Abstract. Internet of Things (IoT) is a concept that envisions all objects around us as part of internet. IoT coverage is very wide and includes variety of objects like smart phones, tablets, digital cameras and sensors. Once all these devices are connected to each other, they enable more and more smart processes and services that support our basic needs, environment and health. Such enormous number of devices connected to internet provides many kinds of services. They also produce huge amount of data and information. IoT is an emerging technology and aims to play an important role in saving money, conserving energy, eliminating gap and better monitoring for intensive management on a routine basis. Our project aims at demonstrating the benefits of IoT by implementing home automation using the IPV6 protocol over Ble operated on low power battery cell. Later part of paper discusses how the nrf51 devices can connect and communicate with other devices over the internet using Bluetooth low energy (BLE). The results can be used as a guideline to develop required application. Keywords: Bluetooth LE, IPV6, nrf51.

1. INTRODUCTION

The Internet of things is the internetworking of physical devices, vehicles, buildings, and other items—embedded with electronics, software, sensors, actuators and network connectivity that enable these objects to collect and exchange. The concept of the Internet of Things was invented by and term coined by Peter T. Lewis in September 1985 in a speech he delivered at a U.S. Federal Communications Commission (FCC) supported session at the Congressional Black Caucus 15th Legislative Weekend Conference data[26]. The Internet of Things may be a hot topic in the industry but it’s not a new concept. In the early 2000’s, Kevin Ashton was laying the groundwork for what would become the Internet of Things (IoT) at MIT’s AutoIDlab. Ashton was one of the pioneers who conceived this notion as he searched for ways that Proctor & Gamble could improve its business by linking RFID information to the Internet. The concept was simple but powerful. If all objects in daily life were equipped with identifiers and wireless connectivity, these objects could be communicating with each other and be managed by computers. In a 1999 article for the RFID Journal Ashton wrote: “If we had computers that knew everything there was to know about things—using data they gathered without any help from us -- we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best. We need to empower computers with their own means of gathering information, so they can see, hear and smell the world for themselves, in all its random glory. RFID and sensor technology enable computers to observe, identify and understand the world—without the limitations of human-entered data.” After all, how would we connect everything on the planet? What type of wireless communications could be built into devices? What changes would need to be made to the existing Internet infrastructure to support billions of new devices communicating? What would power these devices? What must be developed to make the solutions cost effective? There were more questions than answers to the IoT concepts in 1999. Today, many of these obstacles have been solved. The size and cost of wireless radios has dropped
tremendously. IPv6 allows us to assign a communications address to billions of devices. Electronics companies are building Wi-Fi and cellular wireless connectivity into a wide range of devices.

IoT describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired Internet connections. These sensors can use various types of local area connections such as RFID, NFC, Wi-Fi, Bluetooth, and Zigbee. Sensors can also have wide area connectivity such as GSM, GPRS, 3G, and LTE.

**TABLE 1: Comparison of BLE Enabled device**

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<tbody>
<tr>
<td>Advertisement Current(mA)</td>
<td>16.5</td>
<td>19.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flash Data memory(kB)</td>
<td>128</td>
<td>8</td>
<td>32</td>
<td>512</td>
<td>256/128</td>
</tr>
<tr>
<td>sensors</td>
<td>Light,temperature</td>
<td>Moisture/capacitive</td>
<td>Light,temperature</td>
<td>Humidity, pressure</td>
<td>N/A</td>
</tr>
<tr>
<td>Battery Capacity</td>
<td>3v,240mAh</td>
<td>3v</td>
<td>3v,150mAh</td>
<td>3V</td>
<td>3V</td>
</tr>
<tr>
<td>Wireless connectivity</td>
<td>BLE</td>
<td>BLE</td>
<td>BLE</td>
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</table>

Bluetooth low energy (LE) is a radio technology targeted for devices that operate with coin cell batteries or minimalistic power sources, which means that low power consumption is essential[7]. Bluetooth LE is an especially attractive technology for Internet of Things applications, such as health monitors, environmental sensing, proximity applications and many others. Considering the potential for the exponential growth in the number of sensors and Internet connected devices and things, IPv6 is an ideal protocol due to the large address space it provides. In addition, IPv6 provides tools for stateless address autoconfiguration, which is particularly suitable for sensor network applications and nodes which have very limited processing power or lack a full-fledged operating system. RFC 4949 specifies the transmission of IPv6 over IEEE 802.15.4[8]. The Bluetooth LE link in many respects has similar characteristics to that of IEEE 802.15.4. Many of the mechanisms defined in the RFC 4944 can be applied to the transmission of IPv6 on Bluetooth LE links[9]. Bluetooth LE is designed for

**2. OVERVIEW**

**A. Wireless Sensor Networks (WSNs)**

Wireless sensor network topologies have been developed for smart grids and smart homes[5]. A smart home is a system of energy sources, appliances, devices and sensors that allow a homeowner to control and minimize power consumption while automating tasks. Currently, there are smart plugs can report back power consumption and usage time through a wireless link. From a hardware standpoint, in order to generate energy efficient sensor nodes, they must be intrinsically low-power devices. From a communication standpoint, Bluetooth Low Energy (BLE) meets the requirements for low power consumption, low cost, and range operation in homes.

**B. Bluetooth low energy**
transferring small amounts of data infrequently at modest data rates at a very low cost per bit. Bluetooth Special Interest Group (Bluetooth SIG) has introduced two trademarks, Bluetooth Smart for single-mode devices (a device that only supports Bluetooth LE) and Bluetooth Smart Ready for dual-mode devices (devices that support both Bluetooth and Bluetooth LE). In the rest of the paper, the term Bluetooth LE refers to both types of devices. Bluetooth LE was introduced in Bluetooth 4.0 and further enhanced in Bluetooth 4.1. Bluetooth SIG has also published Internet Protocol Support Profile (IPSP), which includes Internet Protocol Support Service (IPSS). The IPSP enables discovery of IP enabled devices and establishment of link-layer connection for transporting IPv6 packets. IPv6 over Bluetooth LE is dependent on both Bluetooth 4.1 and IPSP 1.0 or newer. Bluetooth 5 is the latest version of the Bluetooth specification. With major new features such as long range and high throughput modes it represents one of the biggest advancements in the Bluetooth specification[9].

Devices such as mobile phones, notebooks, tablets and other handheld computing devices which will include Bluetooth 4.1 chipsets will also have the low-energy functionality of Bluetooth. Bluetooth LE will also be included in many different types of accessories that collaborate with mobile devices such as phones, tablets and notebook computers. An example of a use case for a Bluetooth LE accessory is a heart rate monitor that sends data via the mobile phone to a server on the Internet.

All devices in the Internet of Things must be uniquely identifiable, so that direct communication between the devices is possible and each device can be individually addressed. One way of accomplishing this is to assign a unique IPv6 address to each device and handle all communication through IPv6.

C.BLE for IOT Applications in Smart Homes and Smart Cities

In Smart Homes and Smart Cities, one use case for BLE is using smartphone and other Bluetooth enabled devices as gateway device for BLE-enabled sensors. Using BLE eliminates the need to design sensors with various link and physical layer specifications. The major advantage of BLE that enables IOT capabilities is the Internet Protocol Support Profile (IPSP). The IPSP enables IPv6-enabled Bluetooth masters and slaves to discover each other using the BLE Generic Attribute Profile (GATT) and establish a Link-layer connection.

Low-power BLE networks and nodes can rely on batteries as power sources. Battery lifetime has been evaluated for various BLE home Automation applications. Typical battery life time is 1 to 2 years. For BLE network processors with low transmission current, battery lifetimes can be as long as 6 to 4 years. From a BLE standpoint, it has been shown that increasing the size of the payload does not impact battery
lifetime and increasing advertising interval optimizes battery lifetime[6].

3. DEVICE HARDWARE

All components needed for Ble communication are shown in the block diagram.

A. Microcontroller

The nRF51 Series is a family of multiprotocol, System on Chip (SoC) devices for ultra-low power wireless applications. The nRF51 Series SoCs support a range of protocol stacks including Bluetooth Smart, ANT, and proprietary 2.4 GHz protocols such as Gazell and are on-air-compatible with our existing nRF24L products. In addition, they offer their own protocol stack solutions in the form of SoftDevices, which are binary file downloads that you can upload onto nRF51 Series SoCs. The nRF51 DK is a single-board development kit that supports both development for both nRF51822 and nRF51422 SoCs.

B. Border Router

A border router located at the junction of separate 6LoWPAN networks or between a 6LoWPAN (here BLE) network and another IP network, connecting isolated 6LoWPAN networks to a wider IP network or, typically, to the internet. For Bluetooth low energy, the master is assigned the role of a 6LoWPAN border router. Here we have made use of raspberry pi 3 as a border router which takes the central role. It is able to manage multiple simultaneous connection.

nRF51422 SoC.

The nRF51422 is a powerful multiprotocol single chip solution for ANT/Bluetooth® low energy applications. It incorporates Nordic’s latest best-in-class performance radio transceiver, an ARM Cortex M0 CPU and 256kB/128kB flash and 32kB/16kB RAM memory. The nRF51422 supports Bluetooth Smart (formerly known as Bluetooth low energy), ANT, and 2.4GHz proprietary protocol stacks.

B. BLE communication

The nRF51 Series SoCs support a range of protocol stacks including Bluetooth Smart, ANT, and proprietary 2.4 GHz protocols such as Gazell and are on-air-compatible with our existing nRF24L products. Because the physical layer is already compliant with Bluetooth smart

4. Results

Using copper coap we could control various devices such as fan, tube light, bulb etc. in local area network. We could also read the room temperature.

5. FUTURE WORK AND CONCLUSION.

We could successfully set up an test environment for IOT/CoAP and transmit data from PC to nrf51dk over 6BLE(ipv6 over bluetooth Low Energy) in local area network. This can be used as a basis to develop advanced application using 6BLE which will play an important role in the Internet of Things.
Fig. 2. Copper CoAP add-on

References


[2]. Sangwhan Cha; Marta Padilla Ruiz; Monica Wachowicz; Loc Hoang Tran; Hung Cao; Ikechukwu Maduako. The role of an IoT platform in the design of real-time recommender systems. (2016).


[7]. G. Montenegro, N. Kushalnagar, J. D. Culler. 2007 Transmission of IPv6 Packets over IEEE 802.15.4 Networks. tools.ietf.org/html/rfc4944

[8]. Nordic developer zone.