Developer Guide

Wi-Fi Configuration GATT Service

Wi-Fi Configuration BLE GATT Service Profile

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Table of Contents

1 Introduction

Many IoT devices require Internet connectivity through the owner's Wi-Fi network. Delivering the user's Wi-Fi network information to the IoT device has been troublesome. Oftentimes, the IoT device must provide an Access Point interface for the client to connect. There is an additional requirement of a security layer to protect credentials while in transit.

Some IoT devices may have a Bluetooth radio with the Wi-Fi radio that can enable an additional secure communication path between a mobile application and the IoT device. This simplifies the IoT device onboarding process.

Bluetooth Low Energy (BLE) is an application protocol to read, write, and push elements organized into a Generic Attribute Profile (GATT). The application specifies available user profiles in the form of GATT services and characteristics. The Bluetooth specification also defines widely used user-service profiles to standardize those for inter-operability.

Currently, no defined GATT service allows for Wi-Fi network configuration. To provide a seamless Wi-Fi setup flow for IoT devices, this document defines a Bluetooth LE service to securely configure the IoT device with the Wi-Fi network information.

The protocol can discover a device with this capability, provide the configuration, and verify connectivity status.

1.1 About this Document

This document defines the Wi-Fi Configuration GATT Service Profile, its implementation and uses.

1.2 Intended Audience

This document is written for all users of the Ayla Developer Portal, involved in the development of Bluetooth LE (BLE) based device and mobile applications. Specifically, this document is intended for developers implementing Wi-Fi Setup of an Ayla device over BLE.

1.3 Related Documentation

- Ayla Generic GATT Service Guide (AY006DGG3)
- Ayla Connectivity GATT Service Guide (AY006DCG3)
- Module and MCU Interface Specification (AY006MSP3)

1.4 Abbreviations and Acronyms

- BLE – Bluetooth Low Energy
- GATT – Generic Attribute Profile
- UUID – Universally Unique Identifier
- DUID – Device Unique Identifier
- AP – Access Point
- WPS – Wi-Fi Protected Setup

2 Protocol Summary

2.1 Device Discovery

The device that requires configuration to join a Wi-Fi network advertises itself as a GATT server, along with its capabilities.

A GATT client, which could be a low cost BLE controller or a mobile application, scans for BLE devices in its vicinity that support the Ayla Generic GATT Service (UUID: 0xFE28).

When the GATT client discovers an unconfigured device, a connection is established with the device and paired with it.

2.2 Wi-Fi Configuration

Once the device is paired with the BLE controller, the controller may scan for visible Wi-Fi networks and provide a list to the controller.

The user picks the Wi-Fi AP to associate with the device. Credentials are provided (AP's SSID and Passphrase) to the device.

2.4 Registration (optional)

If the device supports the Ayla Connectivity with GATT Service (see the *Ayla Connectivity GATT Service Guide AY006DCG3*), the BLE controller may pass a setup-token for device registration in the Ayla Cloud - before requesting the device connect to the Wi-Fi AP.

2.5 Connectivity Status

The controller can register for connectivity status updates from the device. This provides feedback to the user on the progress of the Wi-Fi association. After the device connects to the AP, the GATT server reports its status to the controller - and then removes the Wi-Fi Configuration Service from its GATT server list.

3 GATT Service Summary

3.1 Abstract

The Wi-Fi Configuration GATT Service allows a user to configure their Wi-Fi credentials to connect the device to their network.

3.2 Summary

This service exposes the following characteristics for Wi-Fi network configuration:

- AP's associated Wi-Fi credentials
- Open the Wi-Fi Protected Setup (WPS) window
- Ongoing progress and final status of the Wi-Fi connect request
- Request to initiate a Wi-Fi scan for available APs
- Scan results generated from a Wi-Fi scan

4 GATT Profile Specification

4.1 Wi-Fi Configuration GATT Service

(UUID: 1CF0FE66-3ECF-4D6E-A9FC-E287AB124B96)

This service contains characteristics required to configure the Wi-Fi network parameters and request the device to connect to a specific Access Point. These characteristic values are used longer than the default ATT_MTU (23B). To ensure it works correctly, initiate an MTU negotiation prior to using this service for notifications.

Table 1: Wi-Fi Configuration GATT Service Characteristics

Overview	Properties	Security	Description
Connect	Write - Mandatory	Authenticated encryption	Connect to the AP with the Wi-Fi connection parameters provided
WPS	Write - Optional	Authenticated encryption	Open the Wi-Fi Protected Setup (WPS) window
Status	Read/Notify - Optional	Authenticated encryption	Ongoing progress of the Wi-Fi connect request
Scan	Write - Optional	Authenticated encryption	Start scanning for available Wi-Fi Access Points (APs)
Scan Results	Read/Write/Notify - Optional	Authenticated encryption	Get the current list of scan results

4.1.1 Connect

(UUID: 1F80AF6A-2B71-4E35-94E5-00F854D8F16F)

Request to connect to a specified network with parameters provided. The characteristic value is provided as a 105B fixed structure.

Names	Field Requirements	Format	Min Value	Max Value	Additional Info.
Connect	Mandatory	struct	N/A	N/A	Connect to the AP with provided Wi-Fi connection parameters

Characteristic Value Format:

Field	Bytes	Format	Description
SSID	32	uint8 array	Selected SSID
SSID length	1	uint8	Length of SSID
BSSID	6	uint8 array	Selected BSSID
Key	64	uint8 array	Passphrase
Key length	1	uint8	Length of passphrase
Security	1	uint8	0x00: open 0x01: WEP 0x02: WPA 0x03: WPA2-Personal

4.1.2 WPS

(UUID: 1F80AF6B-2B71-4E35-94E5-00F854D8F16F)

Initiate Wi-Fi Protected Setup (WPS).

Names	Field Requirements	Format	Min Value	Max Value	Additional Info.
WPS	Optional	boolean	N/A	N/A	Open the Wi-Fi Protected Setup (WPS) window

4.1.3 Status

(UUID: 1F80AF6C-2B71-4E35-94E5-00F854D8F16F)

Status of the Wi-Fi join request.

Names	Field Requirements	Format	Min Value	Max Value	Additional Info.
Status	Optional	struct	N/A	N/A	Ongoing progress of the Wi-Fi connect request

Structure Definition:

Field	Bytes	Format	Description
SSID	32	uint8 array	SSID
SSID length	1	uint8	Length of SSID
Error	1	uint8	Error Code NOTE: This is the Wi-Fi error events listed in the *Ayla Module and MCU Interface Specification (AY006MSP3)* document.
State	1	uint8	Current Wi-Fi state: 0x0: N/A 0x1: Disabled 0x2: Connecting to Wi-Fi 0x3: Connecting to Network (obtaining IP address) 0x4: Connecting to the Cloud 0x5: Up/Connected

4.1.4 Scan

(UUID: 1F80AF6D-2B71-4E35-94E5-00F854D8F16F)

Request to start a Wi-Fi scan to look for available networks.

Names	Field Requirements	Format	Min Value	Max Value	Additional Info.
Scan	Optional	boolean	1	1	Start scanning for available Wi-Fi Access Points (APs)

4.1.5 Scan Results

(UUID: 1F80AF6E-2B71-4E35-94E5-00F854D8F16F)

This holds a single scan result. A scan list may be obtained in two ways.

- Read this characteristic value iteratively to provide the next scan result in the list
- Enable notifications on this characteristic to provide the entire list of scan results one at a time, in the form of notifications.

This is a read/write characteristic. If written with a specific scan index, the next scan result read will be for that specific scan index. Subsequent reads provide the next scan result in the list.

Alternatively, if notifications are enabled, this characteristic may never be written. A scan result produces a list of scan results in the form of notifications. This is the preferred method of operation.

Names	Field Requirements	Format	Min Value	Max Value	Additional Info.
Scan Results	Optional	struct	N/A	N/A	Get the current list of scan results

Structure Definition:

Field	Bytes	Format	Description
Index	1	uint8	Index of the scan result in the list
SSID	32	uint8 array	Discovered SSID
SSID length	1	uint8	Length of the SSID
BSSID	6	uint8 array	Discovered BSSID
RSSI	2	sint16	Signal strength
Security	1	uint8	0x00: Open 0x01: WEP 0x02: WPA 0x03: WPA2-Personal

5 Wi-Fi Configuration Process Flow

This section describes the expected behavior for a GATT client to discover and connect to a GATT server (advertising its Wi-Fi Configuration Service). The process scans for APs visible to the device. When the AP is identified, the Wi-Fi credentials are provided. During the connection, the Wi-Fi association process status is monitored.

5.1 Services Supported by the GATT Server

A BLE GATT server is run when IoT devices require Wi-Fi configuration to connect to an internet-linked network. The following GATT services are required by the protocol.

- Ayla Generic GATT Service - see *Ayla Generic GATT Service Guide (AY006DGG3)*
- Wi-Fi Configuration GATT Service – see *Ayla Connectivity GATT Service Guide (AY006DCG3)*
- Ayla Connectivity GATT Service (optional) – see *Ayla Connectivity GATT Service Guide (AY006DCG3)*

5.2 Device Discovery and Pairing

The IoT device (running a BLE GATT server) advertises the presence of the Ayla Generic GATT Service. See *Ayla Generic GATT Service Guide (AY006DGG3)* document.

The 16-but UUID field us set in the advertisement packet sent to the Ayla Generic GATT Service UUID (0xFE28).

The GATT client scans for GATT servers in its vicinity, Devices that support the Ayla Generic GATT Service are filtered. For link-layer security the connection initiates pairing. The GATT server is checked to ensure it contains the Wi-Fi Configuration GATT Service.

5.3 Scan for Available Wi-Fi Networks

The GATT client may scan and obtain the scan results several ways:

- If the service does not expose the `Scan` characteristic, the GATT client may scan for Wi-Fi devices on its own and provide a list to the user
- If the service exposes the `Scan` characteristic, the GATT client can scan the device and receive the results as follows:
    - The preferred method is for the GATT client to:
        - Enable notifications on the `Scan Results` characteristic
        - Request a scan by writing to the `Scan` characteristic
        - Receive scan results one at a time as notifications

- The last result obtained is a value with the SSID and length set to NULL

- Alternatively, if notifications are not supported, the GATT client could:
  - Write to the `Scan` characteristic
  - Read the `Scan Results` characteristic one at a time to obtain the list of scan results
  - The last result is a value with the SSID with length set to NULL

5.4 Provide Token for Device Registration (optional)

If the GATT server exposes the Ayla Connectivity GATT Service, the client may send a setup-token required for device registration. For more information see *Ayla Connectivity GATT Service Guide (AY006DCG3)*.

5.5 Provide Wi-Fi Credentials

When the scan results are obtained, the GATT client selects an AP and provides credentials to the device with a request to join to this AP. Before the connect request, the GATT client may enable notifications on the `Status` characteristic.

The GATT client writes to the `Connect` characteristic to initiate a Wi-Fi join. The write value contains the AP's SSID, Key, and security, required for Wi-Fi association.

The GATT client monitors the `Status` characteristic for the status of the Wi-Fi association process. The `Status` characteristic value contains information about the connection attempt. This includes the:

- Wi-Fi AP SSID it was configured with
- Error code
- Wi-Fi connection State.

The Error code in the Status characteristic corresponds to the Error codes in the *Connection History* section of the *Ayla Module and MCU Interface Specification (AY006MSP3)* document.

5.6 Wi-Fi Setup Succeeded

Once the Status signals success of the Wi-Fi Setup, the GATT client terminates the connection. This indicates the IoT device successfully associated with the Wi-Fi AP, obtained an IP address, and can communicate with the Ayla Cloud.

The GATT server may tear down all BLE connections and remove the Wi-Fi Configuration Service from its GATT server.

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