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Participation of Bluetooth LE Machines into IoT World

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Abstract: **This is an era of Machine to Machine communication. To make the communication in a broader way, it is necessary for interconnection. Thus the interconnection of machines(not only computers) has led to the new wave, Internet of things(IoT). Bluetooth Low Energy (BLE) is an intelligent version of Bluetooth which is power friendly. By the efforts of IETF, IPv6 expands it's branches into low power wireless devices called the 6LoWPAN. Thus these devices are addressable over the internet . Here we propose a method which makes use of IPv6 addresses over Bluetooth LE packets and enabling the wide scale communication among devices.**

Keywords: **Internet of things (IoT), Bluetooth Low Energy (BLE).**

1. INTRODUCTION

The world is moving rapidly towards ubiquitous connectivity that will further change the aspects of people in the communication world. The Internet can make virtually anything more intelligent—thus playing a vital role in nourishing the field of education, environment, health care, etc. Thus previously it was Human to Human communication .Then came human to machine communication. Now it is an era of Machine to Machine communication. Obviously, the next wave of Internet expansion would be the Internet of Things which involves Machine to Machine communication. It enables everyday objects to communicate and allows them to send and receive data. There are a number of technologies used in real time implementation of Internet of Things, which includes IEEE802.15.4, Z-wave, ANT, Dash7, Wave2M, Low Power variants of IEEE 802.11. But a low power radio technology that is expected to be incorporated in a number of devices is Bluetooth LE that still misses IP capability. The Applications of IoT is vast such that it expands its branches over medical field, Transportation, in creating smart phones and smart cities. One of the implementations is Singapore Bus Transport System which used RFID [2] . This application could provide real time information about the arrival time of buses .It could also provide information about the era machines. Thus, they would be in a better position to schedule extra service depending upon the crowd density. If IoT is implemented in home appliances that would be a revolution. One more example is the use of Sensor in the vehicles, collecting and sending the information about the health condition of the vehicles to the intelligent Transport System through the Mobile Phones of the drivers in order to minimize accidents.

2. BLUETOOTH LOW ENERGY

Bluetooth standard uses the unlicensed band 2.4 GHz ISM band .Though having a shorter coverage area, it has been implemented over a large variety of devices including the mobile phones, laptops, notebook computers, headsets, etc. The number of devices to which it can communicate is also minimum. Thus came the low power version of Bluetooth, which is a new specification that enables a wide range communication and theoretically communicate to an N number of devices with minimum power consumption. This low power variant is currently specified in the revision 4.0 of the Bluetooth. It is specifically designed for power constrained devices. Those devices usually operate on coin size batteries and thus using of BLE may allow the battery power in them last for about one year. BLE is incorporated in a number of devices including those devices that support Bluetooth and also other devices which are used in measuring the real time parameters like heart rate monitor, breath analyzer, proximity sensors, etc. It is also implemented in Google glasses . Because of its advantages over it's counterpart Bluetooth, it has been widely used .

BLE is aimed at transferring small amount of infrequent data at modest rate at a very low power cost per bit . Because of the two varients- Bluetooth and BLE ,Bluetooth SIG has introduced two trademarks ,viz Bluetooth Smart and Bluetooth Smart Ready . Bluetooth Smart includes only those devices which support only BLE .Whereas Bluetooth Smart Ready for dual-mode devices support both classical Bluetooth and BLE. Furthermore, enabling IPv6 over Bluetooth LE contributes to interoperability between IoT devices that utilize different low power radio technologies. Thus there is no constrain that only those devices that support only BLE can participate in the IoT network .

IPv6:

Any device which has to participate in Internet should be uniquely identifiable . Thus they are assigned a numerical IP address. The IPv4 addresses, has run out of space and thus IPv6 addresses, which were previously used ran out of address space. Thus came IPv6 with vast address space . Since, IoT involves the communication of large number of devices and IPv6 has auto configuration capabilities, IPv6 is well suited for IoT . The auto configuration capabilities of IPv6 also allows it suitable for sensor network applications and nodes with limited processing power r for those systems which lag full-fledged operating system.

IPv6 over Bluetooth LE:

Connecting Bluetooth LE nodes to the IoT requires the nodes to use IPv6. However, Bluetooth LE does not natively support IP. A solution [1] for enabling Bluetooth LE to support IPv6 is shown below:-

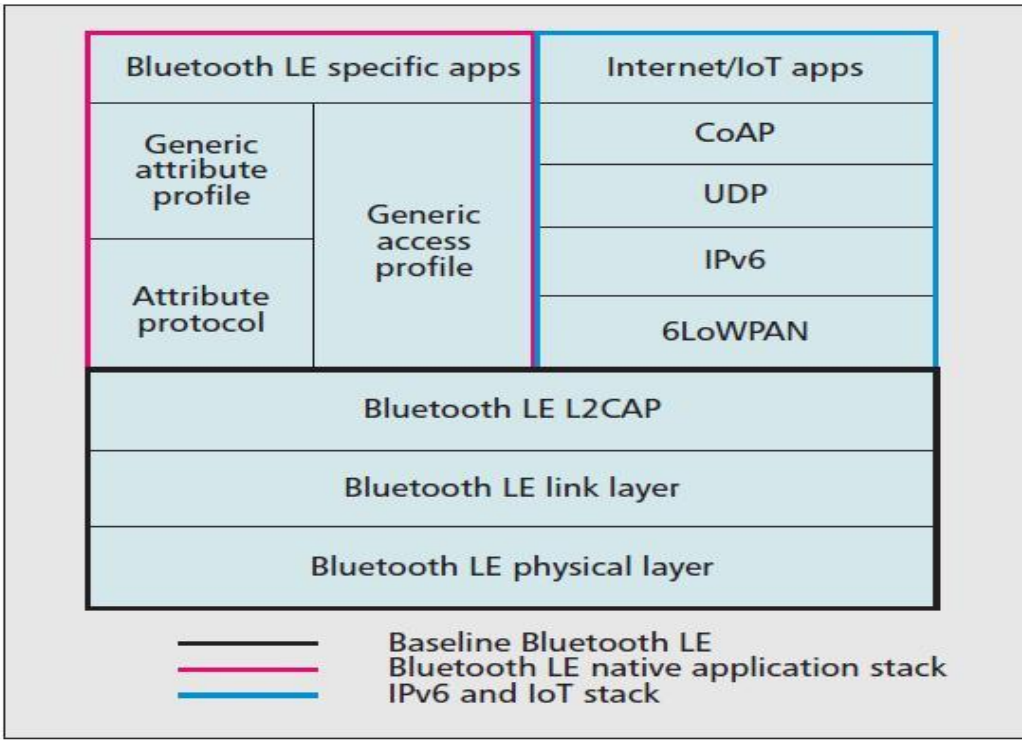

Figure: 1

Previous efforts of using IPv6 across the 802.15.4 networks, has led to 6LoWPAN. However this solution [1] is the basis of an IETF specification that is being standardized and is expected to become a new component the 6LoWPAN protocol suite. The above figure shows Bluetooth LE native protocol stack on left and IPv6- based Bluetooth LE stack on right. 6LoWPAN includes fragmentation, header compression, optimized Neighbor Discovery (ND), etc. Adaptive Frequency Hopping Spread Spectrum (FHSS) is used in the physical layer of BLE. This optimizes the number of channels from 79 in Classical Bluetooth to 40 . BLE has a data rate of about 1 Mb/s. considering the coverage; Bluetooth LE typically has a range of up to a few tens of meters. The Link Layer specifies a bidirectional communication between two devices, which requires them to establish a connection .Each and every device has it's role in the network and there are two roles viz Master and Slave. Every device will be in slave mode prior to communication and will be announcing their presence and connect ability,while the master will listen for such presence and will send Connection Request to the slave to which it is trying to connect to.

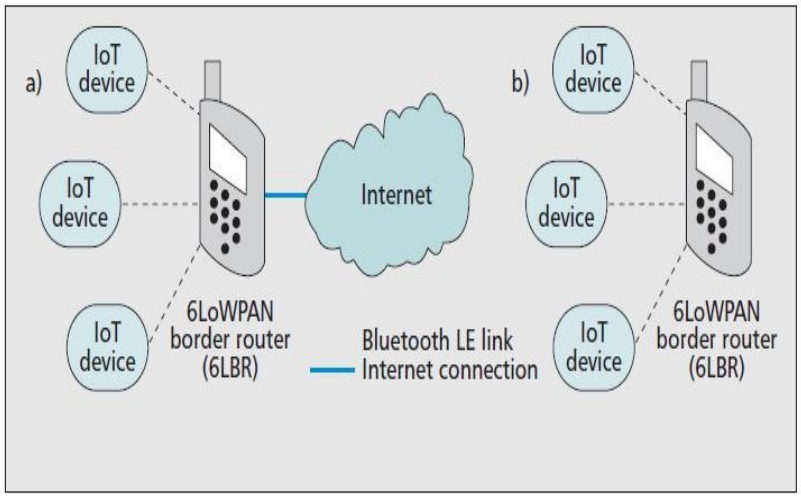

Figure 2. a) Internet connected and b) isolated Bluetooth LE networks.

Here a master can communicate with a number of slave whereas a client can be in communication with only one master at a time .Thus BLE allows the devices to connect in star topology. The connection establishment time between a master and a slave takes less than 3 milliseconds. Since the master communicates to a number of devices, each device is selected on time division basis so that each slave can access the Master .Thus it uses Time Division Multiple Access (TDMA) scheme. To synchronize the process between the master and slave, the connection request message is used . The message contains connection management information, which includes the start time of the first connection event and the time between connection events, also called connection interval (which is defined by the connection Interval parameter).

Each client will be in sleep mode by default which gets awaken periodically at the beginning of it's connection event. When the connection begins, the master transmits the data packet may request a transmission from the slave. The connection remains established until the pending messages are sent .To make this communication reliable; it follows an acknowledged stop and wait protocol.

Hence, Bluetooth LE is duty-cycled by nature. Logical Link Control and Adaptation Protocol (L2CAP)[3] is present on the top of the link layer and is responsible for multiplexing the data from upper layer and depending on the mode it is in, it may perform segmentation, retransmission, and detection of duplicate packets. Bluetooth LE uses the Basic L2CAP Mode, which does not provide segmentation [since BLE packets would be small already] or reliability services. Above L2CAP, the Generic Access Profile (GAP), Generic Attribute Profile (GATT), and the Attribute Protocol (ATT) allow applications to communicate and/or request data stored in structures called attributes.

3. BASIC ARCHITECTURE DIAGRAM

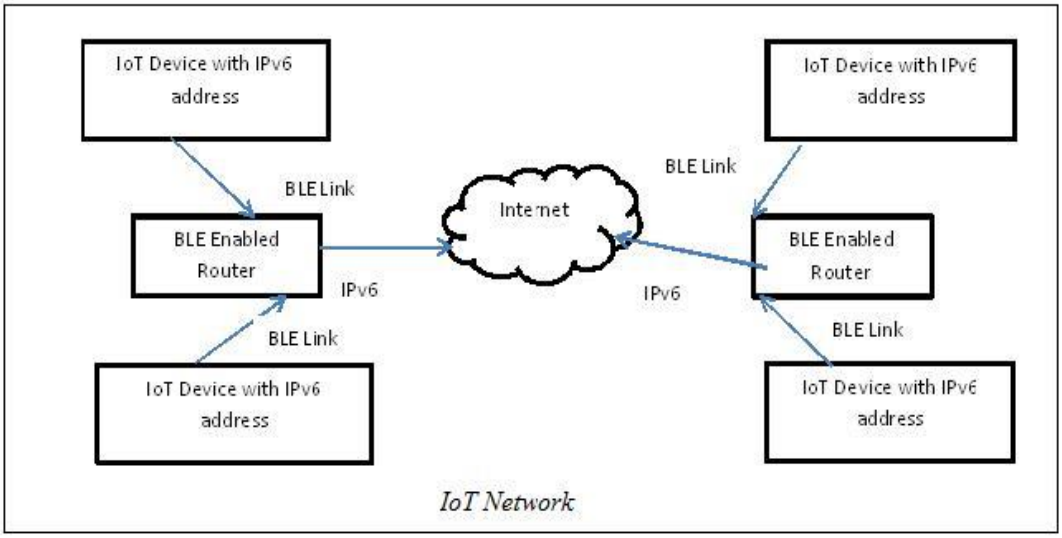

Figure: 3

Thus it is clear from the above diagram that each ode participating in this IoT network , requires the support of IPv6 and Bluetooth LE. The server on the left side sends data to the nearest router using BLE link. This router has to support both the BLE and IPv6 . To enable the real time application of this, the router at the server side communicates with the server at the client side using Internet .Thus, this server at the client side transfer the packet to the appropriate client using IPv6

6LoWPAN:

There will be a border router located at the junction of separate 6LoWPAN networks or between a 6LoWPAN network and another IP network to allow the communication among these wide range of networks .There may be one or more 6LBRs at the 6LoWPAN network boundary. A 6LBR is the responsible authority for IPv6 Prefix propagation for the 6LoWPAN network it is serving. An isolated Low PAN also contains a 6LBR in the network, which provides prefixes for the isolated network

4. CONCLUSION

Thus we conclude that it is possible for low power end devices which supports Bluetooth Low Energy to enter into the IoT world, provided the end-to-end IP connectivity in the most crucial aspect power consumption. Header compression can also be achieved for the IPv6 packets by compressing it's address. The open issues here are IoT device management, optimizing mobile gateways by adapting their Internet connectivity link to support IoT traffic.

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