PSOC BASED IMPLEMENTATION OF BLUETOOTH LOW ENERGY MESH NETWORK

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Abstract - This paper presents an analysis of the implementation of Bluetooth low energy (BLE) mesh network using flooding mechanism and directed addressing mechanism. Several studies have shown the shortcomings of Bluetooth low energy due to its peer to peer architecture. With Bluetooth mesh, all nodes can communicate with one another. Thus, mesh architecture can provide a large, scalable and reliable network for data transmission. In this work, common data is relayed over the network using flooding mechanism. Two methods are implemented. In the first one, data is relayed from one node to another in the network without the need to know the node address. The second implementation is based on the assignment of node address and transmitting the data to that node only.

Keywords - Bluetooth Low Energy (BLE), Internet of Things (IOT), Mesh Network.

I. INTRODUCTION

The Internet of Things (IOT) is a rapidly growing area due to the constant digitization of data and the ever-increasing number of devices using the data. Many IOT devices are available in the market which support Bluetooth connectivity. Bluetooth operates in a personal area network (PAN) consisting of two devices. The communication is peer to peer with one device known as a Master which can establish connection with seven other devices known as slave.
Due to one to one connection supported by Bluetooth, the network becomes short ranged. To overcome this drawback, Mesh network is being implemented which can provide many to many connections among the nodes present in the network.
Mesh topology is very popular with Zigbee but very few devices have a Zigbee chip. Since most devices available in the market are Bluetooth compliant, it is very easy to implement mesh topology. The inclusion of mesh networking support is a fundamental change for Bluetooth technology. The mesh network will make it easier to take control of building services and to wirelessly interact with them and automate their functionality.
Let's consider a case where a smartphone has established connection with a heart-rate monitor. The same smartphone can establish connection with another pressure sensor. The smartphone can establish connection with each of the devices, but the two devices cannot communicate with each other. In such a scenario the mesh network comes into play where each device can relay messages to any other device so that the end-to-end communication range is extended beyond the radio range of each individual device.

Bluetooth Mesh is a networking technology and not a communication technology. This network does not make use of a central hub. All the nodes in the network are free to communicate with every other node. The terms used in mesh networking are as follows:
Nodes: The devices which form the mesh network are known as nodes.
Un-provisioned Device: Devices which are not a part of the mesh network.
Provisioning: The process to turn un-provisioned devices to a node.
Elements: Multiple constituent parts of a node.
Messages: Messages are sent by one node to another to query about the status or control them.
Publishing: The act of sending a message from nodes in the network.
Subscribing: The act of selecting messages sent to certain addresses by the nodes for processing.

II. IMPLEMENTATION

A. SYSTEM OVERVIEW

All the nodes are programmed with the same firmware for easy identification of the nodes in the network. Flooding mechanism is implemented in the network which eliminates the need of separate processing to deal with the changes in the network parameters. There is no limit to the number of nodes that can be a part of the network without considering interference on the BLE channels. This implementation also prevents connection between nodes which has the new relayed data or has already received data from some other node thus making it a reliable network.

B. REQUIREMENTS

The hardware CY8CKIT-042-BLE Bluetooth Low Energy BLE Pioneer Kit is used. The design tool used is PSOC Creator 4.2 and CySmart 1.0.

III. EXPERIMENTAL SETUP

The data among the nodes is relayed after the establishment of a connection. The node which has

the data transmits it to all the nodes or a node whose address has been selected. Each node is made to switch between GAP central and peripheral roles.

Each node supports both GAP central and GAP peripheral role. The GAP peripheral device advertises its data which contains the ADV data counter value ranging from 0-255. Every time a new data reaches the node, the counter is incremented. The GAP central device will scan for the advertisement packets. It will read the value of the counter and determine if the node has received a new data. The central node will connect to the peripheral node only if it has old data.

Once connection is established between the scanning node and advertising node, the scanning node is known as a GATT Client and the advertising node is known as a GATT Server. Once the client writes the data to the server, the server will disconnect and switch its role to that of a central device. Every GAP central node is assigned an internal timer which will trigger a role switch after specified intervals of time.

Five BLE pioneer kits are used for implementation.

Figure 1: Initial Kit Setup

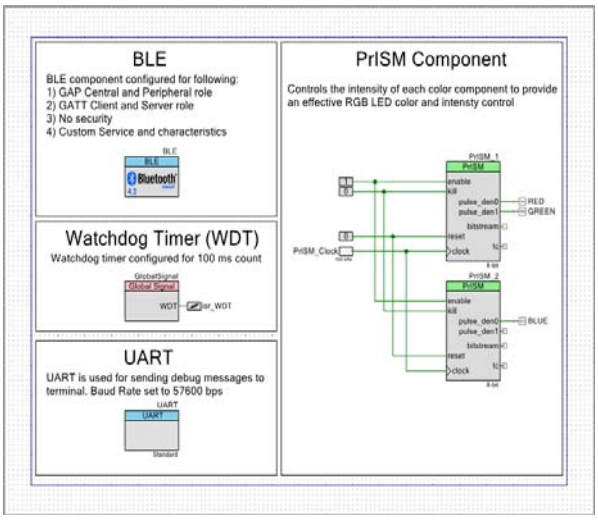

Figure 2: PSoC Creator Schematic

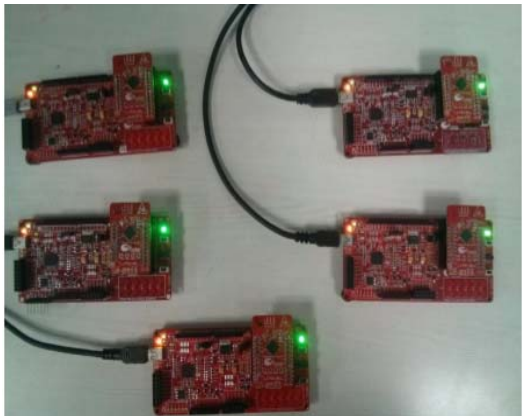

Figure 3: RGB data relayed to all nodes

IV. RESULTS AND DISCUSSIONS

After we program the device with the appropriate firmware, the device acts as a peripheral and starts advertising. The central device which is CySmart Tool, scans for all the peripheral devices which are advertising. The central is made to connect to our peripheral device. The RGB value needs to be located and it is observed that it is a 4 byte value. This value is modified and written to the peripheral device. The format of the value field is [Red:Green:Blue:Intensity]. On writing a value, the device will be disconnected immediately and all the nodes will show the same colour on the led. So, when we changed the RGB led colour on one peripheral node, it got relayed to all the other nodes. In this way, the range of the Bluetooth network can be increased. From a simple point to point link, we demonstrated a mesh architecture.

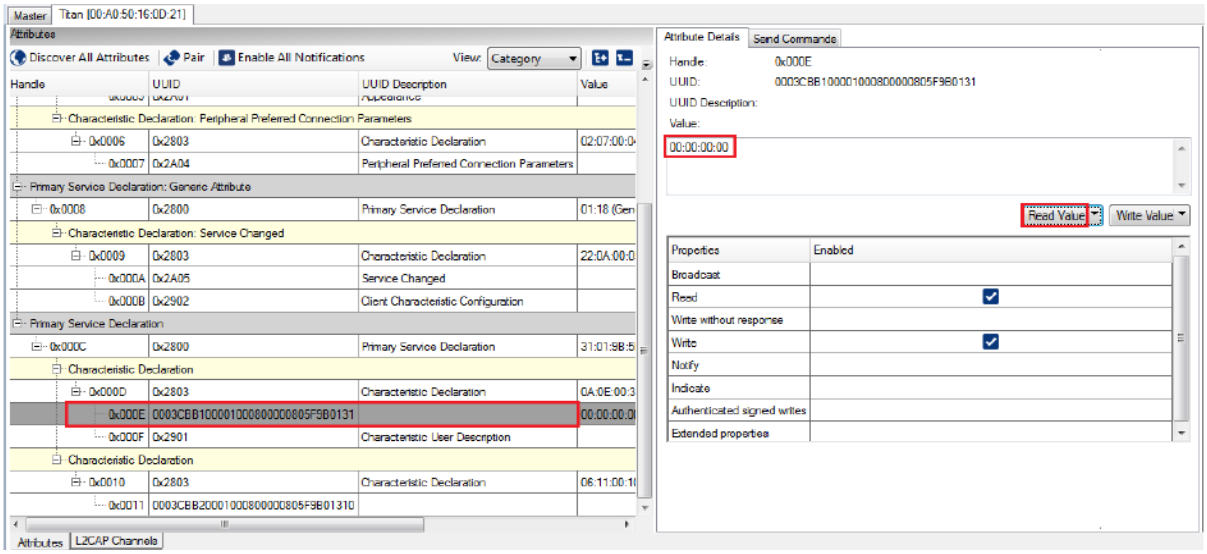

Figure 4: Reading the existing colour value of RGB Led

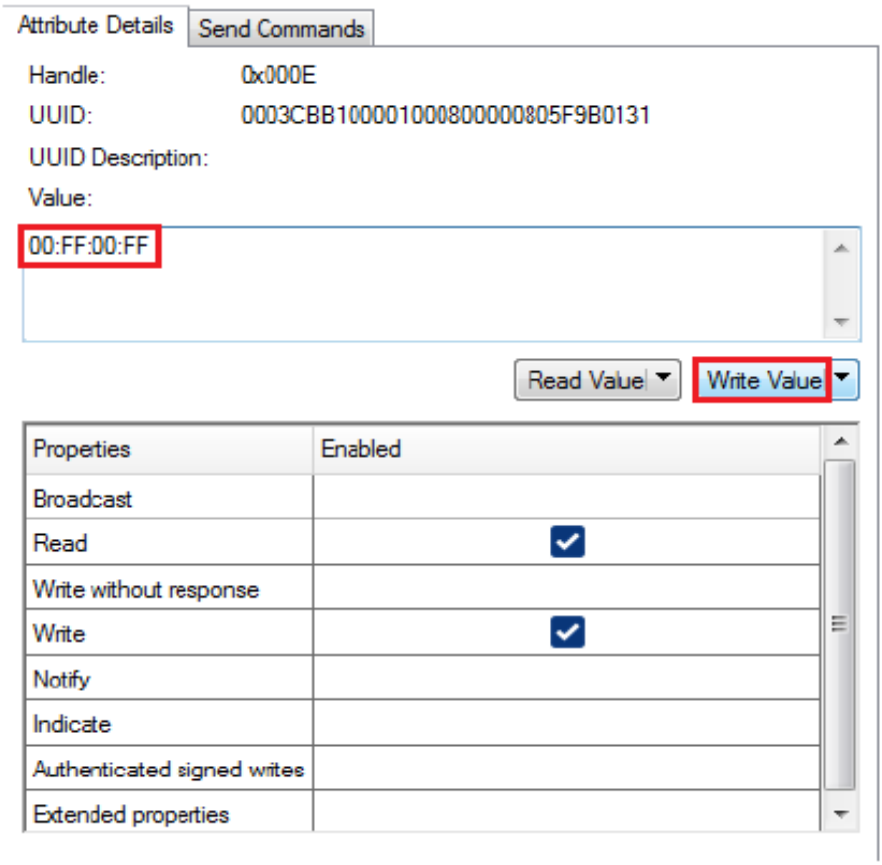

Figure 5: Writing a new RGB value to the peripheral

In case of the directed BLE mesh, the data is transmitted to the peripheral device with a particular device address. After establishing connection between the central and peripheral node, the attribute with a handle of 0x0015 is read from the peripheral and modified to set a unique node address. Each node is assigned a unique address. The 8 byte data is then read from the RGB custom characteristic.

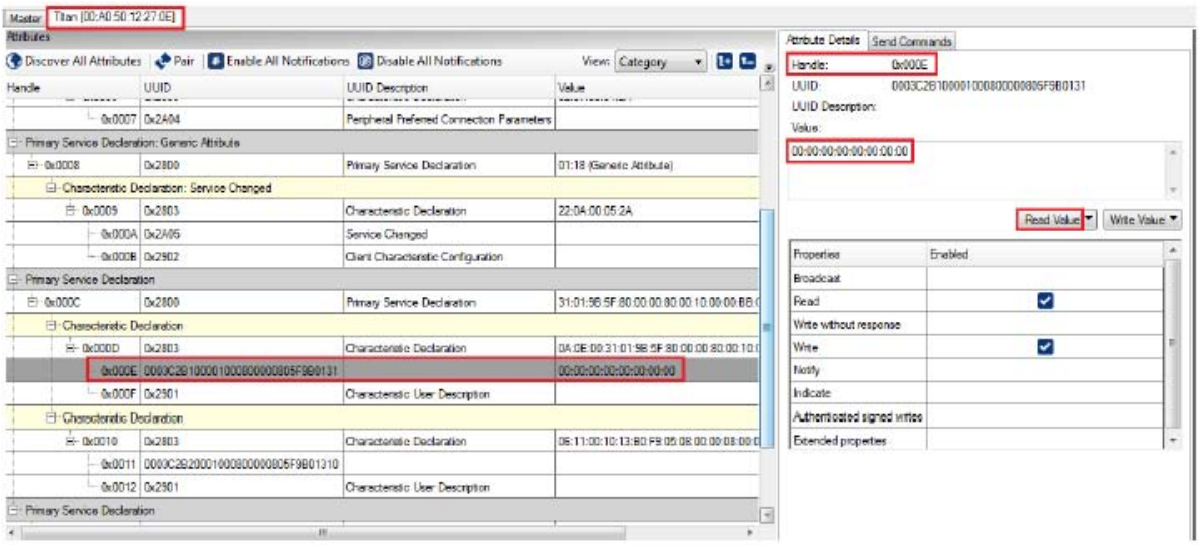

Figure 6: Attributes of the peripheral node

0	1	2	3	4	5	6	7
Address Scheme	Reserve	ADDR 1	ADDR 2	Red	Green	Blue	Intensity

Figure 7: Data format

The first byte represents either general addressing(0x00) or piconet addressing (0x01). The second byte is for future use. The next two bytes indicates the peripheral device address to which the data needs to be sent in the mesh network. We can set a broadcast address (0:00) so that all the nodes accept the data packets. Otherwise, the node whose address is set will receive the data packet. The next four bytes indicates the RGB colour and the intensity which needs to be transmitted to the mesh network. After writing the value to the node, it will be disconnected. Depending on the address field set, either all the nodes will receive the colour value or a particular node.

CONCLUSION

Bluetooth is a very popular technology in this century. But the shortcoming of a peer to peer network can limit its usages. So, the mesh network which can be easily implemented in the Bluetooth can expand the use cases of Bluetooth. It can provide longer range and allow communication between devices which are not in the direct radio range of each other. In this paper, mesh functionality has been demonstrated with PSoC Kit. The data is being relayed to a node which is not in the direct radio range of the transmitting node. Hence, extending the Bluetooth range can be a boon to a lot of IOT applications in today's world.

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