

Asset Tracking Profile

Bluetooth® Profile Specification

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Abstract:

This specification defines a GATT-based profile for connection-oriented Angle of Arrival (AoA) based direction detection of another Bluetooth Low Energy device as described in the Bluetooth Core Specification, Version 5.1 or later [2].



Revision History

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1 Introduction

The Asset Tracking Profile (ATP) defines the procedures used by a Bluetooth Low Energy device (Locator) to find the relative direction and, optionally, the location of another Bluetooth Low Energy device (Asset Tag). While ATP does not define any methods for calculating the relative direction and position, it defines the procedures used by the Locator to configure the Asset Tag and to obtain the data required to perform those calculations.

The ATP enables use of the Constant Tone Extension (CTE) Service [3] on a peer device.

1.1 Profile dependencies

This profile requires the Generic Attribute Profile (GATT) and the Generic Access Profile (GAP).

1.2 Conformance

If conformance to this specification is claimed, all capabilities indicated as mandatory for this specification shall be supported in the specified manner (process-mandatory). This also applies for all optional and conditional capabilities for which support is indicated.

1.3 Language

1.3.1 Language conventions

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

shall	<u>is required to</u> – used to define requirements.
must	is used to express: a natural consequence of a previously stated mandatory requirement. OR an indisputable statement of fact (one that is always true regardless of the circumstances).
will	<u>it is true that</u> – only used in statements of fact.
should	<u>is recommended that</u> – used to indicate that among several possibilities one is recommended as particularly suitable, but not required.
may	<u>is permitted to</u> – used to allow options.
can	<u>is able to</u> – used to relate statements in a causal manner.
is	<u>is defined as</u> – used to further explain elements that are previously required or allowed.
note	Used to indicate text that is included for informational purposes only and is not required in order to implement the specification. Each note is clearly designated as a “Note” and set off in a separate paragraph.

For clarity of the definition of those terms, see Core Specification Volume 1, Part E, Section 1.

1.3.2 Reserved for Future Use

Where a field in a packet, Protocol Data Unit (PDU), or other data structure is described as "Reserved for Future Use" (irrespective of whether in uppercase or lowercase), the device creating the structure shall



set its value to zero unless otherwise specified. Any device receiving or interpreting the structure shall ignore that field; in particular, it shall not reject the structure because of the value of the field.

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

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

The acronym RFU is equivalent to Reserved for Future Use.

1.3.3 Prohibited

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

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

"Prohibited" is never abbreviated.

1.4 Bluetooth Specification release compatibility

This profile is compatible with any Bluetooth Core Specification, Version 5.1 or later that includes the Connection CTE Request, Connection CTE Response, Antenna Switching During CTE Reception (AoA), and Receiving Constant Tone Extensions (AoA) features [\[2\]](#).

2 Configuration

2.1 Roles

This profile defines two roles: Asset Tag and Locator. The Asset Tag is the device that exposes support for the Constant Tone Extension Service.

- Asset Tag shall be an AoA-capable Low Energy transmitter and shall be a GATT server.
- Locator shall be an AoA-capable Low Energy receiver equipped with an antenna array and shall be a GATT client.

2.2 Profile/service role relationships

Figure 2.1 shows the relationships between the Constant Tone Extension Service and the two profile roles.

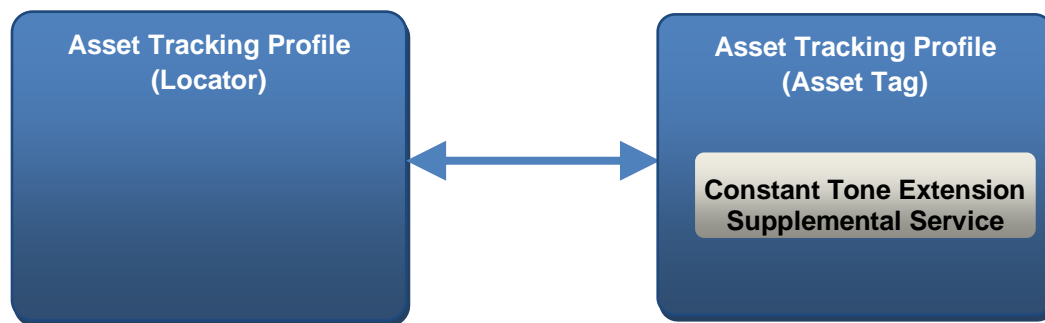


Figure 2.1: Profile and service role relationships

The Locator configures the Asset Tag to transmit direction finding enabled packets using a single antenna (see Section 2.1.5 in [2]).

The Locator, consisting of a Radio Frequency (RF) switch and antenna array, switches antennae while receiving part of those packets and captures in-phase and quadrature (IQ) samples. The Locator uses the IQ samples to calculate the phase difference in the radio signal received using different elements of the antenna array, which in turn are used to estimate the direction to the Asset Tag (see Bluetooth Core Specification Vol 6, Part A, Section 5.2).

The Locator, which knows its own location, the Received Signal Strength Indicator (RSSI) of the packets and the calculated AoA can estimate the distance (by RSSI) to the Asset Tag and can thus also estimate the location (combination of RSSI and AoA) of the Asset Tag.

2.3 Concurrency limitations/restrictions

There are no concurrency limitations or restrictions in this profile.

2.4 Topology limitations/restrictions

The Asset Tag shall support the Generic Access Profile (GAP) Peripheral role and may additionally support the GAP Central role.

The Locator shall support the GAP Central role and may additionally support the GAP Peripheral role.

2.5 Transport dependencies

The Asset Tracking Profile operates only over the Bluetooth Low Energy transport.

The Locator device's Link Layer shall support the Connection CTE Request feature and the Antenna Switching During CTE Reception (AoA) feature [2].

The Asset Tag's Link Layer shall support the Connection CTE Response feature and the Receiving Constant Tone Extensions (AoA) feature [2].

3 Asset Tag role requirements

Asset Tag shall instantiate only one Constant Tone Extension Service.

The Constant Tone Extension Service shall be instantiated as a «Primary Service».

Service	Asset Tag
« Constant Tone Extension Service »	M

Table 3.1: Constant Tone Extension Service requirements

M: Mandatory

3.1 Incremental Constant Tone Extension Service requirements

This section describes additional Asset Tag requirements beyond those defined in the Constant Tone Extension Service.

3.1.1 Service UUIDs AD type

While in GAP Discoverable Mode for initial connection to a Locator, the Asset Tag shall include the Constant Tone Extension Service Universally Unique Identifier (UUID) (defined in [1]) in the Service UUID's AD type field of the Advertising Data. This enhances the user experience because an Asset Tag may be identified by the Locator before initiating a connection.

3.1.2 Local Name AD type

While in GAP Discoverable Mode, the Asset Tag should include the Local Name (containing either the complete or shortened value of the Device Name characteristic defined in [1]) in its Advertising Data or Scan Response Data.

3.1.3 Writable GAP Device Name characteristic

The Asset Tag may support the write property for the Device Name characteristic to allow a Locator to write a device name to the Asset Tag.

3.1.4 Appearance characteristic

For enhanced user experience, an Asset Tag should include the value of the Appearance characteristic (defined in [1]) in its Advertising Data or Scan Response Data.

4 Locator role requirements

This section describes the profile procedure requirements for a Locator.

Profile Requirement	Section	Support in Locator
Service Discovery	4.2	-
Constant Tone Extension Service Discovery	4.2	M
Characteristic Discovery	4.3	-
Constant Tone Extension Service Characteristic Discovery	4.3.1	M

Table 4.1: Profile requirements for the Locator role

M: Mandatory

4.1 GATT sub-procedure requirements

This section presents a minimum set of requirements for a Locator. Other GATT sub-procedures may be used if they are supported by both client and server. [Table 4.2](#) lists the GATT sub-procedures that are required for a Locator in addition to the sub-procedures required for all GATT clients.

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

Table 4.2: Additional GATT sub-procedure requirements

C.1: Mandatory to support at least one of these Service Discovery sub-procedures.

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

M: Mandatory

4.2 Service discovery

In order for the Locator to discover the Constant Tone Extension Service, the Locator shall perform primary service discovery using either the GATT Discover All Primary Services sub-procedure or the GATT Discover Primary Services by Service UUID sub-procedure.



4.3 Characteristic discovery

4.3.1 Constant Tone Extension Service characteristic discovery

The Locator may perform either the GATT Discover All Characteristics of a Service sub-procedure or the GATT Discover Characteristics by UUID sub-procedure to discover the characteristics of the Constant Tone Extension Service.

Table 4.3 lists the discovery requirements for the Locator.

Characteristic	Discovery Requirement for Locator
Constant Tone Extension Enable	M

Table 4.3: Discovery requirements for the Locator

M: Mandatory

4.4 Constant Tone Extension Service characteristics

4.4.1 Constant Tone Extension Enable

To enable the Asset Tag to transmit the Constant Tone Extension field in Link Layer packets, the Locator shall set the value of bit 0 of the Constant Tone Extension Enable characteristic to 1. Thereafter, the Locator may start requesting the Asset Tag to transmit the Constant Tone Extension field using the Constant Tone Extension Request Link Layer Control procedure [2]. The rate at which the Locator requests the Asset Tag to transmit the Constant Tone Extension field should be configured with consideration for user expectations.

The value of the Constant Tone Extension Enable characteristic shall not be retained on the Asset Tag when the connection between the Locator and the Asset Tag ends.

5 Connection establishment procedures

This profile does not add any requirements to those specified in GAP [2].

6 Security considerations

This section describes the security considerations for an Asset Tag and Locator.

6.1 Asset Tag security considerations

All supported characteristics specified by the Constant Tone Extension Service should be set to Security Mode 1 and Security Level 2 or higher.

The Asset Tag may bond with the Locator depending upon the user scenario.

The Asset Tag should use the Privacy feature.

6.2 Locator security considerations

The Locator may bond with the Asset Tag depending upon the user scenario.

The Locator should use the Privacy feature.

7 Acronyms and abbreviations

Abbreviation	Meaning
AoA	Angle of Arrival
ATP	Asset Tracking Profile
CTE	Constant Tone Extension
DFWG	Direction Finding Working Group
GAP	Generic Access Profile
GATT	Generic Attribute Profile
IQ	In-phase and Quadrature
PDU	Protocol Data Unit
RF	Radio Frequency
RFU	Reserved for Future Use
RSSI	Received Signal Strength Indicator
UUID	Universally Unique Identifier

Table 7.1: Acronyms and abbreviations

8 References

- [1] Service UUIDs, Characteristics, and Descriptors available from [Bluetooth SIG Assigned Numbers](#)
- [2] Bluetooth Core Specification, Version 5.1 or later
- [3] Constant Tone Extension Service, Version 1.0 or later