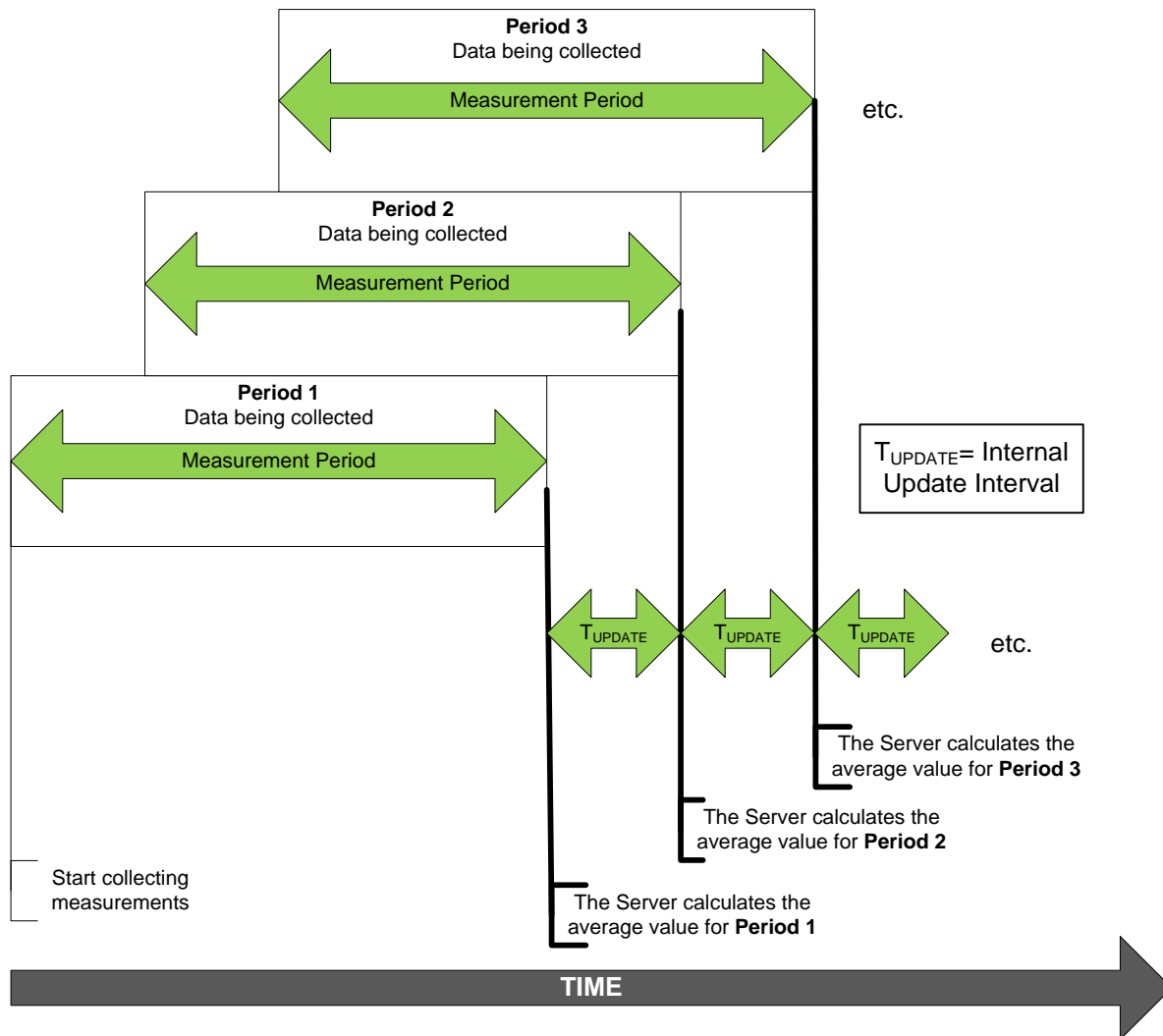


Figure 3.1: Example showing the relationship between Internal Update Interval and Measurement Period

3.1.2.1.1.5 Application

This field specifies the intended application for which the ESS Characteristic is designed to be used (e.g., to differentiate between air pressure versus water pressure or soil temperature versus air temperature). The assigned numbers for this field are enumerated in [Table 3.8](#).

For those cases where the application is not defined, a special number has been assigned indicating 'Unspecified'.

Value and Description
0x00: Unspecified
0x01: Air
0x02: Water
0x03: Barometric
0x04: Soil
0x05: Infrared
0x06: Map Database
0x07: Barometric Elevation Source
0x08: GPS only Elevation Source
0x09: GPS and Map database Elevation Source
0x0A: Vertical datum Elevation Source
0x0B: Onshore
0x0C: Onboard vessel or vehicle
0x0D: Front
0x0E: Back/Rear
0x0F: Upper
0x10: Lower
0x11: Primary
0x12: Secondary
0x13: Outdoor
0x14: Indoor
0x15: Top
0x16: Bottom
0x17: Main
0x18: Backup
0x19: Auxiliary
0x1A: Supplementary
0x1B: Inside
0x1C: Outside
0x1D: Left
0x1E: Right
0x1F: Internal
0x20: External
0x21: Solar
0x22-0xFF: Reserved for future use

Table 3.8: ES Measurement Descriptor – Applications



3.1.2.1.1.6 Measurement Uncertainty

This field shows the measurement uncertainty of the data provided over the supported range in the value of the ESS characteristic, expressed as a percentage as defined in [Table 3.9](#).

Where this value includes random contributions to the measurement uncertainty, this assumes a level of confidence of 95 percent, using a coverage factor as described in National Institute of Standards and Technology (NIST) Technical Note 1297 [\[4\]](#).

For those cases where no measurement uncertainty information is available, a special number has been assigned indicating 'Information not available'.

In addition, the Valid Range descriptor (see [Section 3.1.2.5](#)) may be used to specify upper and lower bounds (inclusive) for the range to which the declared measurement uncertainty applies.

Value and Description
0x00 – 0xFE: The maximum error from the actual value, expressed as a percentage of the reported value.
0xFF: Information not available.

Table 3.9: ES Measurement Descriptor – Measurement Uncertainty

3.1.2.1.2 ES Measurement Descriptor Behavior

If the value of the ES Measurement descriptor changes, the Descriptor Value Changed characteristic shall be indicated as described in [Section 3.2](#).

3.1.2.2 ES Trigger Setting Descriptor

The value of this optional descriptor has two parts: a Condition field and an Operand field. Depending on the Condition, the Operand field may contain a comparison value with which the relevant characteristic value is to be compared. The format of the descriptor and the trigger conditions are defined in [Table 3.11](#).

If the Server supports notifications of an ESS Characteristic, it shall expose one or more ES Trigger Setting descriptors relating to that ESS Characteristic with no more than three instances of ES Trigger Setting descriptors permitted per instance of an ESS Characteristic. Otherwise, ES Trigger Setting descriptors shall not be present for that characteristic.

Requirements associated with multiple instances of the ES Trigger Setting descriptor when associated with an instance of an ESS Characteristic are described in [Section 3.1.2.3.1](#).

The descriptor UUID shall be set to «ES Trigger Setting» as defined in [\[2\]](#).

The definition of the ES Trigger Setting descriptor is shown in [Table 3.10](#):

	LSO	MSO
	Condition	Operand
Octet Order	N/A	LSO ... MSO
Format type	UINT8	(Variable - defined per condition)
Size	1 octet	0 to n octets (defined per condition)

Table 3.10: ES Trigger Setting Descriptor - Structure

The format of the Operand field depends on the Condition value.

The conditions that can be set are enumerated in [Table 3.11](#). For example, for Condition 0x01 (use a fixed time interval between transmissions), the Operand is a UINT24 number representing the requested time interval value in units of seconds.

Condition Value	Condition to trigger data transmission (Note 1)	Operand	
		Format Type	Units
0x00	Trigger inactive	N/A	N/A
0x01	Use a fixed time interval between transmissions	UINT24	seconds
0x02	No less than the specified time between transmissions	UINT24	seconds
0x03	When value changes compared to previous value	N/A	N/A
0x04	While less than the specified value	Variable - Note 2	Variable - Note 2
0x05	While less than or equal to the specified value	Variable - Note 2	Variable - Note 2
0x06	While greater than the specified value	Variable - Note 2	Variable - Note 2
0x07	While greater than or equal to the specified value	Variable - Note 2	Variable - Note 2
0x08	While equal to the specified value	Variable - Note 2	Variable - Note 2
0x09	While not equal to the specified value	Variable - Note 2	Variable - Note 2
0x0A-0xFF	Reserved for future use		

Table 3.11: ES Trigger Setting Descriptor - Conditions

Note 1: The conditions listed in this column refer to the value of the relevant characteristic with which the descriptor is associated. Note that some conditions are not valid with some ESS Characteristics

(e.g. conditions 0x04 – 0x07 are not valid for enumerations such as Barometric Pressure Trend or ESS Characteristics that hold multiple values such as Magnetic Flux Density - 2D or Magnetic Flux Density - 3D).

Note 2: When the Condition is not a time-based condition, the format of any Operand depends on the format of the characteristic to which it applies; the Operand will have the same format, exponent, resolution, and units as the referenced characteristic value.

3.1.2.2.1 ES Trigger Setting Descriptor Behavior

Since the ES Trigger Setting descriptor and the ES Configuration descriptor work together to define a singular behavior, this behavior is defined together in Section 3.1.2.3.1.

3.1.2.3 ES Configuration Descriptor

The ES Configuration descriptor shall be present if more than one ES Trigger Setting descriptor is present for an associated ESS Characteristic. Otherwise it shall not be present for that characteristic.

The ES Configuration descriptor exposes information about the configuration of the Server. The value of the Trigger Logic field indicates whether a logical AND or logical OR Boolean operator shall be used to combine the conditions of multiple ES Trigger Setting descriptors, as described in Section 3.1.2.3.1.

The descriptor UUID shall be set to «ES Configuration» as defined in [2].

The definition of the ES Configuration descriptor is shown Table 3.12:

Field	Trigger Logic
Octet Order	N/A
Format type	UINT8
Size	1 octet

Table 3.12: ES Configuration Descriptor - Structure

The Trigger Logic field is an enumeration. The meaning of each value is as follows:

Trigger Logic Value
0x00: Boolean AND
0x01: Boolean OR
0x02-0xFF: Reserved for future use

Table 3.13: ES Configuration Descriptor – Trigger Logic

3.1.2.3.1 ES Trigger Setting Descriptor and ES Configuration Descriptor Behavior

Where multiple ES Trigger Setting descriptors are present for a given ESS Characteristic, the ES Trigger Setting descriptor and the ES Configuration descriptor work together to define the conditions under which the associated ESS Characteristic value can be notified. As such, this combined behavior is defined together in the same section.

If more than one ES Trigger Setting descriptor is associated with an instance of the ESS Characteristic, the relevant Boolean operation (i.e., either a logical AND or a logical OR operation) shall be configured by using the Trigger Logic field of the ES Configuration descriptor described in Section 3.1.2.3.

The ES Trigger Setting descriptors of each ESS Characteristic share one common Boolean operator relating to that characteristic; therefore, it is not possible for the Boolean operators to be mixed within the trigger conditions for an ESS Characteristic.

If the ES Trigger Setting descriptor is writable, an ES Configuration descriptor, if present, shall also be writable. Conversely, when the ES Trigger Setting descriptor is read-only, an ES Configuration descriptor, if present, shall also be read-only.

Bonding is mandatory if the ES Trigger Setting descriptor and ES Configuration descriptors are writable by the Client. Therefore, writing to the ES Trigger Setting and ES Configuration descriptors shall be subject to authorization as follows: If the Client is a bonded Client and these descriptors are writable, the Client shall be granted authorization to write to these descriptors. A Server shall not grant authorization to unbonded Clients. If the descriptors are writable and an unbonded (i.e., unauthorized) Client attempts to write to any of these descriptors, the Server shall respond with the ATT Error Response “Insufficient Authorization”.

If the Server allows the Client to control the conditions under which data is notified (i.e., the ES Trigger Setting descriptor and ES Configuration descriptor, if present, are writable by the Client), it shall allow separate control for each bonded Client and therefore shall retain a separate value of these descriptors per bond.

Either the ES Configuration descriptor and all of the ES Trigger Setting descriptors associated with an ESS Characteristic shall be writable or all shall be read-only.

In the case where the Server controls the conditions under which data is notified (i.e., the ES Trigger Setting descriptor is either not writable or not yet initialized by the Client), the Server shall set values in any ES Trigger Setting descriptors and the ES Configuration descriptor (if present) to enable a Client to read the notification conditions. If the value of the ES Trigger Setting or ES Configuration descriptors change at the Server, the Descriptor Value Changed characteristic shall be indicated as described in Section 3.2.

Note that when a Server is configured to notify data at time intervals (either by itself or by a Client), it does so on a ‘best effort’ basis and there are no guarantees on the accuracy of time by the Server.

If the value of an ES Trigger Setting descriptor is set to “Trigger inactive”, this effectively disables that specific ES Trigger Setting descriptor. If there are multiple ES Trigger Setting descriptors and each is set to “Trigger inactive”, no notifications are possible and the value of the ESS Characteristic can only be read by the Client. In the case that multiple instances of the ES Trigger Setting descriptor are associated with an ESS Characteristic and the value of any of those ES Trigger Setting descriptor(s) is “Trigger inactive”, the trigger conditions shall be determined as if that particular ES Trigger Setting descriptor did not exist.

If the ES Trigger Setting descriptor and ES configuration descriptor are writable, the Server shall support all defined trigger conditions and shall support both AND and OR operations respectively. This is to avoid interoperability issues with Clients requiring specific functionality.

If the ES Trigger Setting descriptor is writable and a Client attempts to write a Condition Value that is RFU, the Server shall respond with the *Condition not supported* Error Code defined in Section 1.6 and the value of the descriptor shall not be changed.

If the ES Configuration descriptor is writable and a Client attempts to write a value that is RFU, the Server shall respond with the *Write Request Rejected* Error Code defined in Section 1.6 and the value of the descriptor shall not be changed.

If the Client attempts to write an Operand to the ES Trigger Setting descriptor that is outside of the operating range of the Server (refer to Section 3.1.2.5) or otherwise improperly formatted, the Server shall respond with the *Out of Range* Error Code defined in [3] and the value of the descriptor shall not be changed.

If the Client attempts to write a Fixed Time Interval that is lower than the supported Update Interval of the Server, the Server may either attempt to send updates on a best effort basis or respond with the *Write Request Rejected* Error Code.

3.1.2.4 Characteristic User Description

This optional descriptor can be used to associate a verbose name with a specific ESS characteristic to allow a human-readable label to be associated with the measurement. This descriptor allows a textual description to be written as a UTF-8 string of variable size. The text may be defined by the user or by the manufacturer, depending on the implementation. If it is writable, it enables an authenticated Client to write a new value to this descriptor during a connection.

If this descriptor is supported, the user description of the ESS characteristic is global and the Server must make the same value available to all Clients.

If this descriptor is supported, the Server should support string lengths greater than 20 octets.

3.1.2.4.1 Characteristic User Description Descriptor Behavior

In order for writes to the Characteristic User Description descriptor to be enabled, the Bluetooth Core Specification [1] requires that the associated characteristic has the Extended Properties property, the Characteristic Extended Properties descriptor is present, and the Writable Auxiliaries bit of Characteristic Extended Properties descriptor is set to 1.

If the Characteristic User Description descriptor changes, the Descriptor Value Changed characteristic shall be indicated as described in Section 3.2.

The rest of this sub-section applies only when the Characteristic User Description descriptor is writable.

The Server shall permit only an authenticated Client to write a new value to the Characteristic User Description. If pairing has not occurred or only an unauthenticated pairing has occurred, the service request must be rejected with the ATT error code *Insufficient Authentication* specified in the Bluetooth Core Specification [1].

The Server may also choose to reject a write request to the Characteristic User Description if it determines that the contents of the new value are unsuitable, such as a string containing characters in a language that the implementation does not support. The criteria by which a requested value may be determined to be unsuitable are left to the implementation. The Server may reject such a write request by responding with the *Write Request Rejected* Error Code defined in Section 1.6 and the value of the descriptor shall not be changed.

3.1.2.5 Valid Range Descriptor

The Valid Range descriptor defined in [5] is an optional descriptor that allows a Client to read the upper and lower bounds (inclusive) of an associated ESS characteristic value that are supported by the Server. The Server should include the Valid Range descriptor to allow the Client to customize its User Interface and to avoid Out of Range error responses.

The descriptor UUID shall be set to «Valid Range» as defined in [2].

3.1.2.5.1 Valid Range Descriptor Behavior

The value of the Valid Range descriptor shall be static for the lifetime of the device.

3.2 Descriptor Value Changed Characteristic

The Descriptor Value Changed characteristic defined in Table 3.14 is mandatory if any of the following descriptors can be changed by the Server: ES Measurement, ES Trigger Setting, ES Configuration, or Characteristic User Description. It is also mandatory if the Server supports the write property for the Characteristic User Description descriptor.

This enables a Server to alert bonded Clients that the value of one or more ESS-related descriptors for a given ESS Characteristic have changed and need to be re-read. Included in the characteristic value are a Flags field (for showing the source of the change and the affected descriptors) and a Characteristic UUID field to show which ESS characteristic is affected.

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

The structure of the Descriptor Value Changed characteristic is defined in Table 3.14:

	LSO	MSO
	Flags	Characteristic UUID
Octet Order	N/A	LSO...MSO
Format type	16bit	gatt_uuid
Size	2 octets	2 or 16 octets
Units	Unitless	Unitless

Table 3.14: Descriptor Value Changed Characteristic - Structure

3.2.1 Descriptor Value Changed Characteristic Behavior

When the Descriptor Value Changed characteristic is configured for indications via the Client Characteristic Configuration descriptor, the following requirements apply:

For Clients that have a trusted relationship (i.e., bond) with the Server, the attribute cache is valid across connections. For Clients with a trusted relationship and not in a connection when a value change to a relevant descriptor occurs, the Server shall send an indication of the Descriptor Value Changed characteristic to the Client when it next reconnects to the Server. For Clients with a trusted relationship that are connected when a value change to a relevant descriptor occurs, the Server shall send an indication of the Descriptor Value Changed characteristic to the Client. For Clients that do not have a trusted relationship with the Server, the attribute cache is valid only during the connection. Clients without

a trusted relationship shall receive an indication when the relevant descriptor change occurs only during the current connection.

A new value becomes available when a descriptor value is changed by either a Client or at the Server itself (e.g., via the Server UI). [Table 3.15](#) summarizes the required behavior depending on which descriptor changed and by which device:

Descriptor Value That Was Changed	Change Occurred at Server (Bit 0 of Flags = 0)	Change Occurred at Other Client (Bit 0 of Flags = 1)
ES Trigger Setting and/or ES Configuration	Indicate DVC to affected Client	N/A
ES Measurement	Indicate DVC to all Clients	N/A
Characteristic User Description	Indicate DVC to all Clients	Indicate DVC to Clients other than the Client which made the change.

Table 3.15: Descriptor Value Changed Characteristic - Behavior

Note that if a value change to a descriptor was made by a Client, the Server shall not send the DVC indication to the Client that made the change.

When multiple changes are made to descriptors of a single ESS Characteristic, it is recommended to combine these changes, where possible, by setting multiple bits in a single indication of the Descriptor Value Changed characteristic. However, if some changes require a different Source of Change value, these will need to be sent in separate indications.

In some cases, such as when changes are made to descriptors of multiple ESS Characteristics, multiple indications will also be required.

3.2.1.1 Flags Field

The Flags field shall be included in the Descriptor Value Changed 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 are shown in [Table 3.16](#).

Bit	Definition
0	Source of Change 0: Server 1: Client
1	Change to one or more ES Trigger Setting Descriptors 0: False 1: True

Bit	Definition
2	Change to ES Configuration Descriptor 0: False 1: True
3	Change to ES Measurement Descriptor 0: False 1: True
4	Change to Characteristic User Description Descriptor 0: False 1: True
5-15	Reserved for Future Use

Table 3.16: Descriptor Value Changed Characteristic - Flags

Bit 0 (Source of Change) shall be set according to which device made the change. This allows the Client to inform the user about the source of change.

Bits 1 to 5 shall be set according to which descriptor(s) were changed. In cases where multiple descriptors have changed, multiple bits may be set.

3.2.1.2 Characteristic UUID Field

The Characteristic UUID field shall be included in the Descriptor Value Changed characteristic.

The Characteristic UUID field shall be set to the value of the UUID for the affected ESS Characteristic.

3.3 Requirements for Time-Sensitive Data

ESS Characteristics have been identified as being time-sensitive characteristics and the following requirements apply:

The Server shall only make the most recent ESS Characteristic value available (i.e., via read or notifications) and shall not buffer and make older measurements available as this might adversely impact the user experience.

If a notification attempt is in progress when a new measurement value becomes available that no longer fulfills the trigger condition, the old value shall be discarded and the Server shall no longer attempt to notify the characteristic.

Implementations should take into account that, since it is mandatory for all ESS Characteristics to possess the Read property, an ESS Characteristic value may be read at an unknown time after the value was last refreshed.

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	«Environmental Sensing Service»	M
Protocol Descriptor List				M
Protocol #0		UUID	L2CAP	M
Parameter #0 for Protocol #0	PSM	Uint16	PSM = ATT	M
Protocol #1		UUID	ATT	M
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

Abbreviation or Acronym	Meaning
AMP	Alternate MAC PHY
ATT	Attribute Protocol
BR/EDR	Basic Rate / Enhanced Data Rate
ES	Environmental Sensing
ESS	Environmental Sensing Service
GAP	Generic Access Profile
GATT	Generic Attribute Profile
<code>gatt_uuid</code>	16-bit UUID (uint16) or 128-bit UUID (uint128)
LE	Low Energy
RFU	Reserved for Future Use
SDP	Service Discovery Protocol
UI	User Interface
UUID	Universally Unique Identifier

Table 5.1: Example Abbreviations and Acronyms

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 (CSS), Version 11 or later.
- [4] National Institute of Standards and Technology Technical Note 1297
- [5] GATT Supplemental Specification (GSS), <https://www.bluetooth.com/specifications/gss/>

Appendix 1 – Example of Use

The following example illustrates how the optional descriptors can be used with an ESS Characteristic to enrich the user experience.

The diagram in [Figure A.1](#) shows an Environmental Sensing Server that is able to report the *True Wind Speed*. This may be one of several environmental measurements supported by this Server.

The current true wind speed value is 14.25 m/s.

The Server is also exposing an ES Measurement Descriptor associated with the True Wind Speed Characteristic and this provides supplementary information: The true wind speed value being reported is the *Maximum* wind speed that was sampled during a *Measurement Period* of 1800 seconds. The *Measurement Period* is a rolling window and the value reported is refreshed periodically. The *Internal Update Interval* of 600 seconds tells the Client that a new value is calculated and made available by the Server every 10 minutes. The claimed *Measurement Uncertainty* for the measurement data is $\pm 12.5\%$.

The Server is also exposing a *Characteristic User Description* associated with the same ESS Characteristic. This shows that the measurement source has been named “Airfield Anemometer No.1” which enables the user to recognize which sensor the data is coming from easily.

For her application, the user wanted to get notifications of the wind speed only if there was at least a reasonable breeze blowing so she configured an ES Trigger Setting descriptor to set a trigger when the value exceeds 2 m/s. Even when this condition is met, the user has determined that she needs to receive notifications no more frequently than once every ten minutes so she has configured a second ES Trigger Setting descriptor to send notifications with an interval of greater than or equal to 600 seconds between transmissions which will help to minimize power consumption and extend battery life.

Since the user required notifications to be sent only while both of these trigger conditions were satisfied, she has configured the Trigger Logic value of the ES Configuration Descriptor to specify that the trigger conditions shall be combined using a Boolean AND operation.

The dashed characteristic boxes in the diagram illustrate that one Server may expose many ESS Characteristics and each may have its own a set of descriptors associated with it. The service is scalable - the minimum implementation would expose only the ESS Characteristic(s) without any of the optional descriptors.

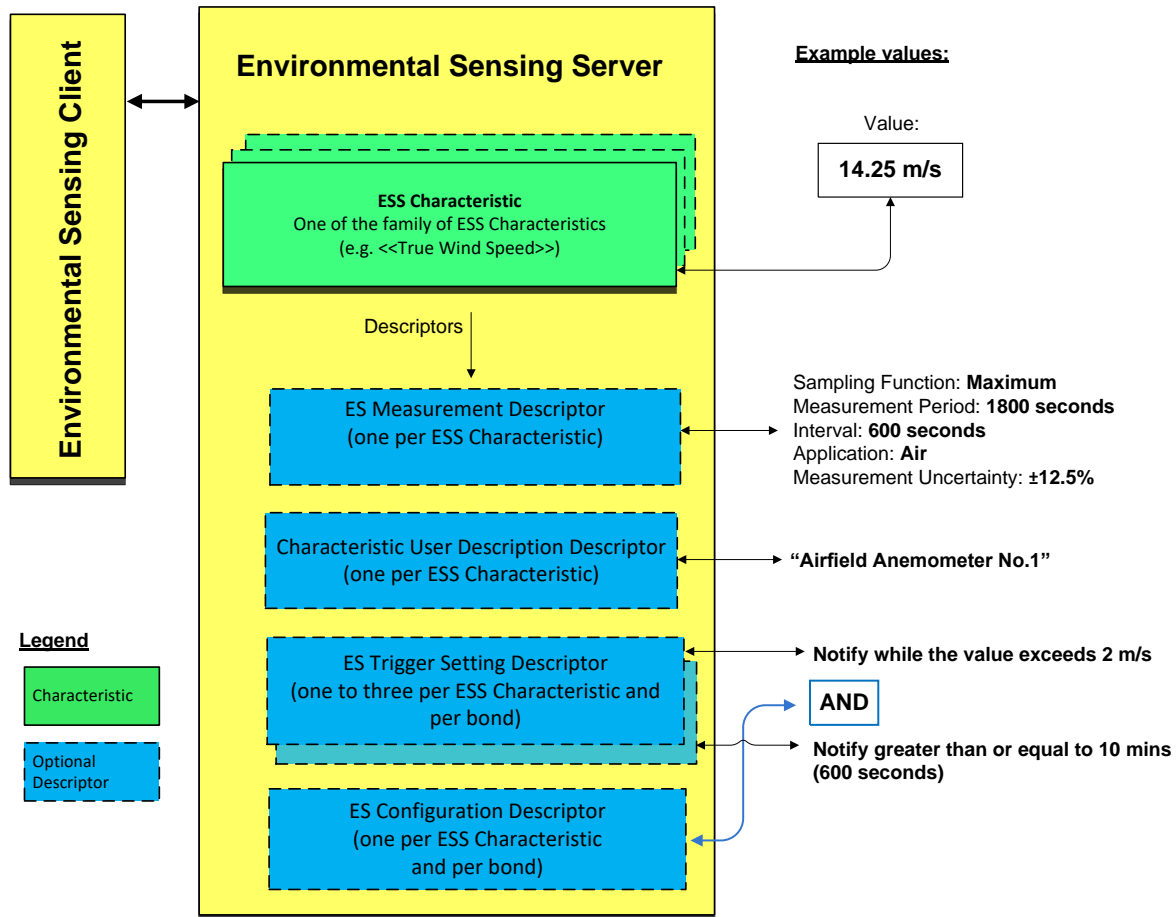


Figure A.1: Example of Environmental Sensing Service Use

Notes:

1. The Characteristic Extended Properties descriptor and the Client Characteristic Configuration descriptor are covered by the GATT specification contained in [1] and have been omitted from the above diagram for clarity.
2. The optional Valid Range descriptor described in Section 3.1.2.5 has not been used in this example.