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Push every boundary.™

CSR µEnergy™

CSRmesh 2.0 Temperature Sensor

Application Note

Issue 3

Document History

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1. Introduction

This document describes the CSRmesh™ Temperature Sensor on-chip application built using the CSR µEnergy™ SDK.

The application demonstrates the following use cases:

- CSRmesh Temperature Sensor: The Temperature Sensor application implements a temperature sensor which periodically reads the air temperature and broadcasts it to the group of devices. It implements the handlers for the CSRmesh messages related to the Sensor Model, Actuator Model, Stream Model, Firmware Model and Attention Model.
- Desired temperature setting: Optionally this application implements a desired temperature setting control using the on-board buttons. It broadcasts the desired temperature whenever the user changes the setting.
- CSRmesh GATT Bridge: The application also implements the CSR custom Mesh Control Service. This service allows a Bluetooth Smart enabled phone to send and receive CSRmesh messages to many devices with the temperature sensor application acting as a bridge.

The CSRmesh Temperature Sensor Application is part of the CSRmesh release to demonstrate CSRmesh Temperature Sensor use case.

The application uses the CSRmesh library provided as part of the CSRmesh release. See the *CSRmesh API Guide* documentation for details.

The CSRmesh Temperature Sensor application does not support bonding and is not compatible with previous releases of CSRmesh.

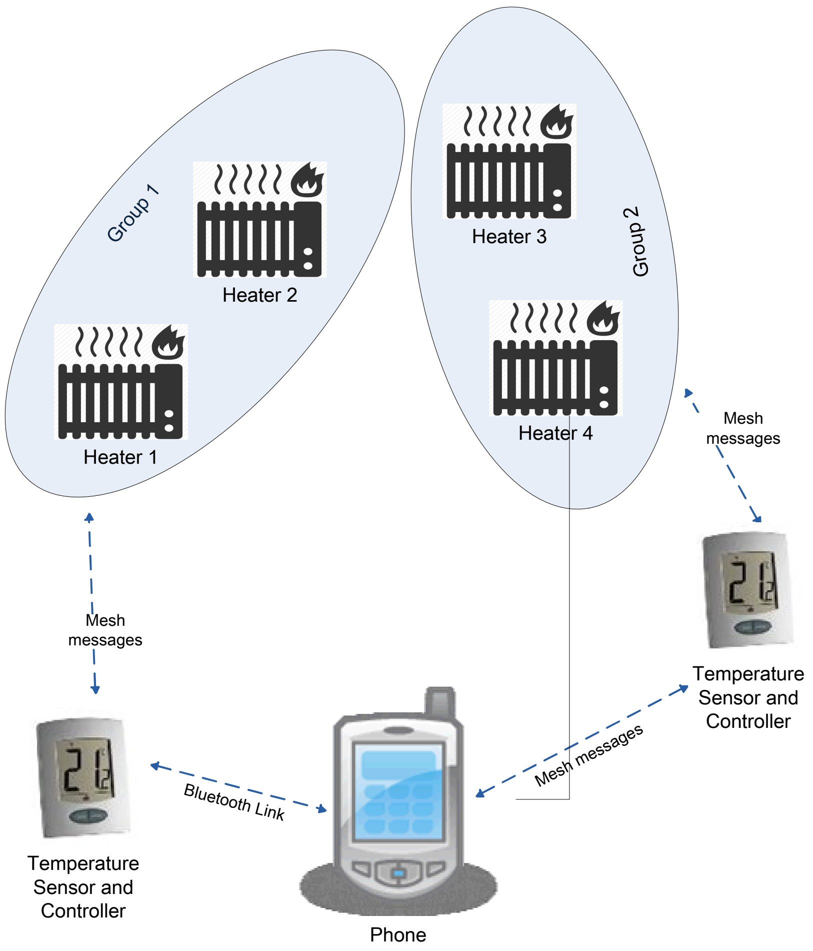


Figure 1.1: CSRmesh Temperature Sensor Use Case

1.1. Application Overview

The CSRmesh Temperature Sensor application uses the CSRmesh library API to communicate with other devices that are associated within the same CSRmesh network. It implements the temperature sensor driver to periodically sample the current temperature and broadcasts it to the group. Additionally it supports a custom GATT profile to allow control of the CSRmesh from a Bluetooth Smart enabled device.

1.1.1. Profiles Supported

The CSRmesh Temperature Sensor application implements the following CSR custom profiles to support the use cases described.

1.1.1.1. CSRmesh Control Profile

The CSRmesh Control Profile defines the behaviour when:

- A network of devices such as temperature sensors and heaters need to be created.
- Controlling the heater device after a network is created. For example, controlling the heaters by sending the desired and current air temperature values.
- Reading the status of the devices in the network, for example desired and current air temperatures currently set on the network.

Table 1.1 lists the roles defined by CSRmesh Control Profile.

Role	Description
CSRmesh Bridge Device	Receives commands from the host and sends them over the CSRmesh network to associated devices. Receives responses from associated devices over the CSRmesh and forwards them to the host via a Bluetooth Smart connection.
CSRmesh Control Device	The CSRmesh Control Device provides the interface to create a network of devices and control the associated devices. The control commands are sent via a Bluetooth Smart connection to the CSRmesh devices.

Table 1.1: CSRmesh Control Profile Roles

The CSRmesh Bridge Device role is implemented on the CSRmesh Temperature Sensor application. The CSRmesh Control Device is implemented on a Bluetooth Smart enabled phone or tablet.

1.1.2. Application Topology

Table 1.2 and Table 1.3 list the topology used by the CSRmesh Bridge.

Role	Mesh Control Service	GAP Service	GATT Service	CSR OTA Update Application Service
GATT Role	GATT Server	GATT Server	GATT Server	GATT Server
GAP Role	Peripheral	Peripheral	Peripheral	Peripheral

Table 1.2: Application Topology

Role	Responsibility
GATT Server	Accepts incoming commands and requests from a client and sends responses, indications and notifications to the client.
GAP Peripheral	Accepts connection from remote device and acts as a slave in the connection.

Table 1.3: Role and Responsibilities

For more information about GATT server and GAP peripheral, see *Bluetooth Core Specification Version 4.1*.

1.1.3. Services Supported in GATT Server Role

The application exposes the following services:

- Mesh Control Service v2.0
- GATT Service
- GAP Service
- CSR OTA Update Application Service v6

The Mesh Control Service is mandated by the CSRmesh Control Profile. The GATT and GAP Services are mandated by *Bluetooth Core Specification Version 4.1*.

Figure 1.2 shows the services supported in the GATT Server Role.

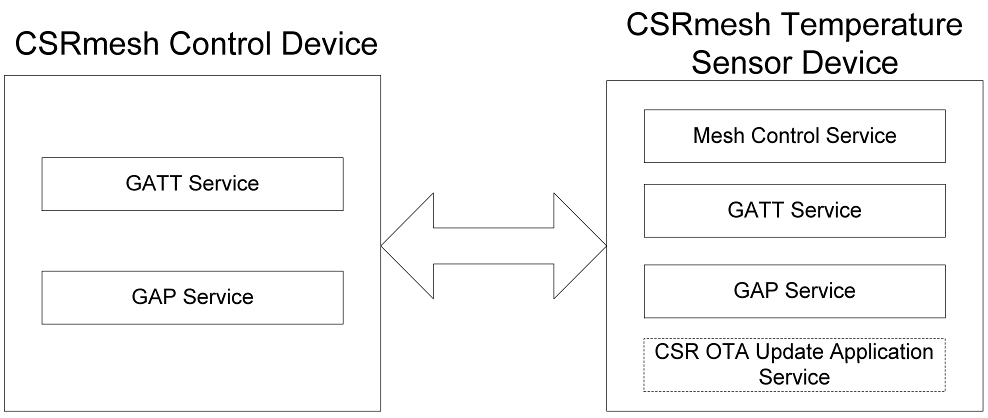


Figure 1.2: Primary Services

1.1.3.1. CSR OTA Update Application Service

The CSR OTA Update Application Service enables wireless update of the application software. A PC or mobile phone application provided by the device manufacturer enables the end-user to keep their device up-to-date with the latest features and bug fixes.

To enable a device for future OTA updates, the application needs to:

- Add OTA Update functionality to the on-chip application
- Add support for the CSR OTA Update Application Service and GATT Services to an application
- Configure the on-chip bootloader

The CSR OTA Update bootloader image must be present on the device and configured to contain the correct device name and optional shared authentication key.

When the device is enabled for OTA Update, the CSR µEnergy Over-the-Air Updater host application included in the SDK can update the device.

For more information on CSR OTA Update, see:

- CSR µEnergy Over-the-Air (OTA) Update System Application Note
- CSR µEnergy Modifying an Application to Support OTA Update Application Note
- CSR µEnergy Over-the-Air (OTA) Update Application and Bootloader Services Specification

For information on CSR OTA Update applications for iOS and Android, see www.csrsupport.com.

2. Using the Application

This section describes how the CSRmesh Temperature Sensor application can be used with CSRmesh Control application to control devices.

2.1. Demonstration Kit

Table 2.1 lists the components that demonstrate the application.

Component	Hardware	Application
Temperature Sensor	CSRmesh Development PCB (DB-CSR1010-10185-1A)	CSRmesh Temperature Sensor Application v2.0
CSRmesh Android Control Device	Android Bluetooth LE Device	CSRmesh Control Application v2.0
CSRmesh iOS Control Device	iOS Bluetooth LE Device	CSRmesh Control Application v2.0

Table 2.1: CSRmesh Components

2.1.1. CSRmesh Development Board

The µEnergy SDK downloads the CSRmesh Temperature Sensor application on the development boards. See *CSR µEnergy xIDE User Guide* for more information.

Ensure the development board is switched on using the Power Slider switch. Figure 2.1 shows the switch in the **Off** position.

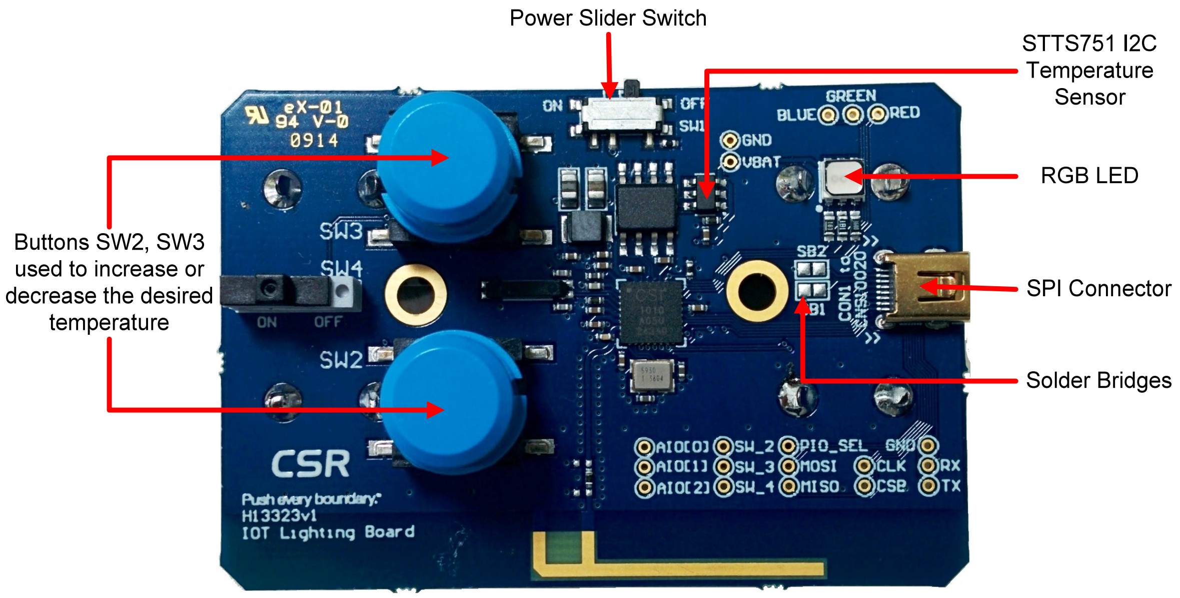

Power Slider Switch
STTS751 I2C Temperature Sensor
RGB LED
SPI Connector
Solder Bridges
Buttons SW2, SW3 used to increase or decrease the desired temperature

Figure 2.1: CSRmesh Development board

Note:

When disconnected from the USB to SPI Adapter, wait at least 1 minute before switching the board on. This allows any residual charge received from the SPI connector to be dissipated.

Shorting the solder bridges allows the UART to be brought out via the CSR SPI connector. The PIOs connected to SW2 and SW3 in Figure 2.1 are also mapped to UART Rx and Tx lines. Pressing any of these buttons shorts the UART lines to ground and corrupts the data on the UART. It is recommended not to press these buttons during UART communication.

2.1.1.1. User Interface

This application uses the components available on the CSRmesh development board for the CSRmesh Temperature Sensor applications. Table 2.2 lists the components of the board user interface shown in Figure 2.1.

User Interface Component	Function
Switch SW1	Power slider switch allows the user to power on/off the board.
Button SW2	Each button press increases the current set desired temperature by 1 degree. If the button is pressed and held for more than 1 second the temperature is changed by 1 degree every 1 second as long as the button is pressed. See Section 6.7 for details.
Button SW3	Each button press decreases the current set desired temperature by 1 degree. If the button is pressed and held for more than 1 second the temperature is changed by 1 degree every 1 second as long as the button is pressed. See Section 6.7 for details.
Switch SW4	Unused.
RGB LED	Blinks blue until it is not associated with any CSRmesh network. Blinks yellow when the device association is in progress. Blinks red when device attention is requested. The application turns the light off after association.

Table 2.2: CSRmesh Development Board User Interface

2.1.1.2. CSRmesh Device Tag

The CSRmesh development board is supplied with a CSRmesh device tag sticker as shown in Figure 2.2. The sticker contains:

- BT: Device Bluetooth Address
- SN: Serial Number
- XTAL TRIM: Crystal trim value to be set in the CS Config File
- UUID: CSRmesh Device UUID
- AC: CSRmesh Authorisation Code
- QR-Code: Encodes UUID and AC

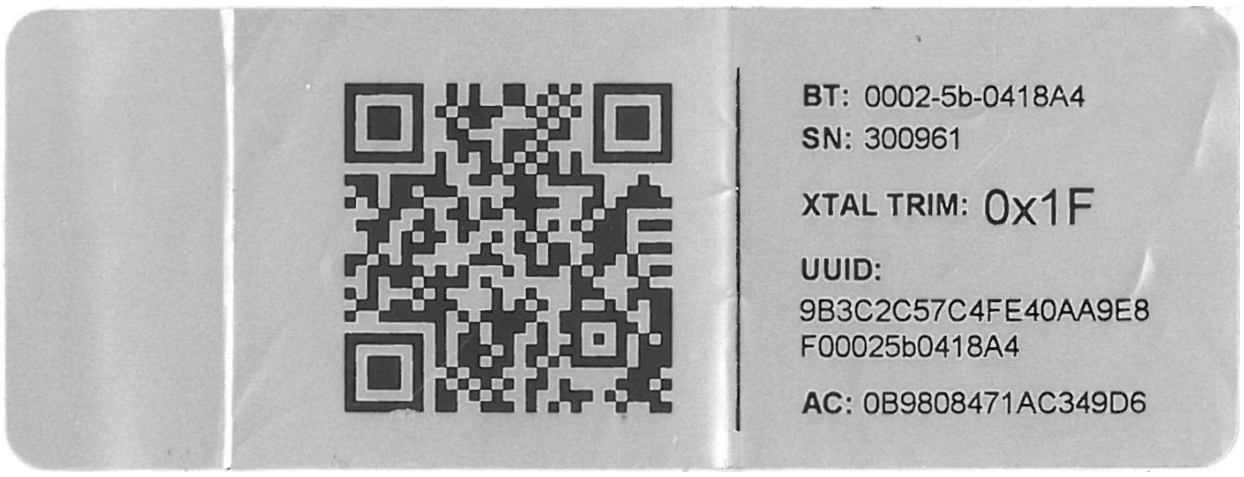


Figure 2.2: CSRmesh Device Tag Sticker

The user can program the device with the Bluetooth Address and the XTAL Trim printed on the sticker by setting these values in the `tempsensor_csr101x_A05.keyr` file.

The Device UUID and the Authorisation Code printed on the sticker can be programmed on the NVM at the offsets defined in Table 5.1 using the USB to SPI adapter.

To program the example UUID `0x0123456789ABCDEFFEDCBA9876543210` and Authorisation Code on the NVM:

1. Open a command prompt.
2. Program the device UUID and Authorisation Code to the device EEPROM over the SPI link as follows:
   - If base `NVM_START_ADDRESS` is defined in the `.keyr` file, the device UUID and Authorisation Code to the device can be programmed as below:

     ```
     <CSR_uEnergy_Tools path>\uEnergyProdTest.exe -k
     CSRmesh_tempsensor_csr101x_A05.keyr -m1 0x02 0x3210 0x7654 0xBA98
     0xFEDC 0xCDEF 0x89AB 0x4567 0x0123 0xCDEF 0x89AB 0x4567 0x0123
     ```

     The first value following `-m1` is the NVM offset from `NVM_START_ADDRESS`. The command takes the NVM offset as the byte address. Word offset 1 for device UUID will be byte offset 2 (see Table 5.1).
   - If the `.keyr` file is not included in the command, the device UUID and Authorisation Code to the device can be programmed as below:

     ```
     <CSR_uEnergy_Tools path>\uEnergyProdTest.exe -m1 0xF804 0x3210 0x7654
     0xBA98 0xFEDC  0xCDEF 0x89AB 0x4567 0x0123 0xCDEF 0x89AB 0x4567
     0x0123
     ```

     The first value following `-m1` is the NVM address, obtained by adding base address `4100` and word offset 1, see Table 5.1 for device UUID. The command takes the NVM address as the byte address. Word offset 1 is byte offset 2, so effective address is `0x4102`.

The CSRmesh Control application reads the device Authorisation Code and the UUID from the QR-Code printed on the sticker during association. See *CSRmesh 2.0 Android Control Application Note* or the *CSRmesh 2.0 iOS Control Application Note* for details. For further information about programming the NVM, see *CSRmesh 2.0 Production Test Tool User Guide.*

2.1.2. CSRmesh Control Application

The CSRmesh Control application runs on an Android or iOS device that supports Bluetooth Low Energy. It communicates with the CSRmesh devices by connecting to one of the devices that support the CSR custom CSRmesh Control Profile. This application is required for:

- Setting up a network by associating devices.
- Configuring and grouping the network devices.

Note:

For details about using the CSRmesh Control Application on an Android device, see *CSRmesh 2.0 Android Control Application Note*.

For details about using the CSRmesh Control Application on an iOS device, see *CSRmesh 2.0 iOS Control Application Note.*

For details about the supported iOS and Android version, see *CSRmesh 2.0 Node Release Note*.

3. Application Structure

3.1. Source Files

Table 3.1 lists the source files and their purposes.

File Name	Purpose
`app_data_stream.c`	Handles data stream model events. Implements a protocol to exchange large blocks of data with other CSRmesh devices. See Section 0 for more details.
`app_fw_event_handler.c`	The handler functions for firmware events are defined here.
`app_mesh_event_handler.c`	The handler functions for CSRmesh events are defined here.
`battery_hw.c`	Implements the routines to read the battery level.
`csr_mesh_tempsensor.c`	Implements all the entry functions e.g. `AppInit()`, `AppProcessSystemEvent()`, `AppProcessCsrMeshEvent()` and `AppProcessLmEvent()`. Events received from the hardware, CSRmesh network and firmware are first handled here. This file contains handling functions for all the LM, CSRmesh and system events.
`csr_mesh_tempsensor_gatt.c`	Implements routines for triggering advertisement procedures.
`csr_mesh_tempsensor_hw.c`	Implements the abstract hardware interface to configure and control the peripherals on specific hardware.
`csr_mesh_tempsensor_util.c`	Implements some utilities functions called by other handlers.
`csr_ota_service.c`	Implements the routines for handling the read/write access on the CSR custom OTA Update Service.
`gap_service.c`	Implements routines for GAP service, e.g. handling read/write access indications on the GAP service characteristics, reading/writing device name on NVM etc.
`gatt_service.c`	Defines routines for using the GATT service.
`i2c_comms.c`	Implements the I^2C interface drivers for communicating with the peripheral device.
`iot_hw.c`	Implements the hardware interface to configure and control the peripherals on the CSRmesh development board.
`mesh_control_service.c`	Implements routines for handling read/write access on Mesh Control characteristics and for sending notifications of CSRmesh device responses.
`nvm_access.c`	Implements the NVM read/write routines.
`stts751_temperature_sensor.c`	Implements the hardware interface to configure and control the STTS751 temperature sensor device.

Table 3.1: Source Files

3.2. Header Files

Table 3.2 lists the header files and their purposes.

File Name	Purpose
`appearance.h`	Contains the appearance value macro of the application.
`app_data_stream.h`	Contains enumerations and function prototypes for externally referred functions defined in `app_data_stream.c`.
`app_debug.h`	Contains macro definitions for enabling debug prints.
`app_fw_event_handler.h`	Contains prototypes of the externally referred functions defined in `app_fw_event_handler.c`.
`app_gatt.h`	Contains macro definitions, user defined data type definitions and function prototypes used across the application.
`app_mesh_event_handler.h`	Contains prototypes of the externally referred functions defined in `app_mesh_event_handler.c`.
`battery_hw.h`	Contains prototypes of the externally referred functions defined in `battery_hw.c`.
`csr_mesh_tempsensor.h`	Contains the macros and definitions used in the `csr_mesh_tempsensor.c` application file.
`csr_mesh_tempsensor_gatt.h`	Contains macro definitions for enabling debug prints.
`csr_mesh_tempsensor_hw.h`	Contains the function declarations to control the hardware interfaces.
`csr_ota_service.h`	Contains prototypes of the externally referred functions defined in the `csr_ota_service.c` file.
`csr_ota_uuids.h`	Contains macros for UUID values for CSR OTA Update service.
`gap_conn_params.h`	Contains macro definitions for fast/slow advertising, preferred connection parameters, idle connection timeout values etc.
`gap_service.h`	Contains prototypes of the externally referred functions defined in the `gap_service.c` file.
`gap_uuids.h`	Contains macros for UUID values for GAP service.
`gatt_service.h`	Contains prototypes of the externally referred functions defined in the `gatt_service.c` file.
`gatt_service_uuids.h`	Contains macros for UUID values for GATT service.
`i2c_comms.h`	Contains macro definitions and the prototypes for externally defined functions in the `i2c_comms.c`.
`iot_hw.h`	Contains the function declarations to control the IoT hardware interfaces.
`mesh_control_service.h`	Contains prototypes of the externally referred functions defined in the `mesh_control_service.c` file.
`mesh_control_service_uuids.h`	Contains macros for UUID values for Mesh Control service.
`ota_customisation.h`	Contains defines for the application data variables used by `csr_ota_service.c`.
`stts751_temperature_sensor.h`	Contains the function declarations to control the STTS751 temperature

	sensor device.
`user_config.h`	Contains macros for customising the application.

Table 3.2: Header Files

3.3. Database Files

The SDK uses database files to generate attribute database for the application. For more information on how to write database files, see *GATT Database Generator User Guide*.

Table 3.3 lists the database files and their purposes.

File Name	Purpose
`app_gatt_db.db`	Master database file which includes all service specific database files. This file is imported by the GATT database generator.
`csr_ota_db.db`	Contains information related to CSR OTA Update service characteristics, their descriptors and values. See Table A.3 for CSR OTA service characteristics.
`gap_service_db.db`	Contains information related to GAP service characteristics, their descriptors and values. See Table A.2 for GAP service characteristics.
`gatt_service_db.db`	Contains information related to GATT service characteristics, their descriptors and values. See Table A.1 for GATT service characteristics.
`mesh_control_service_db.db`	Contains information related to CSRmesh Control service characteristics, their descriptors and values. See Table A.4 for CSRmesh Control service characteristics.

Table 3.3: Database Files

4. Code Overview

This section describes significant functions of the application.

4.1. Application Entry Points

4.1.1. AppInit()

This function is invoked when the application is powered on or the chip resets and performs the following initialisation functions:

- Initialises the application timers, hardware and application data structures
- Configures GATT entity for server role
- Configures the NVM manager to use I^{2}C EEPROM
- Initialises all the services
- Reads the persistent store. Sets a random device UUID based on the Bit 3 of `CS_USER_KEY 1` setting when the application runs for the first time
- Initialises the CSRmesh stack:
  - Configures CSRmesh bearer parameters and initialises the CSRmesh scheduler:
    `CSRSchedSetConfigParams(params)`
    `CSRSchedStart()`
  - Registers an application callback function for handling core mesh events:
    `CSRmeshRegisterAppCallback(CSRmeshAppProcessMeshEvent)`
  - Initialises the core stack: `CSRmeshInit()`
  - Initialises the supported model server and client modules
- Registers the attribute database with the firmware

4.1.2. AppProcessLmEvent()

This function is invoked whenever the system receives a LM-specific event. It handles the following events:

4.1.2.1. Database Access

- `GATT_ADD_DB_CFM`: This confirmation event marks the completion of database registration with the firmware. On receiving this event, the application starts advertising.
- `GATT_ACCESS_IND`: This indication event is received when the CSRmesh control device tries to access an ATT characteristic managed by the application.

4.1.2.2. LS Events

- `LS_CONNECTION_PARAM_UPDATE_CFM:` This confirmation event is received in response to the connection parameter update request by the application. The connection parameter update request from the application triggers the L2CAP connection parameter update signalling procedure. See Volume 3, Part A, Section 4.20 of *Bluetooth Core Specification Version 4.1*.
- `LS_CONNECTION_PARAM_UPDATE_IND`: This indication event is received when the remote central device updates the connection parameters. On receiving this event, the application validates the new connection parameters against the preferred connection parameters and triggers a connection parameter update request if the new connection parameters do not comply with the preferred connection parameters.
- `LS_RADIO_EVENT_IND`: This radio event indication is received when the chip firmware receives an acknowledgement for the Tx data sent by the application. On receiving this event, the application aligns the timer wakeup, which sends data periodically to the collector with the latent connection interval.

4.1.2.3. LM Events

- `LM_EV_ADVERTISING_REPORT`: This event is received when an advertisement packet is received. This can be a CSRmesh advertisement. The application passes the event data to the CSRmesh library to process the packet by calling the `CsrMeshProcessMessage()` API.

- `LM_EV_CONNECTION_COMPLETE`: This event is received when the connection with the master is considered to be complete and includes the new connection parameters.
- `LM_EV_DISCONNECT_COMPLETE`: This event is received on link disconnection. Disconnection can be due to link loss, locally triggered or triggered by the remote connected device.
- `LM_EV_ENCRYPTION_CHANGE`: This event indicates a change in the link encryption.
- `LM_EV_CONNECTION_UPDATE`: This event indicates that the connection parameters are updated to a new set of values and is generated when the connection parameter update procedure is either initiated by the master or the slave. These new values are stored by the application for comparison against the preferred connection parameter, see Section 6.2.

4.1.2.4. SMP Events

- `SM_SIMPLE_PAIRING_COMPLETE_IND`: This event indicates that the pairing completes successfully or otherwise. See Volume 3, Part H, Section 2.4 and Section 3.6 of *Bluetooth Core Specification Version 4.1Connection Events*.

4.1.2.5. GATT Events

- `GATT_CONNECT_CFM`: This confirmation event indicates that the connection procedure completes. If the connection does not complete successfully, the application goes to idle state and waits for user action. See Section 0 for more information on application states.
- `GATT_CANCEL_CONNECT_CFM`: This confirmation event confirms the cancellation of connection procedure. When the application stops advertisements to changes advertising parameters or to save power, this signal confirms the successful stopping of advertisements by the CSRmesh application.

4.1.3. AppProcessSystemEvent()

This function handles the system events such as a low battery notification or a PIO change. The CSRmesh applications currently handle the following system events:

- `sys_event_pio_changed`: This event indicates a change in PIO value. Whenever the user presses or releases the button, the corresponding PIO value changes and the application receives a PIO changed event and takes the appropriate action.

4.1.4. AppProcessCsrMeshEvent()

This function handles the CSRmesh events received from the CSRmesh network or internal state changes.

4.1.4.1. Network Association Messages

- `CSR_MESH_ASSOC_STARTED_EVENT`: This event is received when a CSRmesh Control application sends an association request to a light which is ready for association. The application starts blinking yellow to indicate association in progress.
- `CSR_MESH_KEY_DISTRIBUTION`: This event is received when the CSRmesh Control device provides the network key for all future messages to communicate on the network. The application switches the state to associate and switches off the LED to indicate association completion and stores the association status on the NVM.
- `CSR_MESH_ASSOC_COMPLETE_EVENT/CSR_MESH_SEND_ASSOC_COMPLETE_EVENT`: One of these events is received when the association completes. The application updates the network association state and stops the **ready for association** LED display. It disables the promiscuous state so that the device only relays known network messages.
- `CSR_MESH_ASSOCIATION_ATTENTION_EVENT`: This event is received when a CSRmesh Control application seeks the attention of the device. The application starts blinking green to display attention. The attention display continues till timeout or till the association state changes.
- `CSR_MESH_CONFIG_RESET_DEVICE_EVENT`: This event is received when a configuring device removes the device. The association with the network is removed. The application uses this event to clean up the model data and then sets the device in ready for association state.
- `CSR_MESH_BEARER_STATE_EVENT`: This message is received when a configuring device sends a bearer state change message.

4.1.4.2. Device configuration Messages

- `CSR_MESH_CONFIG_RESET_DEVICE_EVENT`: This message is received when a configuring device wants to remove all the CSRmesh network information from device. The application resets all the assigned model group IDs.

4.1.4.3. Device Information Messages

The application receives `CSR_MESH_OPERATION_REQUEST_FOR_INFO` for the following events, which have sub-events relating to device information.

- `CSR_MESH_GET_VID_PID_VERSTION_EVENT`: This message is received when configuring device requests for Vendor Identifier, Product Identifier and Version number information from the device. Application sends this information to the library for transmission.
- `CSR_MESH_GET_DEVICE_APPEARANCE_EVENT`: This message is received when configuring device requests for device appearance information from the device. Application sends this information to the library for transmission.

4.1.4.4. Group Model Messages

- `CSR_MESH_GROUP_SET_MODEL_GROUPID_EVENT`: This message is received when the control device sets a new group ID to a supported model. The CSRmesh Light application stores the assigned Group IDs in the Group ID list for the model and saves it on the NVM.

4.1.4.5. Bearer Model Messages

- `CSR_MESH_BEARER_STATE_EVENT`: The application enables or disables the relay and promiscuous mode as set in the message when receiving this message.

4.1.5. AppActuatorEventHandler

- `CSRMESH_ACTUATOR_GET_TYPES:` This event is received when a CSRmesh Control application sends a command to get the supported sensor types in the actuator model. The CSRmesh Temperature Sensor application returns the updated actuator state data to the actuator model to send the response back.
- `CSRMESH_ACTUATOR_SET_VALUE:` This event is received when a CSRmesh Control application sends a command to set the desired temperature value on the temperature sensor device. The CSRmesh Temperature Sensor application returns the updated actuator state data to the actuator model to send the response back. It calls the `SensorWriteValue` function to send the `CSRMESH_SENSOR_WRITE_VALUE` message with the desired and the current air temperature.

  `CSRMESH_ACTUATOR_SET_VALUE_NO_ACK:` This event is received when the CSRmesh Control application sends a command to set the desired temperature value on the temperature sensor device. The CSRmesh Temperature Sensor application calls the `SensorWriteValue` function to send the `CSRMESH_SENSOR_WRITE_VALUE` message with the desired and the current air temperature.

4.1.6. AppSensorEventHandler

- `CSRMESH_SENSOR_GET_TYPES:` This event is received when a device in the network sends a command to get the supported sensor types in the sensor model. The CSRmesh Temperature Sensor application returns the updated sensor state data to the sensor model to send the response back.
- `CSRMESH_SENSOR_READ_VALUE`: This event is received when a CSRmesh Heater application sends a command to read the value of the current temperature or desired temperature. The CSRmesh Temperature Sensor application returns the updated sensor state data to the sensor model to send the response back. It calls the `SensorWriteValue` message with the current or desired temperature values.
- `CSRMESH_SENSOR_MISSING:` This event is received when a device in the group reports that it does not have the latest values for supported sensor types. On receiving this event, CSRmesh Temperature Sensor application sends the updated sensor values using the `SensorWriteValue` message for the requested sensor types.

- CSRMESH_SENSOR_SET_STATE: This event is received when a CSRmesh Controller application sends a command to set the repeat interval for a specific sensor type. The CSRmesh Temperature Sensor application returns the updated sensor state data to the sensor model to send the response back.

  The CSRmesh Temperature Sensor application calls the SensorWriteValue function to send the CSR_MESH_SENSOR_WRITE_VALUE message with the desired and the current air temperature at every repeat interval.
- CSRMESH_SENSOR_GET_STATE: This event is received when a CSRmesh Controller application to read the repeat interval for a specific sensor type. The CSRmesh Temperature Sensor application returns the updated sensor state data to the sensor model to send the response back.
- CSRMESH_SENSOR_WRITE_VALUE:This event is received when another CSRmesh Temperature Sensor broadcasts the current air temperature and desired temperature.

  The application updates its own desired_temperature value with the received value and returns the sensor state data. If the desired temperature is changed, the application calls the SensorWriteValue function to send the CSR_MESH_SENSOR_WRITE_VALUE message with the desired and the current air temperature.
- CSRMESH_SENSOR_WRITE_VALUE_NO_ACK: This event is received when another CSRmesh Temperature Sensor application broadcasts the current air temperature and desired temperature. The application updates its own desired air temperature value with the received value. If the desired temperature is changed, the application calls the SensorWriteValue function to send the CSR_MESH_SENSOR_WRITE_VALUE message with the desired and the current air temperature.

4.1.7. AppBatteryEventHandler

This function handles the CSRmesh Battery model events received from the CSRmesh network, such as getting the battery state or any other responses for Battery model commands sent over CSRmesh.

- CSRMESH_BATTERY_GET_STATE: This message is received when the control device queries the battery status. The application returns the current battery status.

4.1.8. AppAttentionEventHandler

This function handles the CSRmesh Attention model events received from the CSRmesh network, such as setting the attention state or any other responses for Attention model commands sent over CSRmesh.

- CSRMESH_ATTENTION_SET_STATE: This is received when a control device requests the attention of a device in the network. The application blinks the LED in red when Attention state is set and resumes the last set light colour when the Attention state is reset. If the duration is provided in the message, a timer is started to turn off the attention state upon timeout.

4.1.9. AppDataServerHandler

- CSRMESH_DATA_STREAM_FLUSH_IND: This message is received when a data stream client wants to start sending a data stream or to indicate completion of data transfer in the current stream.
- CSRMESH_DATA_STREAM_DATA_IND: This message is received when the next stream data block is received from the data stream client. The application verifies the type of streamed message and stores it into the device information string.
- CSRMESH_DATA_BLOCK_IND: This message is received when a data stream client sends a single block of data.

4.1.10. AppDataClientHandler

- CSRMESH_DATA_STREAM_RECEIVED: This message is received when the data stream server acknowledges the reception of a stream data block sent by the device using the StreamSendData function.

4.2. Internal State Machine for GATT Connection

This section describes the different state transition in the application during connection. Figure 4.1 shows the state transition process.

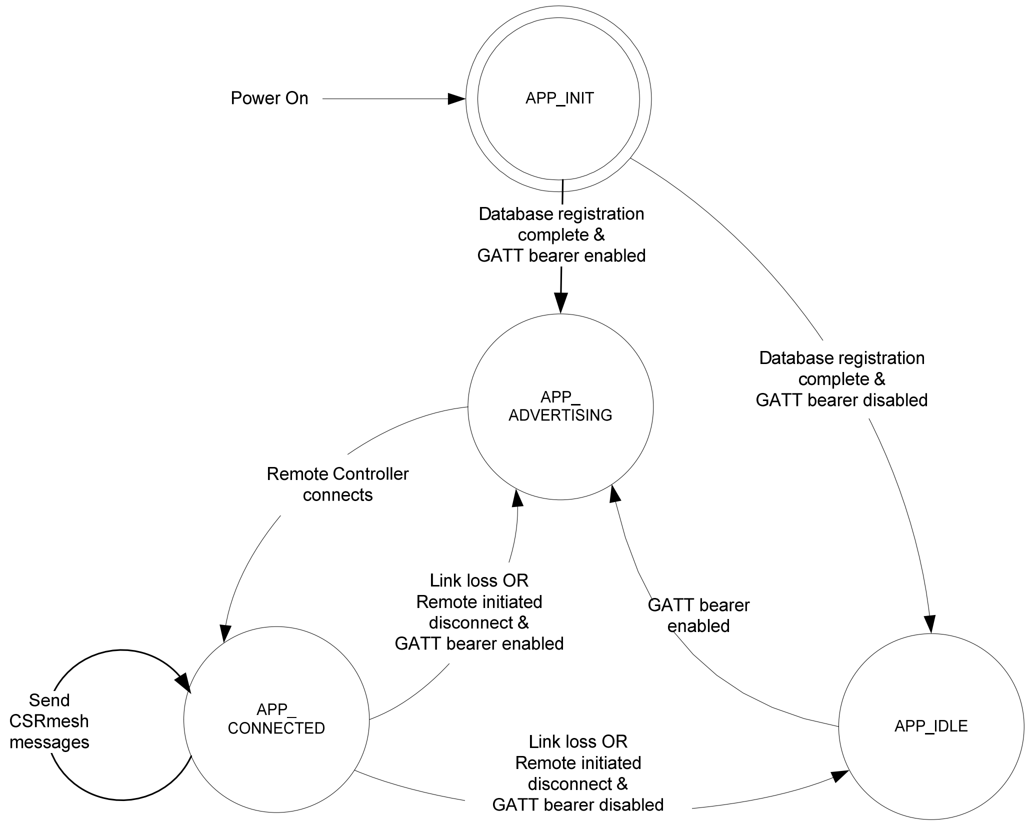

Power On
APP_INIT
Database registration complete & GATT bearer enabled
APP_ADVERTISING
Database registration complete & GATT bearer disabled
Remote Controller connects
Link loss OR Remote initiated disconnect & GATT bearer enabled
GATT bearer enabled
Send CSRmesh messages
APP_CONNECTED
Link loss OR Remote initiated disconnect & GATT bearer disabled
APP_IDLE

Figure 4.1: Internal GATT State Machine

4.2.1. app_state_init

When the application is powered on or the chip resets, it enters this state. The application registers the service database with the firmware and waits for confirmation. On a successful database registration the application starts advertising if the GATT bearer is enabled. If the GATT bearer is disabled, move to the `app_state_idle` state.

4.2.2. app_state_advertising

The application starts in this state and transmits connectable advertising events at an interval defined by `ADVERT_INTERVAL`. When a central device connects to the application, the application stops advertising and enters the `app_state_connected` state. See Section 6.1 for more information on advertisement timers. If the GATT bearer is disabled in this state then the application moves to the `app_state_idle` state.

4.2.3. app_state_idle

The CSRmesh application enters this state when the GATT bearer is disabled and the application is not in the `app_state_connected` state.

4.2.4. app_state_connected

In this state, the CSRmesh application is connected to a CSRmesh Control device using connection intervals specified in Table 6.2. It can receive commands from the Control device or send responses received over CSRmesh to control device.

- If link loss occurs and the GATT bearer is enabled then the application switches to the `app_state_advertising` state; otherwise the application moves to the `app_state_idle` state.

- In case of a remote triggered disconnection, the application switches to the `app_state_advertising` state if the GATT bearer is enabled; otherwise the application moves to the `app_state_idle` state.

4.2.5. app_state_disconnecting

The CSRmesh application never triggers a disconnection on its own. If the disconnection is triggered, the application enters the `app_state_advertising` state if the GATT bearer is enabled; otherwise it moves to the `app_state_idle` state.

4.3. CSRmesh Association

The device needs to be associated with a CSRmesh network to communicate with other devices in the network. In CSRmesh 2.0, the application does not send device identification messages periodically by default. The UUID and AC of the device can be programmed into the device by the uEnergy Production Test Tool. **CSRmeshQRCodeScanner** generates the QR code corresponding to the known UUID and Authorization Code, see Figure 4.3. For details about device association, see *CSRmesh 2.0 Android Control Application Note* or *CSRmesh 2.0 iOS Control Application Note*.

Figure 4.2 shows the application association state machine:

- `app_state_not_associated`: When the application is first flashed on the device it is in this state. In this state the application is ready to associate with a CSRmesh network and sends the CSRmesh device ID advertisements every 5 seconds.
- `app_state_association_started`: The application enters this state when it receives an association request from the control device.
- `app_state_associated`: The application enters this state when association completes. The application saves the association state on the NVM and it continues to be associated after power cycle. The application moves to the `app_state_not_associated` state when it receives `CSR_MESH_CONFIG_RESET_DEVICE` or on a 2 second long press of the SW2 button.

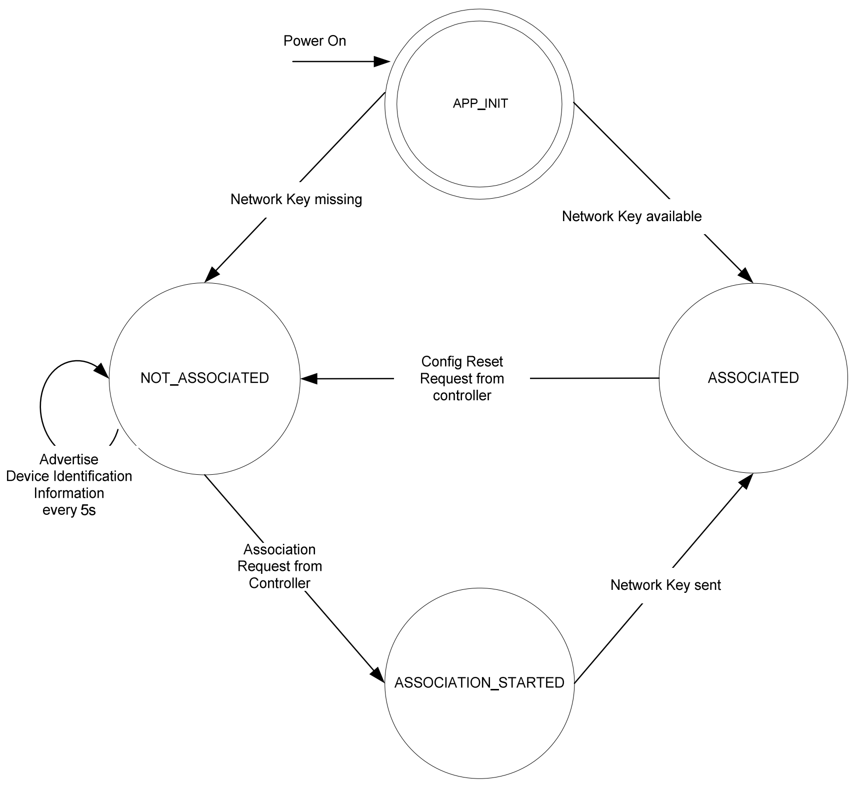
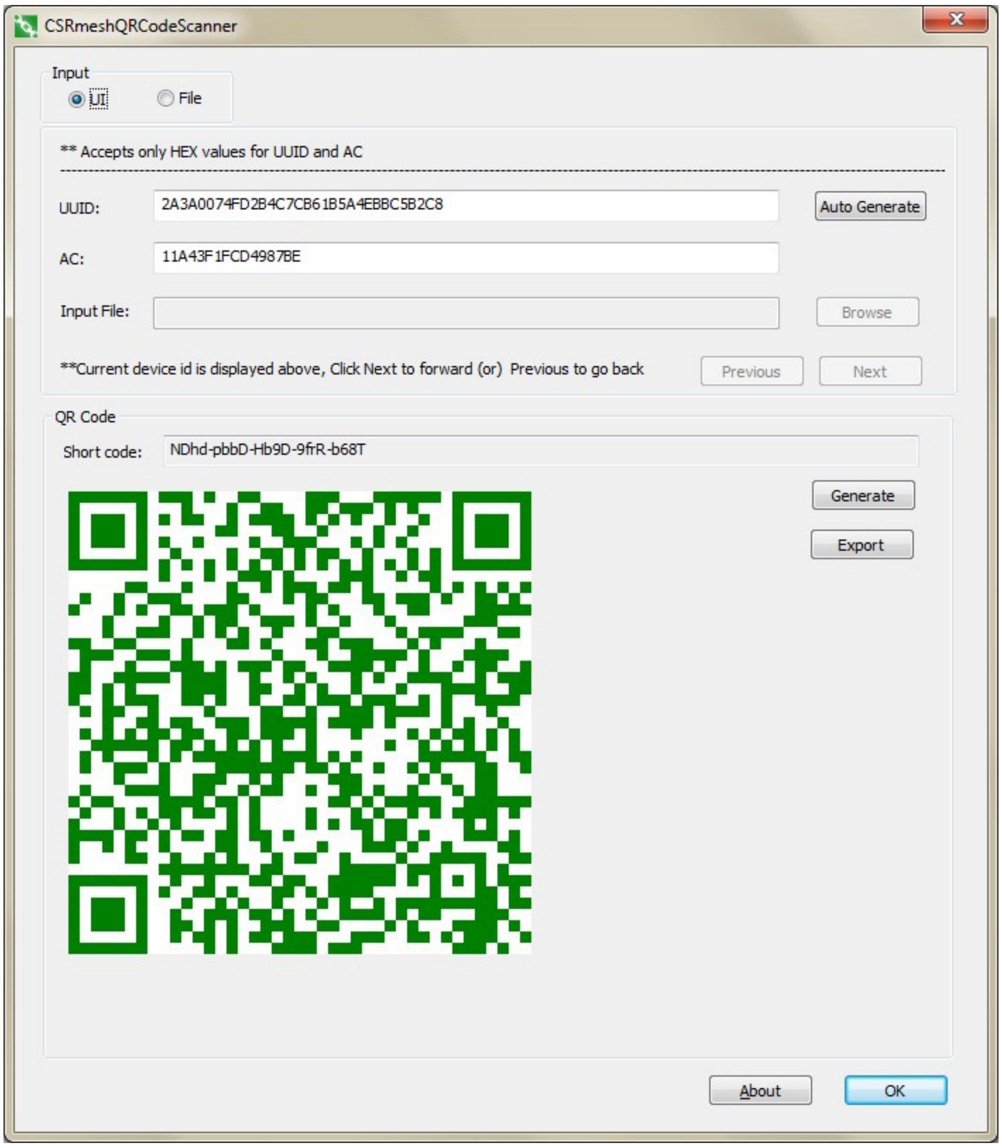

Power On
APP_INIT
Network Key missing
Network Key available
NOT_ASSOCIATED
Config Reset Request from controller
ASSOCIATED
Advertise Device Identification Information every 5s
Association Request from Controller
Network Key sent
ASSOCIATION_STARTED

Figure 4.2: CSRmesh Association State Machine


CSRmeshQRCodeScanner

Input
[✓ UI] File

** Accepts only HEX values for UUID and AC

UUID: 2A3A0074FD2B4C7CB61B5A4EBBC5B2C8

AC: 11A43F1FCD4987BE

Input File:

**Current device id is displayed above, Click Next to forward (or) Previous to go back

QR Code

Short code: NDhd-pbbD-Hb9D-9frR-b68T

Figure 4.3: CSRmesh QR Code Scanner Application

4.4. Supported CSRmesh Models

Table 4.1 lists the CSRmesh models that he Temperature Sensor application supports.

CSRmesh Model	Application Action
Sensor Model	Handles the sensor model messages. The application provides the provision of writing and reading the sensor type values from the supported devices.
Actuator Model	Handles the actuator model messages from the control devices. The application provides the provision of writing the desired temperature value from the control devices.
Attention Model	Handles the `CSR_MESH_ATTENTION_SET_STATE` command. When the attract attention is set the application blinks in red colour.
Battery Model	Upon receiving the `CSR_MESH_GET_BATTERY_STATE` message, it reads the battery level and responds with the current battery level and the state. The application is implemented with reference to the CSRmesh development board which runs on AA Batteries. So the application sets `BATTERY_MODEL_STATE_POWERING_DEVICE` indicating that the device is battery powered. If the battery level is below threshold it sets the `BATTERY_MODEL_STATE_NEEDS_REPLACEMENT` bit.
Data Model	This model enables the application to send and receive stream of bytes from another CSRmesh device.

Table 4.1: Supported CSRmesh Models

Note:

The CSRmesh Temperature Sensor application supports groups for sensor, actuator, data stream and attention models. It statically allocates memory to store the assigned group IDs and save them on the NVM.

4.5. Synchronising with CSRmesh Activity

The CSRmesh Temperature Sensor application can connect to the CSRmesh Control application in a bridge device role. The Temperature Sensor application has to synchronise with the CSRmesh library to avoid collision of the advertisements and connection events with the CSRmesh activity. The application calls the CSRmesh APIs to synchronise the connection radio events and the connectable advertisements with the CSRmesh library.

4.5.1. Application Connectable Advertising

The application sends connectable advertisements at regular intervals as long as the device is powered and not connected. The interval at which the advertising events are sent is defined by `ADVERT_INTERVAL`.

The application calls `CSRSchedSendUserAdv()` for sending connectable adverts instead of the firmware API. This function schedules one application advertising event as soon as it is called.

4.5.2. Connection Events

The application notifies the GATT connection events to the CSRmesh stack for it to schedule the CSRmesh activity. The application calls `CSRSchedNotifyGattEvent(ucid, conn_interval)` for the CSRmesh library to synchronise with connection events. This is called in the following event handlers:

- `LM_EV_CONNECTION_COMPLETE`
- `LS_CONNECTION_PARAM_UPDATE_IND`
- `LM_EV_DISCONNECT_COMPLETE`

4.6. Bearer State Management

The CSRmesh Temperature Sensor application supports 2 bearers:

- GATT Bearer
- BLE Advertising Bearer

The application adopts the following policies with regard to the supported bearer state:

- Relay is always enabled on both the bearers unless it is disabled by the `CSR_MESH_BEARER_SET_STATE` message or the CS User Key configuration. See Section 0.
- When the device is not associated the promiscuous mode is enabled on both the bearers. This helps relay the messages authenticated by the network key that are addressed to other associated devices.
- Both relay and promiscuous modes are enabled when the device is connected as a GATT bridge. This means any message sent from the control application over a GATT connection is relayed on the CSRmesh network promiscuously. This is useful because any device in the vicinity that supports bridge role, regardless of the association status and the network to which it is associated to can be used as a bridge by the control device.
- The last configured bearer state is restored when the connection is terminated.

4.7. Temperature Measurement

4.7.1. Sensor

The application uses the STTS751 I^{2}C temperature sensor on the CSRmesh development board to read the temperature periodically. The interval at which the temperature is read can be configured by `TEMPERATURE_SAMPLING_INTERVAL`. The drivers for configuring the sensor and the interfacing peripherals are implemented in `stts751_temperature_sensor.c` and `stts751_temperature_sensor.h` files.

4.7.2. Broadcasting Temperature Change

The application starts broadcasting the current temperature at the defined sampling interval when the device is associated and grouped with other sensors and actuators. The current temperature value is broadcasted only if the change in temperature is more than the tolerance value from the last broadcast value. The tolerance value can be configured by `TEMPERATURE_CHANGE_TOLERANCE`. See Section 6.7 for configuration

4.8. Low Power Operation

The sensors are expected to consume very low power as they are generally battery powered and have to give a good battery life. Scanning for CSRmesh messages by far consumes the maximum power compared to any other application activity. Reducing the scan duty cycle to a very low value reduces the power consumption almost proportionally.

4.8.1. Dynamic Scan Duty Cycle

When scanning in very low duty cycles, the probability of the messages received is greatly reduced, causing failures in association and configuration. So the application dynamically switches between `DEFAULT_RX_DUTY_CYCLE` (a very low percentage value) and `HIGH_RX_DUTY_CYCLE` in different application states as listed below:

- When the application is not associated and the sensor model is not grouped, the application runs with `HIGH_RX_DUTY_CYCLE`.
- Once associated and grouped to a group it switches to `DEFAULT_RX_DUTY_CYCLE`.
- Upon receiving a `CSR_MESH_ATTENTION_SET_STATE` message with attention set to attract attention, the application moves to `HIGH_RX_DUTY_CYCLE` till the attention times out or it is explicitly reset.
- When a control device requests for device data, the application sets `HIGH_RX_DUTY_CYCLE` and starts the data stream. It switches back to the `DEFAULT_RX_DUTY_CYCLE` once the stream transfer completes or the stream times out.

CSR

4.8.2. Periodic Behaviour and multiple retransmissions

The temperature sensor sends the sensor value messages to the group of which the device is a member. The sensor messages are broadcast periodically as configured by the user. Since all the recipients of the sensor value messages are expected to be running on low scan duty cycle, the probability of the message received by the devices is low. To increase the probability of the messages received by the destination devices, the application retransmits each message multiple times. `NUM_OF_RETRANSMISSIONS` defines the number of times the same sensor message needs to be re-transmitted.

4.8.2.1. Transmit Message Density

Transmit message density is defined as the number of retransmissions of a message within the CSRmesh advertising period. The application uses the message interleaved advertising feature of the CSRmesh stack to set the message density. CSRmesh stack holds the messages in a queue and advertises each message multiple times, interleaving them in the same order as they are inserted in the queue. The interval between adjacent messages are dynamically adjusted with number of messages in the queue such that the time interval between successive transmissions of a message in the queue is the same.

Table 4.2 lists the different transmission density settings.

Message Transmit Density	Advertising Period (approximate)	Number of Advertising Events
1	500 ms	6
2	700 ms	12
3	800 ms	18
4	900 ms	24
5	1100 ms	36

Table 4.2: Transmit Message Density

4.8.3. Acknowledged Mode Message Broadcast

The application implements an acknowledged mode of message retransmission where it waits for an acknowledgement for the sensor value messages from the destination devices. Once a response is received from another device in the group, the device stops further retransmissions of the messages until the next period.

4.9. Application Data Stream Protocol

The application implements a protocol to transfer large blocks of data with another CSRmesh device on the network. The application uses a message format listed in Table 4.4 to exchange messages.

Message Code (1 octet)	Length (1 or 2 octets)	Data (0 – 32767 octets)
Identifies type of message. See Table 4.4 for supported messages.	Length of the data. 1. If the MSB of the first octet is 0 then length will be only 7 bits. 2. If the MSB of the first octet is 1 then the length will be a 15 bits value	Data associated with the message

Table 4.3: Application Data Stream Message Format

Message	Code	Length	Data	Description
`CSR_DEVICE_INFO_REQ`	`0x01`	0	None	Used to request device information. It can be sent as stream or a datagram message.
`CSR_DEVICE_INFO_RSP`	`0x02`	Variable (1-32767)	Device information	A text string containing information about device. Will be sent over a stream. The application sends a text string containing information about supported CSRmesh features.
`CSR_DEVICE_INFO_SET`	`0x03`	Variable (1-32767)	Device information	A text/binary data that is stored on the device as device information. The application stores the data associated with this message as the device information and responds with this data for any further device information requests.
`CSR_DEVICE_INFO_RESET`	`0x04`	0	None	Resets device information. The application returns default string to any further device information requests.
-	`0x05 - 0xFF`	-	-	Not defined.

Table 4.4: Application Data Stream Messages

5. NVM Map

The application stores the parameters listed in Table 5.1 in the NVM to prevent loss in case of a power off or a chip panic.

Entity Name	Type	Size of Entity (Words)	NVM Offset (Words)
CSRmesh Stack NVM	`uint16 array`	32	0
CSRmesh Device UUID (This is part of 31 words of Stack NVM)	`uint16 array`	8	1
CSRmesh Device Authorisation Code (This is part of 31 words of Stack NVM)	`uint16 array`	4	9
Sanity Word	`uint16`	1	32
Application NVM Version	`uint16`	1	33
CSRmesh Association State	`boolean`	1	34
Sensor State Data	`uint16`	2	35
Sensor Actuator Model Group IDs	`uint16 array`	4	37
Attention Model Group IDs	`uint16 array`	4	41
Data Model Group IDs	`uint16 array`	4	45
Sensor State Data	`structure`	4	49

Table 5.1: NVM Map for Application

Entity Name	Type	Size of Entity (Words)	NVM Offset (Words)
GAP Device Name Length	`uint16`	1	53
GAP Device Name	`uint8 array`	20	54

Table 5.2: NVM Map for GAP Service

Note:

The application does not pack the data before writing it to the NVM. This means that writing a `uint8` takes one word of NVM memory.

5.1. Application NVM Version

Before reading the parameters from the NVM in Table 5.1 and Table 5.2, the application reads NVM version at word offset 1. If the application updates and the version number stored on the NVM does not match with the defined `APP_NVM_VERSION`, the application re-initialises the NVM starting from Sensor and Actuator Model Group Id's and stores the defined `APP_NVM_VERSION` at word offset 1.

Note:

Device UUID, Authorisation Code, CSRmesh library data and association information are not reset.

This ensures that the contents of the NVM are valid for the NVM offsets defined in the application. If the NVM offsets of the parameters change upon an application update, this value can be incremented to invalidate the contents of the NVM.

6. Customising the Application

This section provides details on how to customise some parameters of the CSRmesh applications.

The developer can customise the application by modifying the following parameter values.

6.1. Advertisement Timers

The CSRmesh Temperature Sensor application sends connectable advertisements as long as it is powered on and not connected. The application uses a timer to send a connectable advertising event at regular intervals. The advertising interval is defined in `csr_mesh_tempsensor_gatt.h`.

Timer Name	Timer Value
`ADVERT_INTERVAL`	1250 ms ± (0~10) ms

Table 6.1: Advertisement Timers

6.2. Connection Parameters

The CSRmesh Temperature Sensor application uses the connection parameters listed in Table 6.2 by default. The macros for these values are defined in `gap_conn_params.h`. These values are chosen by considering the overall current consumption of the device and optimum performance of the device in the CSRmesh network. It is strongly recommended not to modify these parameters. If the connection interval is set to fewer than 13 ms, the device is not able to scan for CSRmesh messages from the associated network, and only messages received from the GATT connection are processed. See *Bluetooth Core Specification Version 4.1* for the connection parameter range.

Parameter Name	Parameter Value
Minimum Connection Interval	90 ms
Maximum Connection Interval	120 ms
Slave Latency	0 interval
Supervision Timeout	6000 ms

Table 6.2: Connection Parameters

6.3. Number of Supported Model Groups

The CSRmesh application supports Group ID assignment for sensor, actuator, stream and attention models of CSRmesh. The maximum number of model groups supported by default is set to 4 in `user_config.h`.

Parameter Name	Parameter value
`MAX_MODEL_GROUPS`	`4`

Table 6.3: Number of Supported Model Groups

Note:

Each supported model group requires one word on the RAM and one word on the NVM. The maximum number of groups supported is limited by the available RAM and NVM space.

6.4. Device Name

The user can change the device name for the application. By default, it is set to `CSRmesh` in `gap_service.c`. The maximum length of the device name is 20 octets.

6.5. Device Address

The application uses a public address by default. The `USE_STATIC_RANDOM_ADDRESS` macro in the `user_config.h` file enables the support for static random addresses.

6.6. Non-Volatile Memory

The application uses one of the following macros to store and retrieve persistent data in either the EEPROM or Flash-based memory.

- `NVM_TYPE_EEPROM` for I^{2}C EEPROM.
- `NVM_TYPE_FLASH` for SPI Flash.

Note:

The macros are enabled by selecting the NVM type using the Project Properties in xIDE. This macro is defined during compilation to let the application know which NVM type it is built for. If EEPROM is selected, `NVM_TYPE_EEPROM` is defined and for SPI Flash the macro `NVM_TYPE_FLASH` is defined. Follow the comments in the `.keyr` file as per the selection above.

6.7. Application Features

This section describes how to customise some parameters on the CSRmesh Temperature Sensor application. The application can be configured by uncommenting the required define in `user_config.h`.

Configuration	Description
`ENABLE_DEVICE_UUID_ADVERTS`	If defined application sends UUID adverts periodically with an interval defined in `DEVICE_ID_ADVERT_TIME`. Otherwise the device UUID adverts are not sent. Disabled by default.
`ENABLE_BATTERY_MODEL`	Enables support for CSRmesh battery model.
`USE_AUTHORISATION_CODE`	Enforces Authorisation Code check on device during association. If this is enabled, the associating control device must have the same authorisation code to associate device to network.
`ENABLE_DATA_MODEL`	Enables data stream model to send/receive stream of octets to/from another CSRmesh device. If this is enabled, the application supports streaming of device information string over the data model. The application uses a simple protocol to send and receive messages. See Section 0 for details.
`ENABLE_TEMPERATURE_CONTROLLER`	Enables the Temperature Sensor application to operate as a temperature controller which can set the desired temperature value on the application. If `DEBUG_ENALBE` is defined, the desired temperature setting can be controlled via UART. The desired temperature can be changed by typing **+** or **-** on the UART terminal. If `DEBUG_ENABLE` is not defined, the desired temperature value can be changed by pressing the SW2 or SW3 button on the CSRmesh development board. See Section 2.1.1.1 for the button functions.
`DEBUG_ENABLE`	Enables application debug logging on UART. If enabled, the debug messages can be viewed on a terminal application by connecting the device to the PC and opening the corresponding COM Port with 2400-8-N-1 configuration. Enabled by default. See Section 2.1.1 for details.
`TEMPERATURE_SENSOR_STTS751`	Enables the initialisation and working with the STTS751 temperature sensor on the CSRmesh development board.

Configuration	Description
`TEMPERATURE_SAMPLING_INTERVAL`	Defines the interval in seconds to query the current air temperature from the temperature sensor. The application queries the temperature every sampling interval indefinitely. Default: 15 seconds.
`TEMPERATURE_CHANGE_TOLERANCE`	Defines the temperature change tolerance in 1/32 kelvin units. Default: 32 (=1 degree kelvin) See Section 4.7 for details.
`DEFAULT_RX_DUTY_CYCLE`	The percentage Rx duty cycle set by the application once the device is associated and grouped. Default: 2%.
`HIGH_RX_DUTY_CYCLE`	Defines the percentage Rx duty cycle value when the device is either in attention mode or in data transfer mode. A higher value here makes the device more responsive for the period of time defined during attention or data transfer. Default: 100%.
`TRANSMIT_MSG_DENSITY`	Defines the number of messages inserted into the mesh queue in one single instance. The value that can be defined is 1 to 5. The default value is set to 2. See Section 4.8.2.1 for details.
`NUM_OF_RETRANSMISSIONS`	Defines the number of times the message needs to be retransmitted. This is by default set to 60.
`ENABLE_ACK_MODE`	This enables the acknowledged mode communication between the Temperature Sensor and Heater applications. If `ENABLE_ACK_MODE` is defined, the application stores and manages the group of heaters it is communicating with and waits for the acknowledgement from the heaters for all the `SensorWriteValue` messages.

Table 6.4: Application Configuration

6.8. Configuring the CSRmesh Parameters

The CS user keys can be defined in the `.keyr` file to override the default CSRmesh parameters. The CSRmesh library sets the parameters based on the CS user key values. Table 6.5 lists the recommended values for these values for optimal performance of the devices over the CSRmesh network.

CS User Key Index	Parameter	Recommended Value	Description
0	CSRmesh Configuration Bitmask	`0000` to `0007`	▪ Bit-0 : CSRmesh Relay Enable ▪ `1`: Enables relay of CSRmesh messages ▪ `0`: Disables relay of CSRmesh messages ▪ Bit-1 : CSRmesh Bridge Enable ▪ `0`: Disables connectable advertisements ▪ `1`: Enables connectable advertisements Disabling bridge leaves the device unconnectable on any service. The connectable adverts can be enabled by sending a `CSR_MESH_BEARER_SET_STATE` message with the LE GATT server bearer bit set. ▪ Bit-2 : CSRmesh Random Device UUID Enable ▪ `1`: Enables generation of random device UUID ▪ `0`: Reads the UUID from NVM If this bit is set to `1`, the application generates a random UUID and stores it in the NVM when it runs for the first time. This can avoid having same UUID on multiple devices without explicitly programming a UUID on each device. ▪ Bits 3 to 15 are ignored.

Table 6.5: Configuring CSRmesh Parameters

Appendix A CSRmesh Application GATT Database

A.1 GATT Service Characteristics

Characteristic Name	Database Handle	Access Permissions	Managed By	Security Permissions	Value
Service Changed	`0x0003`	Indicate	Application	Security Mode 1 and Security Level 1	Service Changed handle value
Service Changed Client Characteristic Configuration Descriptor	`0x0004`	Read, write	Application	Security Mode 1 and Security Level 1	Current client configuration for Service Changed characteristic

Table A.1: GATT Service Characteristics

A.2 GAP Service Characteristics

Characteristic Name	Database Handle	Access Permissions	Managed By	Security Permissions	Value
Device Name	`0x0007`	Read, write	Application	Security Mode 1 and Security Level 1	Device name Default value : `CSRmesh`
Appearance	`0x0009`	Read	Firmware	Security Mode 1 and Security Level 1	Unknown: `0x0000`
Peripheral Preferred Connection Parameters	`0x000b`	Read	Firmware	Security Mode 1 and Security Level 1	Connection interval - Min 90 ms - Max 120 ms Slave latency - 0 Connection timeout - 6 s

Table A.2: GAP Service Characteristics

For more information on GAP service and security permissions, see *Bluetooth Core Specification Version 4.1*.

A.3 CSR OTA Update Application Service Characteristics

Characteristic Name	Database Handle	Access Permissions	Managed By	Security Permissions	Value
Current Application	`0x000e`	Read, write	Application	Security Mode 1 and Security Level 2	Current live application 0x0 - OTA Update Bootloader 0x1 - Identifies application 1 0x2 - Identifies application 2
Read CS Block	`0x0010`	Write	Application	Security Mode 1 and Security Level 2	Format - uint16[2] Index 0 - An offset in 16-bit words into the CS defined in the SDK documentation. Index 1 - The size of the CS block expected, in octets.
Data Transfer	`0x0012`	Read, notify	Application	Security Mode 1 and Security Level 2	This characteristic is ATT_MTU-3 (20)-bytes long. The format of the 20-bytes is defined by the message context.
Data Transfer Client Characteristic Configuration	`0x0013`	Read, write	Application	Security Mode 1 and Security Level 2	Current client configuration for Data Transfer characteristic
Version	`0x0015`	Read	Firmware	Security Mode 1 and Security Level 2	Service version Format - uint8

Table A.3: CSR OTA Update Application Service Characteristics

A.4 Mesh Control Service Characteristics

Characteristic Name	Database Handle	Access Permissions	Managed By	Security Permissions	Value
Network Key	`0x0018`	Write	Application	Security Mode 1 and Security Level 1	0
Device UUID	`0x001a`	Read	Application	Security Mode 1 and Security Level 1	`22e4-b12c-5042-11e3-9618-ce3f-5508-acd9`
Device ID	`0x001c`	Read, write	Application	Security Mode 1 and Security Level 1	`0x8001`
MTL Continuation Control Point	`0x001e`	Write	Application	Security Mode 1 and Security Level 1	Dynamic
MTL Continuation Control Point Client Characteristic Configuration	`0x001f`	Read, write	Application	Security Mode 1 and Security Level 1	Current client configuration for MTL Continuation Control Point characteristic
MTL Complete Control Point	`0x0021`	Write, notify	Application	Security Mode 1 and Security Level 1	Dynamic
MTL Complete Control Point Client Characteristic Configuration	`0x0022`	Read, write	Application	Security Mode 1 and Security Level 1	Current client configuration for MTL Complete Control Point characteristic
MTL TTL	`0x0024`	Read, write	Application	Security Mode 1 and Security Level 1	50
MESH Appearance	`0x0026`	Read, write	Application	Security Mode 1 and Security Level 1	0

Table A.4: Mesh Control Service Characteristics

CSR

Document References

Document	Reference
Bluetooth Core Specification Version 4.1	www.bluetooth.org
CSR µEnergy Modifying an Application to Support OTA Update Application Note	CS-304564-AN
CSR µEnergy Over-the-Air (OTA) Update System Application Note	CS-316019-AN
CSR µEnergy xIDE User Guide	CS-212742-UG
CSRmesh 2.0 Android Controller Application Note	CS-337680-AN
CSRmesh 2.0 Gateway SB User Guide	CS-332701-UG
CSRmesh 2.0 iOS Controller Application Note	CS-337682-AN
CSRmesh 2.0 Mobile Application User Guide	CS-337051-UG
CSRmesh 2.0 Production Test Tool User Guide	CS-335123-UG
CSRmesh 2.0 Node API Guide	www.csrsupport.com
CSRmesh 2.0 Node Release Note	CS-339050-RN
GATT Database Generator	CS-219225-UG
Installing the CSR Driver for the Profile Demonstrator Application	CS-235358-UG
Over-the-Air Update Application and Bootloader Services Specification	CS-316220-SP
Service Characteristics And Descriptions	developer.bluetooth.org
Bluetooth Core Specification Version 4.1	www.bluetooth.org

CSR

Terms and Definitions

AC	Authorisation Code
API	Application Programmer's Interface
BLE	Bluetooth Low Energy (now known as Bluetooth Smart)
BlueCore®	Group term for CSR's range of Bluetooth wireless technology chips
Bluetooth®	Set of technologies providing audio and data transfer over short-range radio connections
CS	Configuration Store
CSR	Cambridge Silicon Radio
CSRmesh™	A CSR protocol that enables peer-to-peer-like networking of Bluetooth Smart devices
e.g.	*exempli gratia*, for example
EEPROM	Electrically Erasable Programmable Read Only Memory
etc.	*et cetera*, and the rest, and so forth
GAP	Generic Access Profile
GATT	Generic Attribute Profile
i.e.	*Id est*, that is
I^2C	Inter-Integrated Circuit
IoT	Internet of Things
IRK	Identity Resolving Key
LED	Light Emitting Diode
LM	Link Manager
LS	Least Siginificant
MTL	Message Transport Layer
NVM	Non Volatile Memory
OTA	Over The Air
PCB	Printed Circuit Board
PIO	Programmable Input Output
PWM	Pulse Width Modulation
QR-Code	Quick Response Code
Rx	Receiver
SDK	Software Development Kit
SMP	Security Manager Protocol
SPI	Serial Peripheral Interface

Tx	Transmit
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus
UUID	Universally Unique Identifier