Running Speed and Cadence Profile

***Bluetooth*® Profile Specification**

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Abstract:

This profile enables a Collector device to connect and interact with a Running Speed and Cadence Sensor for use in sports and fitness applications.

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 Running Speed and Cadence Profile is used to enable a data collection device to obtain data from a Running Speed and Cadence Sensor (RSC Sensor) that exposes the Running Speed and Cadence Service [1].

1.1 Profile Dependencies

This profile requires the Generic Attribute Profile (GATT).

1.2 Conformance

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

1.3 Bluetooth Specification Release Compatibility

This specification is compatible with any *Bluetooth* Core Specification [2] that includes the Generic Attribute Profile (GATT).

2 Configuration

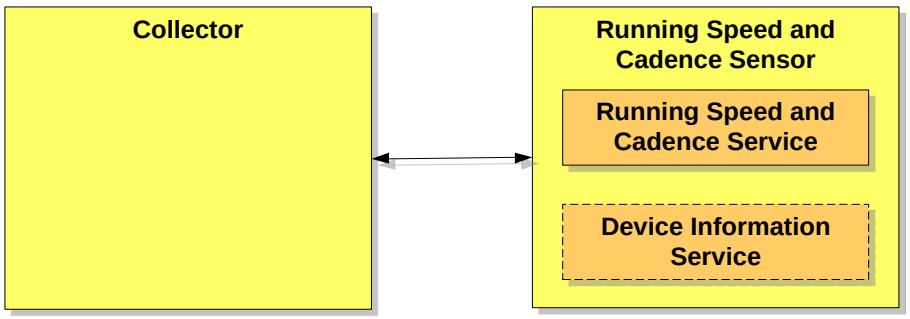
2.1 Roles

The profile defines two roles: RSC Sensor and Collector. The RSC Sensor is the device that measures speed, cadence and other information and the Collector is the device that receives the measurement and other data from a RSC Sensor.

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

2.2 Role/Service Relationships

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



Notes: Profile roles are represented by yellow boxes and services are represented by orange boxes.

Items within dashed boxes are optional.

A RSC Sensor instantiates the Running Speed and Cadence Service [1] and optionally the Device Information Service [4].

2.3 Concurrency Limitations and Restrictions

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

For cases where bonding is supported multiple bonds may be supported, but is outside the scope of this profile.

2.4 Topology Limitations and Restrictions

2.4.1 Topology Restrictions for Low Energy

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

The RSC Sensor shall use the GAP Peripheral role.

The Collector shall use the GAP Central role.

2.4.2 Topology Limitations and Restrictions for BR/EDR

This section describes topology limitations and restrictions when the profile is to be used over BR/EDR transport.

There are no fixed Central or Peripheral roles in the profile.

2.5 Transport Dependencies

There are no transport restrictions imposed by this profile specification.

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

3 RSC Sensor Role Requirements

The RSC Sensor shall instantiate one and only one Running Speed and Cadence Service [1].

The Running Speed and Cadence Service shall be instantiated as a «Primary Service».

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

Service	RSC Sensor
Running Speed and Cadence Service	M
Device Information Service	O

Table 3.1: Running Speed and Cadence Service Requirements for the RSC Profile.

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

3.1 Incremental Running Speed and Cadence Service Requirements

3.1.1 Additional Requirements for Low Energy Transport

This section describes additional RSC Sensor requirements beyond those defined in the Running Speed and Cadence Service when using this profile over Low Energy transport.

3.1.1.1 Service UUIDs AD Type

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

3.1.1.2 Local Name AD Type

For enhanced user experience a RSC Sensor should include the Local Name (containing either the complete or shortened value of the Device Name characteristic as defined in [2]) in its Advertising Data or Scan Response Data.

3.1.1.3 Writable GAP Device Name characteristic

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

3.1.1.4 Appearance AD Type

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

3.2 Incremental Device Information Service Requirements

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

Device Information Service Characteristic	Requirement
Manufacturer Name String	O
Model Number String	O

Table 3.2: Device Information Service Requirements

4 Collector Role Requirements

The Collector shall support the Running Speed and Cadence Service [1].

The Collector may support the Device Information Service [4].

Service	Collector
Running Speed and Cadence Service	M
Device Information Service	O

Table 4.1: Collector Service Requirements

This section describes the profile procedure requirements for a Collector.

Profile Requirement	Section	Support in Collector
Service Discovery	4.2	M
Running Speed and Cadence Service Discovery	4.2.1	M
Device Information Service Discovery	4.2.2	O
Characteristic Discovery	4.3	M
Running Speed and Cadence Service Characteristic Discovery	4.3.1	M
Device Information Service Characteristic Discovery	4.3.2	O
RSC Measurement	4.4	M
RSC Feature	4.5	M
Sensor Location	4.6	O
SC Control Point	4.7	C.1

Table 4.2: Collector Requirements

C.1: Mandatory if at least one SC Control Point procedure is supported, otherwise excluded.

4.1 GATT Sub-Procedure Requirements

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

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

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

Table 4.3: Additional GATT Sub-Procedure Requirements

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

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

C.3: Mandatory if at least one SC Control Point procedure is supported.

4.2 Service Discovery

When using the Low Energy transport, the Collector shall perform primary service discovery using either the GATT *Discover All Primary Services* sub-procedure or the GATT *Discover Primary Services by Service UUID* sub-procedure. Recommended fast connection parameters and procedures for connection establishment are defined in section 5.2.4.

When using the BR/EDR transport, the Collector shall perform service discovery by retrieving the SDP record of the Running Speed and Cadence Service [1]. The SDP record can be found in section 4 of [1].

4.2.1 Running Speed and Cadence Service Discovery

The Collector shall discover the Running Speed and Cadence Service.

4.2.2 Device Information Service Discovery

The Collector may discover the Device Information Service.

4.3 Characteristic Discovery

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

4.3.1 Running Speed and Cadence Service Characteristic Discovery

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

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

4.3.1.1 RSC Measurement Characteristic

The Collector shall discover the RSC Measurement characteristic.

The Collector shall discover the *Client Characteristic Configuration* descriptor of the RSC Measurement characteristic.

4.3.1.2 RSC Feature Characteristic

The Collector shall discover the RSC Feature characteristic.

If the RSC Sensor supports indication of the RSC Feature characteristic, the Collector shall discover the Client Characteristic Configuration descriptor of the RSC Feature characteristic.

4.3.1.3 Sensor Location Characteristic

The Collector may discover the Sensor Location characteristic.

4.3.1.4 SC Control Point Characteristic

The Collector may discover the SC Control Point characteristic.

If the Collector discovers the SC Control Point characteristic, it shall also discover the *Client Characteristic Configuration* descriptor of the SC Control Point characteristic.

4.3.2 Device Information Service Characteristic Discovery

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

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

4.4 RSC Measurement

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

The Collector shall be able to receive multiple notifications of the RSC Measurement characteristic from the RSC Sensor at regular intervals.

When a Collector requires a connection to a RSC Sensor to receive speed and cadence measurements it shall follow the connection procedures described in section 5.

The Collector shall determine the contents of the RSC Measurement characteristic structure based on the content of the Flags field. This allows the Collector to determine whether or not the following fields are present: Instantaneous Stride Length and Total Distance.

The Collector shall determine the features supported by the RSC Sensor by reading the RSC Feature characteristic (see section 4.5).

If the Collector has a display, it should alert the user when instantaneous speed or instantaneous cadence is no longer being received (e.g. due to link loss or sensor misalignment). This can be done by displaying “--" (i.e. 2 dashes) or by other means. Once the data is again received (e.g. the link is restored or sensor position readjusted), the display should return to normal.

The Total Distance value cannot practically roll over during the life of the RSC Sensor but if the Collector needs to update this value (e.g. in case of a sensor upgrade, when the user wants to program their new sensor with the value of the distance travelled from the previous sensor), it shall follow the procedure described in section 4.7.2.1.

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

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

4.5 RSC Feature

The Collector shall read the RSC Feature characteristic to determine the supported features of the RSC Sensor in order to understand the capabilities of the RSC Sensor. In many cases, this will allow the Collector to operate more efficiently. For example, if the Instantaneous Stride Length Measurement Supported bit is set to 0 (meaning this feature is not supported), then it is unnecessary for the Collector to check the value of the Instantaneous Stride Length Present bit with each RSC Measurement characteristic.

If the Instantaneous Stride Length Measurement Supported bit is set to 0 (False), the Collector should ignore the Instantaneous Stride Length Present bit of the Flags field of the RSC Measurement characteristic.

If the Total Distance Measurement Supported bit is set to 0 (False), the Collector should ignore the Total Distance Present bit of the Flags field of the RSC Measurement characteristic. Otherwise, the Collector may request the reset of the total distance as described in section 4.7.2.1.

If the Walking or Running Status Supported bit is set to 0 (False), the Collector shall ignore the Walking or Running Status bit of the Flags field of the RSC Measurement characteristic.

If the Calibration Procedure Supported bit is set to 0 (False), the Collector shall assume that the RSC Sensor doesn’t support the Calibration Procedure. Otherwise, the Collector may initiate the calibration of the RSC Sensor as described in section 4.7.2.2.

If the Multiple Sensor Locations Supported bit is set to 0 (False), the Collector shall assume that the RSC Sensor doesn’t support the configuration of multiple sensor locations. Otherwise, the Collector may request a list of supported sensor locations (see section 4.7.2.4) and configure the RSC Sensor as described in section 4.7.2.3 with the appropriate sensor location.

Whether a bit is defined as static during the lifetime of the device or static during a connection, is defined on a bit by bit basis in Table 3.2 of [1] (Static Requirements for RSC Feature Bits).

If the Collector reads RSC Feature characteristic bits that are set and yet are designated as Reserved for Future Use (RFU) in [3] it shall ignore those bits and behave as if all the RFU bits had been zero. The Collector may nevertheless preserve the state of the RFU bits when storing the data and/or providing the data for use by the implementation. What a Collector does with the received RFU information is left to the implementation.

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

4.6 Sensor Location

The Sensor Location characteristic describes the location where the device is intended to be installed. If the RSC Sensor supports the Multiple Sensor Locations feature, the value of the Sensor Location characteristic may change while in a connection; otherwise, if the Sensor Location characteristic is present and the Multiple Sensor Locations feature is not supported, the value of the Sensor Location characteristic is static for the lifetime of the RSC Sensor.

If the RSC Sensor supports the Multiple Sensor Locations Feature, the Collector should read the value of the Sensor Location characteristic each time the connection is established to determine if the RSC Sensor is properly configured. This should be done in case the Sensor Location characteristic value was altered by another Collector or in case the RSC Sensor is unable to cache the value. See section 4.7.3 for information relating to the caching of the Sensor Location characteristic.

If the Collector reads a Sensor Location value that is designated as Reserved for Future Use (RFU), it shall either ignore the value or substitute it with the value for ‘Other’ (0x00).

4.7 SC Control Point

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

The Collector may perform a write to the SC Control Point to request a desired procedure. A procedure begins when the Collector writes the SC Control Point to perform some desired action and ends when a *Response Code* SC Control Point indication is sent by the RSC Sensor.

When a Collector requires a connection to a RSC Sensor, it shall follow the connection procedures described in section 5.

4.7.1 SC Control Point Procedure Requirements

The table below shows the requirements for the SC Control Point procedures (Op Codes) in the context of this profile:

Procedure (Op Code)	Requirement
Set Cumulative Value	O
Start Sensor Calibration	O
Update Sensor Location	C.1
Request Supported Sensor Locations	C.1

Table 4.4: SC Control Point Procedure Requirements

C.1: If one of Update Sensor Location feature or Request Supported Sensor Locations feature is supported, both are required.

4.7.2 SC Control Point Behavioral Description

The Collector shall write to the SC Control Point characteristic using one of the supported Op Codes in Table 4.4 to request a RSC Sensor to perform a procedure. This may include a Parameter that is valid within the context of that Op Code as defined in [1].

4.7.2.1 Set Cumulative Value Procedure

If the Total Distance Measurement Supported bit of the RSC Feature characteristic is set to 1, then this procedure is supported by the RSC Sensor.

To request a specific setting of the Total Distance value within the RSC Sensor, the Collector shall write the *Set Cumulative Value* Op Code followed by a UINT32 parameter. For example, writing a parameter of 0x00000000 will set the Total Distance value to 0 within the RSC Sensor.

In some cases it may be desirable for a user to transfer the distance value from their old sensor onto their new sensor (e.g. if they desire to keep track of the total distance they have travelled).

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

See section 4.7.3 for general error handling procedures.

4.7.2.2 Start Calibration Procedure

If the Calibration Procedure Supported bit of the RSC Feature characteristic is set to 1, then this procedure is supported by the RSC Sensor.

To start the calibration procedure within the RSC Sensor, the Collector shall write the *Start Calibration Procedure* Op Code.

The Collector shall wait for the *Response Code* SC Control Point Indication with the Response Value set to *Success* indicating success of the operation as per the request or an error response value as

described in section 4.7.3 or for the procedure to time out according to the procedure time out operation described in section 4.7.4.

See section 4.7.3 for general error handling procedures.

4.7.2.3 Update Sensor Location Procedure

If the Multiple Sensor Locations Supported bit of the RSC Feature characteristic is set to 1, then this procedure is supported by the RSC Sensor.

To update the sensor location within the RSC Sensor, the Collector shall write the *Update Sensor Location* Op Code with a Parameter that represents a supported location. A list of supported sensor locations, for a particular RSC Sensor, is determined through the use of the Request Supported Sensor Locations procedure described in section 4.7.2.4. The possible sensor location values are defined in the Sensor Location characteristic description in [3].

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

See section 4.7.3 for general error handling procedures.

4.7.2.4 Request Supported Sensor Locations Procedure

If the Multiple Sensor Locations Supported bit of the RSC Feature characteristic is set to 1, then this procedure is supported by the RSC Sensor.

To request the list of the sensor locations supported by the RSC Sensor, the Collector shall use the *Request Supported Sensor Locations* procedure.

The Collector shall wait for the *Response Code* SC Control Point Indication with the Response Value set to *Success* indicating successful of operation as per the request with the list of supported locations or an error response value as described in section 4.7.3 or for the procedure to time out according to the procedure time out operation described in section 4.7.4. The possible sensor location values are defined in the Sensor Location characteristic description in [3].

Since the list of supported locations is static for the lifetime of the device as defined in the Running Speed and Cadence Service, the Collector should cache the list of supported values.

See section 4.7.3 for general error handling procedures including information relating to the caching of the Sensor Location characteristic.

4.7.3 General Error Handling

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

If the Collector writes an Op Code to the SC Control Point characteristic that is unsupported by the RSC Sensor, the RSC Sensor will respond with a *Response Code* SC Control Point indication with the *Response Value* set to *Op Code not supported*.

If the Collector writes a Parameter to the SC Control Point characteristic that is invalid (e.g. the Collector writes the *Update Sensor Location* Op Code with a sensor location that is not valid in the context of the

RSC Sensor), it will receive a *Response Code* SC Control Point indication with the *Response Value* set to *Invalid Parameter*.

If the Collector writes an Op Code to the SC Control Point characteristic which results in an operation failure (e.g. the Collector writes the *Start Sensor Calibration* Op Code and the RSC Sensor cannot perform the calibration procedure for any reason), it will receive a *Response Code* SC Control Point indication with the *Response Value* set to *Operation Failed*.

If the Collector attempts to perform any defined SC Control Point procedure before a previous procedure is complete and receives an ATT Error Response with the error code set to *Procedure Already in Progress*, the Collector shall wait until the current SC Control Point procedure completes before starting a new procedure.

If the Collector attempts to request any defined SC Control Point procedure before it has configured the SC Control Point characteristic for indications (all via the appropriate *Client Characteristic Configuration* descriptor) as required in previous sections, then the RSC Sensor will transmit an ATT Error Response with the error code set to *Client Characteristic Configuration Descriptor Improperly Configured*. This means that the Collector has not configured the RSC Sensor correctly. The Collector must properly configure this characteristic for indications where appropriate, as defined by other portions of this document.

4.7.4 Procedure Timeout

In the context of the SC Control Point characteristic, a procedure is started when the RSC Sensor sends the response to the Collector's Write request for the SC Control Point characteristic. The procedure is considered to be complete when the SC Control Point characteristic is indicated with the Op Code set to *Response Code*.

In the context of the SC Control Point characteristic, a procedure is not considered started and not queued in the RSC Sensor when a write to the SC Control Point results in an ATT Error Response defined in section 1.6 of the Running Speed and Cadence Service [1].

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

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

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

4.7.4.1 SC Control Point Procedure Timeout Handling

If an SC Control Point procedure times out (see section 4.7.4 for details of how this may occur) then no new SC Control Point procedure shall be started by the Collector until a new link is established with the RSC Sensor.

4.8 Device Information Service Characteristics

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

5 Connection Establishment Procedures

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

The following scenario description is informative for Low Energy Transport:

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

5.1 RSC Sensor Connection Establishment for Low Energy Transport

This section describes connection procedures to address the following scenarios:

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

5.1.1 Connection Procedure for Unbonded Devices

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

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

It is recommended that the RSC Sensor advertises using the parameters in Table 5.1. The interval values in the first row are designed to attempt fast connection to devices during the first 30 seconds; however, if a connection is not established within that time, the interval values in the second row are designed to reduce power consumption for devices that continue to advertise.

Advertising Duration	Parameter	Value
First 30 seconds (fast connection)	Advertising Interval	30 ms to 60 ms
After 30 seconds (reduced power)	Advertising Interval	1 s to 1.2 s

Table 5.1: Recommended Advertising Interval Values

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

The RSC Sensor shall accept any valid values for connection interval and connection latency set by the Collector until service discovery, bonding and encryption (if required) are complete. Only after that should the RSC Sensor request to change to the preferred connection parameters that best suit its use case.

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

The RSC Sensor should be in a bondable mode during this procedure to optimize the future connections to the Collector (e.g., a Watch or a Phone) using the procedure described in section 5.1.2.

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

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

When the RSC Sensor is disconnected by the Collector and it is ready for connection (e.g., when the RSC Sensor detects some activity or when commanded by the user), the RSC Sensor should initiate the Connection Procedure for Bonded Devices described in section 5.1.2. This will enable reconnection with bonded Collectors.

5.1.2 Connection Procedure for Bonded Devices

This procedure is used after the RSC Sensor is bonded with one or more Collectors using the connection procedure in section 5.1.1 and ready for connection (e.g., when the RSC Sensor detects some activity or when commanded by the user).

The RSC Sensor should use the GAP General Discoverable Mode with connectable undirected advertising events when establishing a connection. For the first 10 seconds a Filter Accept List containing addresses of only bonded devices should be used to allow only active bonded Collectors to establish a connection. In order to allow connection with additional Collectors, a Filter Accept List should not be used after the ten second period has expired.

It is recommended that the RSC Sensor advertises using the parameters in Table 5.1. The interval values in the first row are designed to attempt fast connection to devices during the first 30 seconds; however, if a connection is not established within that time, the interval values in the second row are designed to reduce power consumption for devices that continue to advertise.

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

The RSC Sensor shall accept any valid values for connection interval and connection latency set by the Collector until service discovery, bonding and encryption (if required) are complete. Only after that should the RSC Sensor request to change to the preferred connection parameters that best suit its use case.

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

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

5.1.3 Link Loss Reconnection Procedure

When a connection is terminated due to link loss, a RSC Sensor should attempt to reconnect to the Collector by entering a GAP Connectable Mode using the recommended advertising interval values shown in Table 5.1.

5.2 Collector Connection Establishment for Low Energy Transport

This section describes connection procedures to address the following scenarios:

- Section 5.2.1 describes the connection procedure if the Collector needs to initiate a connection to an unbonded RSC Sensor.
- Section 5.2.2 describes the connection procedure when the Collector needs to initiate a connection with a bonded RSC Sensor.
- Section 5.2.3 is used when the established connection is broken after a link loss.

5.2.1 Connection Procedure for Unbonded Devices

This procedure is used for connection establishment when the Collector connects to a RSC Sensor to which it is not bonded. A Collector will typically execute a connection establishment procedure at the start of a training session such that it scans for a connectable RSC Sensor in the background or when commanded by the user.

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

A Collector may use one of the following GAP connection procedures based on its connectivity requirements:

- *General Connection Establishment* procedure. The Collector may use this procedure when it requires measurements from one or more RSC Sensors. This procedure allows a Collector to connect to a RSC Sensor discovered during a scan without using the Filter Accept List.
- *Direct Connection Establishment* procedure. The Collector may use this procedure when it requires measurements from a single RSC Sensor.

A Collector should use the recommended scan interval values shown in Table 5.2. For the first 30 seconds, the Collector should use the first scan window / scan interval pair to attempt fast connection. However, if a connection is not established within that time, the Collector should switch to one of the other scan window / scan interval options as defined below to reduce power consumption.

Scan Duration	Parameter	Value
First 30 seconds (fast connection)	Scan Interval	30 ms to 60 ms*
	Scan Window	30 ms
After 30 seconds (reduced power) - Option 1	Scan Interval	1.28 s
	Scan Window	11.25 ms

Scan Duration	Parameter	Value
After 30 seconds (reduced power) - Option 2	Scan Interval	2.56 s
	Scan Window	22.5 ms

Table 5.2: Recommended Scan Interval and Scan Window Values

* A scan interval of 60 ms is recommended when the Collector is supporting other operations to provide a 50% scan duty cycle versus 100% scan duty cycle.

Option 1 in Table 5.2 uses the same background scanning interval used in BR/EDR so the power consumption for LE will be similar to the power consumption used for background scanning on BR/EDR. Option 2 uses a larger background scanning interval (i.e. twice as long) than used in BR/EDR so the power consumption for LE will be less than the power consumption used for background scanning on BR/EDR. Connection times during background scanning will be longer with Option 2.

The Collector should use a scan window and scan interval suitable to its power and connection time requirements. Increasing the scan window increases the power consumption, but decreases the connection time.

The scan interval and scan window should be configured with consideration for user expectations of connection establishment time.

When the connection is established, the Collector should bond with the RSC Sensor during this procedure to optimize the future connections to the device using the procedure described in section 5.2.2.

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

Once connected, the Collector shall configure the RSC Measurement characteristic for notification.

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

When the Collector is disconnected, the Collector may initiate the Connection Procedure for Bonded Devices described in section 5.2.2. This will enable reconnection with bonded RSC Sensors.

5.2.2 Connection Procedure for Bonded Devices

This procedure is used for connection establishment with a bonded RSC Sensor. A Collector will typically execute a connection establishment procedure at the start of a training session such that it scans for a bonded connectable RSC Sensor in the background or when commanded by the user.

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

A Collector may use one of the following GAP connection procedures based on its connectivity requirements:

- *General Connection Establishment* procedure. The Collector may use this procedure when it requires measurements from one or more RSC Sensors. This procedure allows a Collector to connect to a RSC Sensor discovered during a scan without using the Filter Accept List.
- *Direct Connection Establishment* procedure. The Collector may use this procedure when it requires measurements from a single RSC Sensor.
- *Auto Connection Establishment* procedure. The Collector may use this procedure when it requires measurements from one or more RSC Sensors. This procedure will automatically connect to a RSC Sensor in the Filter Accept List.
- *Selective Connection Establishment* procedure. The Collector may use this procedure when it requires measurements from one or more RSC Sensors. This procedure allows a Collector to connect to a RSC Sensor discovered during a scan while using the Filter Accept List.

A Collector should use the recommended scan interval values shown in Table 5.2. For the first 30 seconds, the Collector should use the first scan window / scan interval pair to attempt fast connection. However, if a connection is not established within that time, the Collector should switch to one of the other scan window / scan interval options as defined in Table 5.2 to reduce power consumption.

The Collector should use a scan window and scan interval suitable to its power and connection time requirements. Increasing the scan window increases the power consumption, but decreases the connection time.

The scan interval and scan window should be configured with consideration for user expectations of connection establishment time.

The Collector shall start encryption after each connection creation to verify the status of the bond. If encryption fails upon connection establishment (i.e. the bond no longer exists), the Collector must, after user interaction, re-bond, perform service discovery (unless the Collector had previously determined that the RSC Sensor did not have the <<Service Changed>> characteristic), and configure the RSC Sensor *Client Characteristic Configuration* descriptors again before using any of the services referenced by this profile in case the configuration was altered or lost.

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

When the Collector is disconnected the Collector may reinitiate the Connection Procedure for Bonded Devices described in section 5.2.2.

5.2.3 Link Loss Reconnection Procedure

When a connection is terminated due to link loss, a Collector should attempt to reconnect to the RSC Sensor using any of the GAP connection procedures with the parameters in Table 5.2.

5.2.4 Fast Connection Interval

To avoid very long service discovery and encryption times, the Collector should use the connection intervals defined in Table 5.3 in the connection request.

Parameter	Value
Minimum Connection Interval	50 ms
Maximum Connection Interval	70 ms

Table 5.3: Recommended Fast Connection Interval Values

At any time a low latency is required, for example to perform key refresh or encryption setup, this should be preceded with a connection parameter update to the minimum and maximum connection interval values defined in Table 5.3 and a connection latency of zero. This fast connection interval should be maintained as long as low latency is required. After that, it should switch to the preferred connection parameters as decided by the RSC Sensor using the GAP *Connection Parameter Update* procedure.

5.3 Connection Establishment for BR/EDR

This section describes the connection establishment and connection termination procedures used by a RSC Sensor and Collector using a BR/EDR transport. Unlike the LE Connection procedures, which describe specific connection parameters, BR/EDR connection establishment does not state requirements beyond those described in GAP based on potential interactions with other BR/EDR profiles operating concurrently on the RSC Sensor and/or Collector. Therefore, power consumption may not be optimized for the BR/EDR transport as compared to an LE transport when no other profiles are operating over the BR/EDR transport.

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

5.3.1 Connection Procedure

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

5.3.1.1 Connection Procedure for Unbonded Devices

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

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

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

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

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

Once connected and the Running Speed and Cadence Service is discovered, the Collector shall configure the SC Measurement characteristic for notification.

The Collector should initiate bonding between the two devices. If a bond is created, the Collector should cache the SDP Service Record for the Running Speed and Cadence Service.

When the RSC Sensor no longer detects user activity for several seconds (e.g., 10 to 20 seconds), the RSC Sensor may disconnect the link, depending on the use cases of the devices and other profiles connected on either device.

5.3.1.2 Connection Procedure for Bonded Devices

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

The Collector should be Connectable to accept a connection from a RSC Sensor to which it is bonded.

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

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

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

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

When the RSC Sensor no longer detects user activity for several seconds (e.g., 10 to 20 seconds), the RSC Sensor may disconnect the link, depending on the use cases of the devices and other profiles connected on either device. When the RSC Sensor is disconnected and it is ready for reconnection (e.g., when the RSC Sensor detects some activity or when commanded by the user), the RSC Sensor should initiate a connection with the Collector.

5.3.2 Link Loss Reconnection Procedure

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

6 Security Considerations

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

6.1 RSC Sensor Security Considerations for Low Energy

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

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

The RSC Sensor should bond with the Collector.

The RSC Sensor should use the SM *Peripheral Security Request* procedure.

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

6.2 Collector Security Considerations for Low Energy

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

The Collector should bond with the RSC Sensor.

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

6.3 Security Considerations for BR/EDR

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

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

7 Generic Access Profile for BR/EDR

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

7.1 Modes

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

- General Discoverable mode shall be supported by RSC Sensors supporting BR/EDR.
- Bondable mode should be supported by RSC Sensors and Collectors

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

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

Table 7.1: Modes

7.2 Idle Mode Procedures

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

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

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

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

Table 7.2: Idle mode procedures

8 Acronyms and Abbreviations

Acronyms and Abbreviations	Meaning
ACL	Asynchronous Connection-oriented [logical transport]
AD	Advertising Data
AMP	Alternate MAC PHY
BR/EDR	Basic Rate / Enhanced Data Rate
GAP	Generic Access Profile
GATT	Generic Attribute Profile
LE	Low Energy
RFU	Reserved for Future Use
RSC	Running Speed and Cadence
SC	Speed and Cadence
SDP	Service Discovery Protocol
SM	Security Manager
UUID	Universally Unique Identifier

Table 8.1: Acronyms and Abbreviations

9 References

[1] Running Speed and Cadence Service

[2] Bluetooth Core Specification v4.2 or later

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

[4] Device Information Service v1.1 or later