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Analysis of BLE on Sensor Tag

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Abstract: Bluetooth Low Energy (BLE) has become the word in field of IOT. With upcoming field of Wearable Devices and Home Automation, BLE has become the latest technology in implementation of IOT. Inside this paper, we will be comparing BLE with traditional BLUETOOTH, discussing Pros and Cons, and what are applications for which we should select BLE over Traditional BLUETOOTH, we will be discussing about BLE Profiles on TI CC-2650 SensorTag.
Keywords: Bluetooth Low Energy, GATT, GAP Profile

I. INTRODUCTION

TI-CC2650 Sensor Tag is a important device not only due to wide variety of sensors present onboard , but mainly due to Bluetooth Low Energy(BLE) available On-Board . BLE has made a name for itself in the field of IOT these days.
What is IoT? IoT is connecting a physical object to the Internet or the cloud. IOT is basically defined as large network of connected computing devices that can communicate and exchange of data with each other and with surrounding objects including sensors and actuators. Each device is connected to a specific identifier for connectivity and data exchange purposes. Ubiquitous Internet protocol technology is growing rapidly. New domains where embedded devices such as actuators and sensors are intensively located. Everyday more things are added to the network of Internet of Things. Estimates say the number of connected smart commodities is projected to reach 50 billion by 2020. Predictions also suggest that the average number of connected devices per person will be approximately 6.58 devices. Therefore, IoT is projected to be a common platform to provide communication between smart objects with different protocols and data types in the future.

II. BLUETOOTH LOW ENERGY

Bluetooth Low Energy (BLE, Bluetooth 4, Bluetooth Smart) is an innovative technology that has been developed by Bluetooth SIG, which aims to be the best choice for large. Number of standard wireless technologies already present and widespread in the(i.e. Bluetooth Classic (Bluetooth 3.0, Basic Rate / Enhanced Data Rate), ZigBee, ANT +, IEEE 802.11b (Wi-Fi)). BLE [2]

A. Traditional Bluetooth vs Bluetooth Low Energy

Bluetooth was originally designed to exchange huge quantity of data at nearby range in a continuous, with applications streaming with data. Devices had the capability of sending and receiving of data at a common time range. It's suitable for many regular consumer products, such as computer headsets, where two devices are present near to each other.
When Bluetooth low energy (BLE, formerly called Bluetooth Smart) entered market in 2011, the main advantage that it gives as compared to other standards of Bluetooth is its same length of range, but with decrease in bandwidth. It is specifically designed for devices which periodically exchanges small amounts of data, giving battery life of months upto years which helps in monitoring and surveillance of object. [3]

Fig. 1 Key Features and apps of BLE

The Bluetooth protocol stack is distributed into two categories: controller and host. Each category has subcategories, which play specified roles. The two subcategories we will see are the Generic Access Profile (GAP) and the Generic Attribute Profile (GATT).

As of DEC, 2016	Bluetooth		
Specifications	**Classic Bluetooth**	**Bluetooth Low Energy (V 4.2)**	**Bluetooth 5**
Range	100 m	Greater than 100 m	Greater than 400 m
Data Rate	1-3 Mbps	1 Mbps	2 Mbps
Application Throughput	0.7 -2.1 Mbps	0.27 Mbps	—
Frequency	2.4 GHz	2.4 GHz	—
Security	56/128-bit	128-bit AES with Counter Mode CBC-MAC	—
Robustness	Adaptive fast frequency hopping, FEC, fast ASK	24-bit CRC, 32-bit Message Integrity Check	—
Latency	100 ms	6 ms	—
Time Lag	100 ms	3 ms	—
Voice Capable	Yes	No	—
Network Topology	Star	Star	—
Power Consumption	1 W	0.01 to 0.5 W	—
Peak Current Consumption	less than 30 mA	less than 15 mA	—

Comparison of Bluetooth standards — everythingRF

Fig 2 Comparison b/w Classic Bluetooth , BLE , Bluetooth 5

B. GAP Profile

BLE protocol stack's GAP layer has the responsibility for connection functionality This layer handles device access modes and processes, which includes link establishment , device discovery, initiation of security features , device configuration and link termination. See GAP state diagram. for more information.

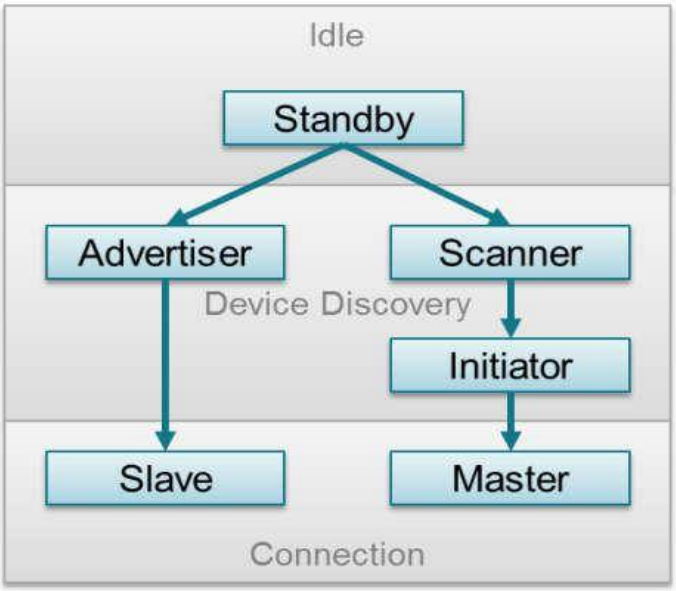

Fig 3 State Diagram of GAP State Diagram

C. GATT Profile

GAP layer is responsible for much of the connection-related functionality, Bluetooth low-energy protocol stack's GATT layer is used by applications for communication of data between two connected devices. Data is stored and passed as attributes and are stored in memory on a BLE device. From point of view of GATT, when two devices are connected, they are each in one of two roles.

1) *The GATT Server:* Characteristic database in device is being written or read by a GATT client.
2) *The GATT Client:* Writing or reading of data by device from or to the GATT server.

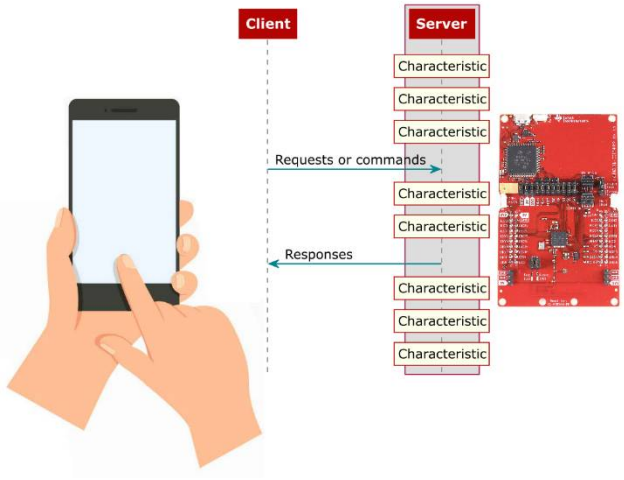

Fig 4 : GATT Client and Server Interaction Overview

III.PROGRAMMING GAP AND GATT IN SENSOR TAG

TI CC2650 SENSOR TAG is a wireless microcontroller with Arm-cortex M4 processor with around 10 low-powered sensors surrounding the processor and uses 75% less power than other Bluetooth products. TI CC2650 SENSOR TAG USES CODE COMPOSER STUDIO(CCS) To program the device. Following is the code flow to enable BLE in your applications.
It has TI-RTOS kernel to capture real time data generated by sensors.

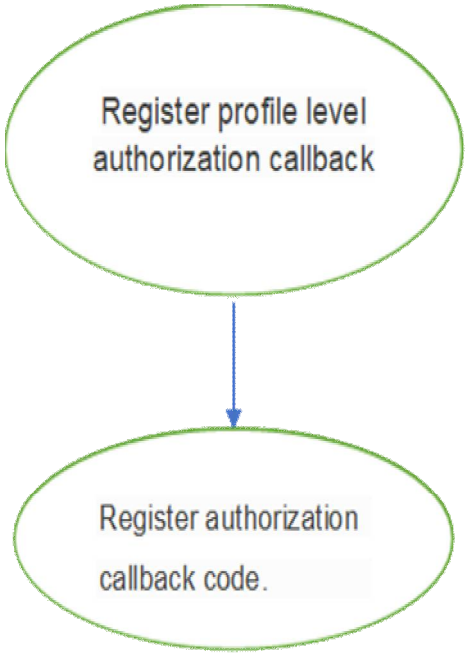

Fig 5 : Flowchart of GAP

The above figure is a flowchart for your C++ code to incorporate and intalise GAP profile in your code ,

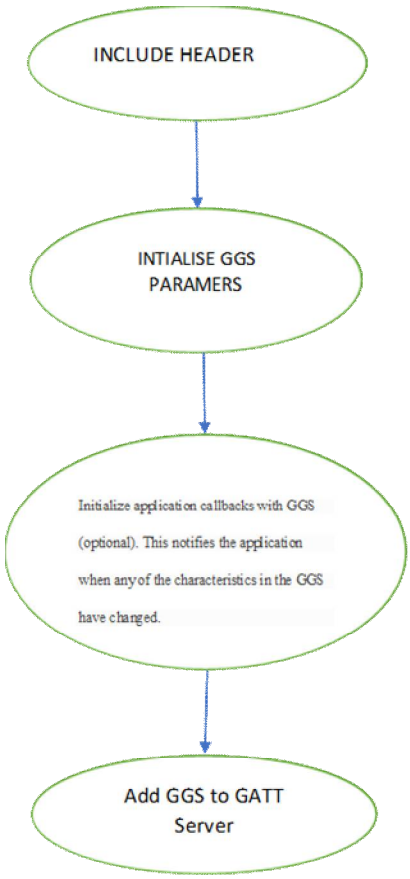

Fig 6 : Flowchart to configure, start, and use the GAP Gatt Service

IV. COMPARISON OF RSSI VALUES

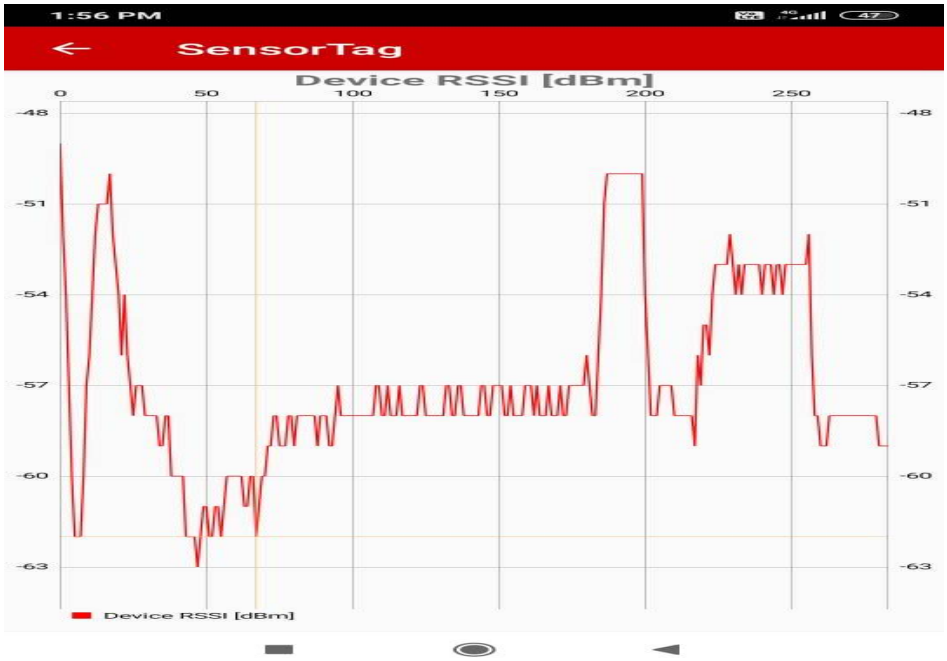

Fig 7 : : RSSI vs sampling-time graph of Bluetooth Low Energy obtained by TI SensorTag.

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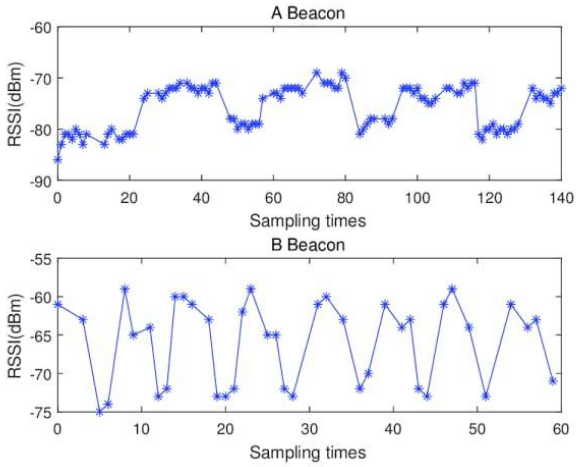

Fig 8 : RSSI vs sampling-time graph of classic Bluetooth.

V. CONCLUSION

TI CC2650 Sensor tag is a advanced device which has a BLE ON-BOARD and can be easily programmed using Code Composer Studio. Even Though Bluetooth Low Energy is powered by a button cell still it delivers RSSI Comparable to Classic Bluetooth. Making it a very power efficient option for modern IOT Applications.

Bluetooth Low Energy (BLE) over Classic Bluetooth is best suited for wearable and home automation applications. BLE is powered by coin cell and have a duration of months and even years making it suitable to be used as a portable sensor.

Below we can also see various services which are available by default from sensor-tag.

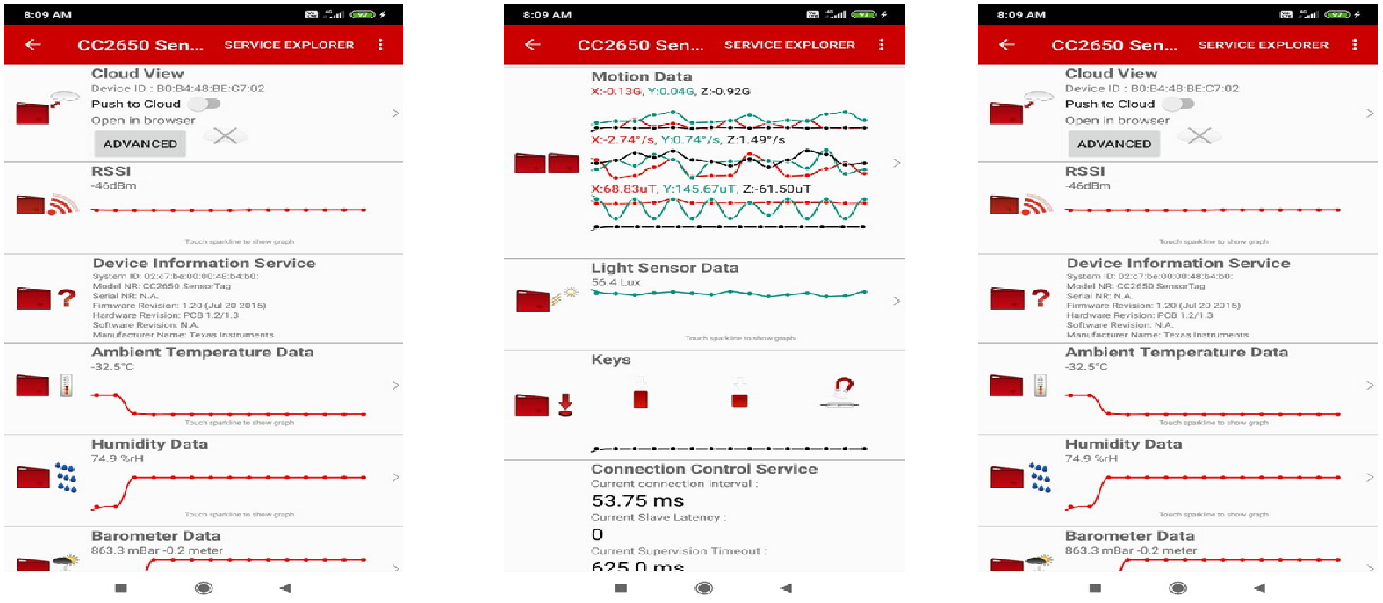

Fig 9 : Sensor tag data on mobile

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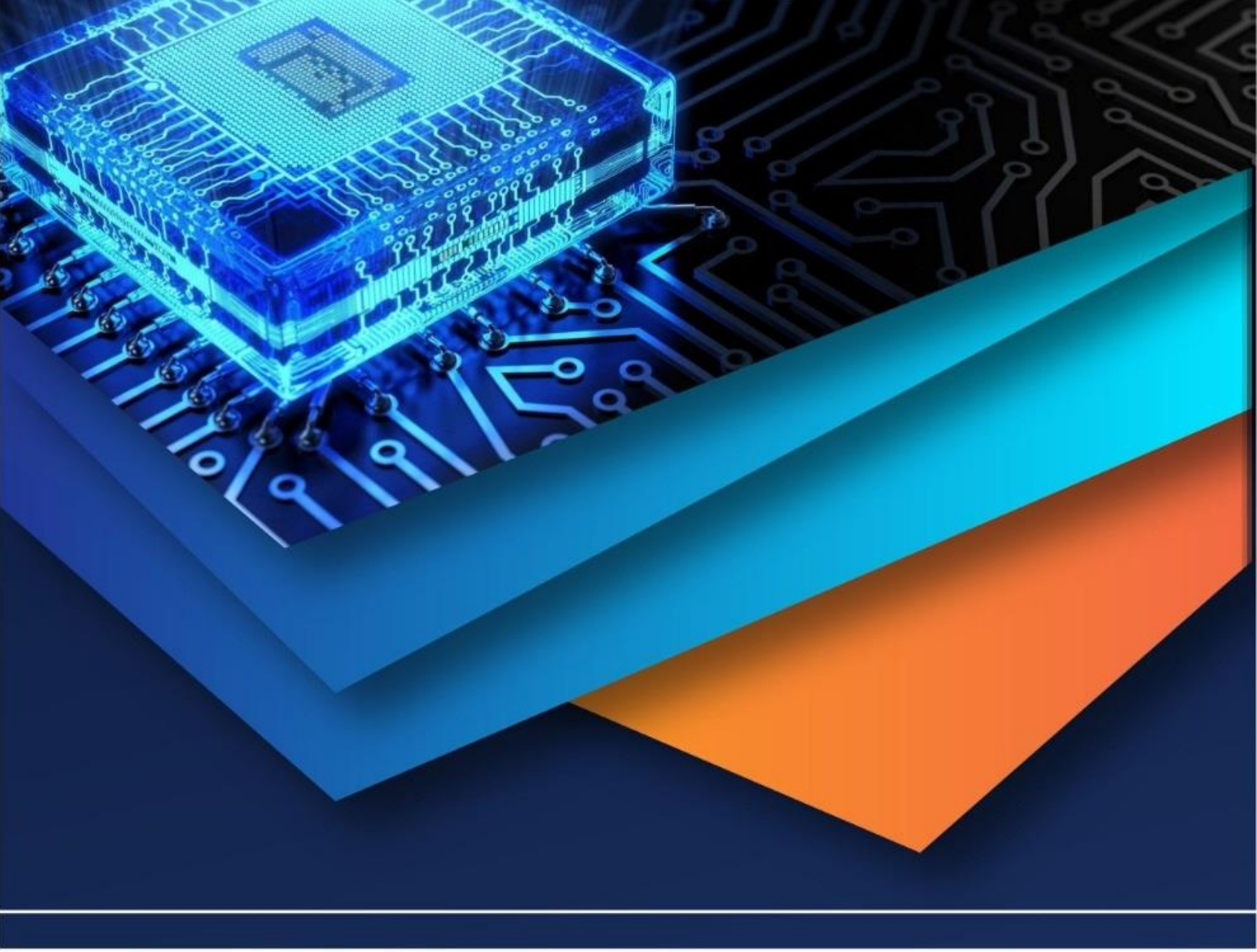

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