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Migration from ZigBee to IPv6 based Lighting System

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Abstract: ***The vision of the IoT is the embedded devices, also known as smart objects which are becoming IP enabled and an important part of the Internet. The IPv4 address is 32 bits and it is saturating. Hence using IPv6 address is preferred. The 6LoWPAN is built on IEEE 802.15.4 and it uses IPv6 address. The 6LoWPAN can communicate with IEEE 802.15.4 devices and any other types of devices on the Internet. 6LoWPAN uses RPL protocol for routing. The ZigBee is also built on the IEEE 802.15.4 and other layers are implemented on top of that. The problem with ZigBee is interoperability ie to communicate with non-ZigBee devices it needs a separate gateway. But in 6LoWPAN, the nodes can communicate with the devices of same network and any other devices. This paper discusses about 6LoWPAN technology and compares it with ZigBee.***

Keywords: IoT, IEEE 802.15.4, ZigBee, 6LoWPAN

1. Introduction

The Internet of things (adapted Internet of Things or IoT) is devices ("smart devices"), structures and different things—inserted with hardware, programming, sensors, actuators, and system network that empower these items to gather and trade information [1]. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) characterized the IoT as "the foundation of the data society." The IoT enables items to be detected as well as controlled remotely crosswise over existing system infrastructure,[4] making open doors for more straightforward combination of the physical world into PC based frameworks, and bringing about enhanced effectiveness, exactness and monetary advantage. At the point when IoT is expanded with sensors and actuators, the innovation turns into an example of the more broad class of digital physical frameworks, which additionally includes advances, for example, keen lattices, savvy homes, astute transportation and shrewd urban areas.

Internet Protocol version 6 (IPv6) is the latest rendition of the Internet Protocol (IP), the correspondences convention that gives an ID and area framework for PCs on systems and courses movement over the Internet. IPv6 was created by the Internet Engineering Task Force (IETF) to manage the since quite a while ago foreseen issue of IPv4 address fatigue. IPv6 is proposed to supplant IPv4.

Each device on the Internet is relegated an interesting IP address for distinguishing proof and area definition. With the quick development of the Internet after commercialization in the 1990s, it ended up noticeably apparent that much more delivers would be expected to interface device than the IPv4 address space had accessible. By 1998, the Internet Engineering Task Force (IETF) had formalized the successor convention. IPv6 utilizes a 128-bit address, hypothetically permitting 2128, or roughly 3.4×1038 address. IPv6 addresses are represented as eight groups of four hexadecimal digits with the groups being separated by colons, for example 2001:0db8:0000:0042:0000:8a2e:0370:7334, but methods to abbreviate this full notation exist.

IEEE 802.15.4 is a specialized standard which characterizes the operation of low-rate remote individual zone systems (LR-WPANs). It determines the physical layer and media get to control for LR-WPANs, and is kept up by the IEEE 802.15 working gathering, which characterized the standard in 2003. It is the reason for the ZigBee, ISA100.11a, WirelessHART, MiWi, and Thread determinations, each of which further broadens the standard by building up the upper layers which are not characterized in IEEE 802.15.4. On the other hand, it can be utilized with 6LoWPAN, the innovation used to convey the IPv6 variant of the Internet Protocol (IP) over WPANs, to characterize the upper layers.

The ZigBee innovation was presented by the ZigBee Alliance [6]. The ZigBee innovation has advanced in view of an institutionalized arrangement of arrangements called 'layers'. These ideally planned layers have given the ZigBee special components including ease, simple usage, dependable, low power, and high security. The ZigBee was based on top of IEEE 802.15.4 standard. The IEEE 802.15.4 standard characterizes the qualities of the physical and Medium Access Control (MAC) layers for Wireless Personal Area Network (WPAN). Taking this standard as a "case" the ZigBee Alliance has characterized the upper layers in the ZigBee standard.

6LoWPAN is an open standard characterized in RFC6282 by the Internet Engineering Task Force (IETF), the principles body that characterizes large portions of the open gauges utilized on the Internet, for example, UDP, TCP and HTTP to give some examples. An effective element of 6LoWPAN is that while initially imagined to bolster IEEE 802.15.4 low-control remote systems in the 2.4-GHz band, it is currently being adjusted and utilized over an assortment of other systems administration media including Sub-1 GHz low-control RF, Bluetooth Smart, control line control (PLC) and low-control Wi-Fi.[4].

In this paper, Section II describes the architecture of 6LoWPAN. In Section III, the protocol stacks of zigBee and 6LoWPAN are explained. The adaptation layer is explained in section IV. In section V, routing in 6LoWPAN is discussed. Finally, the Conclusion is given in Section VI.

2. Architecture of 6LoWPAN

The uplink to the Internet is dealt with by the Access Point (AP) going about as an IPv6 switch. A few unique devices are associated with the AP in a run of the mill setup, for example, PCs, servers, and so forth. The architecture of 6LoWPAN is as shown in the below figure 1.1.

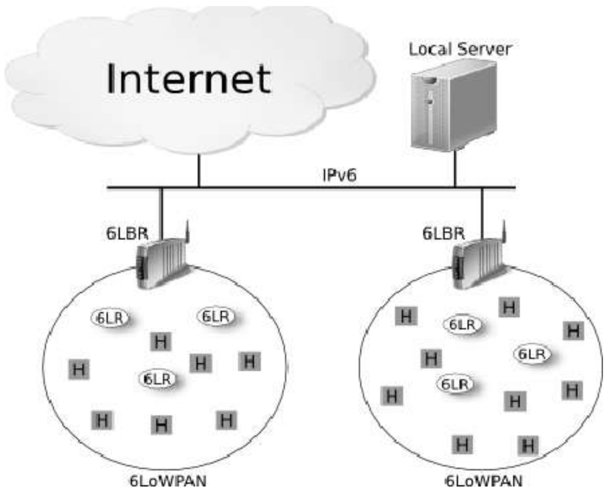

Figure 1.1: Architecture of 6LoWPAN

The 6LoWPAN network is associated with the IPv6 arrange utilizing an edge switch. The edge router handles three actions:

- The information trade between 6LoWPAN devices and the Internet (or other IPv6 network).
- Local information trade between devices inside the 6LoWPAN.
- The generation and maintenance of the radio subnet (the 6LoWPAN network).

By discussing locally with IP, 6LoWPAN systems are associated with different systems basically utilizing IP switches. The 6LoWPAN systems will regularly work on the edge, going about as stub systems. This implies information going into the system is bound for one of the devices inside the 6LoWPAN. One 6LoWPAN system might be associated with other IP organizes through at least one edge switches that forward IP datagrams between various media. Availability to other IP systems might be given through any subjective connection, for example, Ethernet, Wi-Fi or 3G/4G. Since 6LoWPAN just indicates operation of IPv6 over the IEEE 802.15.4 standard, edge routers may likewise bolster IPv6 move systems to associate 6LoWPAN systems to IPv4 systems, for example, NAT64 characterized in RFC 6146.

Two other device types are included inside a typical 6LoWPAN network: routers and hosts.. Routers can, as the name suggests, course information bound to another hub in the 6LoWPAN system. Hosts are otherwise called end devices and are not ready to course information to different devices in the system. Host can likewise be a sluggish device, awakening occasionally to check its parent (a switch) for information, empowering low power utilization.

3. Protocol Stack of 6LoWPAN

6LoWPAN solves this dilemma by introducing an adaptation layer between the IP stack's link and network layers to enable transmission of IPv6 datagrams over IEEE 802.15.4 radio links. The figure 1.2 shows the ZigBee protocol stack and the 6LoWPAN stack.

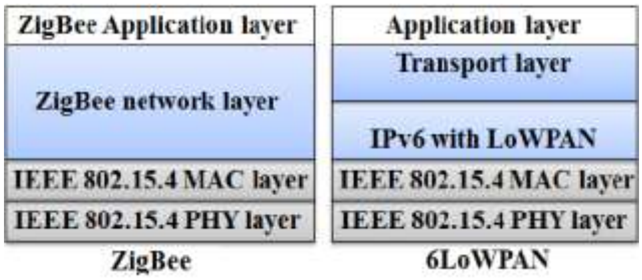

Figure 1.2: ZigBee and 6LoWPAN protocol stack

The physical layer converts data bits into signals that are transmitted and received over the air. In the 6LoWPAN example, IEEE 802.15.4 is used. The data link layer provides a reliable link between two directly connected nodes. The data link layer includes the media access layer (MAC) which provides access to the media, using features like carrier sense multiple access – collision avoidance (CSMA-CA) where the radio listens that no one else is transmitting before actually sending data over the air. This layer also handles data framing. In the 6LoWPAN example, the MAC layer is IEEE 802.15.4. The 6LoWPAN adaptation layer, providing adaptation from IPv6 to IEEE 802.15.4, also resides in the link layer.

The network layer addresses and routes data through the network, if needed over several hops. IP (or Internet Protocol) is the networking protocol used to provide all devices with an IP address to transport packets from one device to another. The transport layer generates communication sessions between applications running on end devices. The transport layer allows multiple applications on each device to have their own communications channel. TCP is the dominant transport protocol on the Internet. However, TCP is a connection-based protocol (including packet ordering) with large overhead and therefore not always suitable for devices demanding ultra-low power consumption. For those types of systems, UDP, a lower overhead, connectionless protocol, can be a better option. Secure transport layers examples include TLS (transport layer security) running atop TCP and DTLS, which is based on UDP.

Finally, the application layer is responsible for data formatting. It also makes sure that data is transported in application-optimal schemes. A broadly used application layer on the Internet is HTTP running over TCP. HTTP uses XML, which is a text-based language with a large overhead.

Therefore, it is not optimal to use HTTP in many 6LoWPAN systems. However, HTTP can still be very useful for communications between 6LoWPAN and the Internet. For this reason, the industry and community have developed alternative application layer protocols, such as the constrained application protocol (COAP), a message protocol running over UDP with a bit-optimized REST mechanism very similar to HTTP. COAP is defined by IETF in RFC 7252 and defines retransmissions, confirmable and non-confirmable messages, support for sleepy devices, block transfers, subscription support and resource discovery. COAP is also easy to map to HTTP via proxies. Another application layer protocol that should be mentioned is message queue telemetry transport (MQTT), an open-source protocol that was invented by IBM. MQTT is a publish/subscribe type of protocol running over TCP. Data is not transported directly between end points. Instead a broker (i.e., server) is used to relay messages [6]. MQTT introduces the "topic" entity; devices can publish and subscribe to different topics. Once a topic is updated that a specific device has subscribed to, the device will get notified and receive the data via the broker. Devices can use wildcards like # and * to subscribe to a hierarchy of topics. MQTT supports several layers of quality of service (QoS) making sure that messages are delivered. The broker can run both locally in an IP intranet and on the Internet and multiple brokers are supported interacting in the same system. Several public brokers are available and many of the cloud service providers provide MQTT access.

4. Adaptation Layer

When sending data over MAC and PHY layers, an adaptation layer is always used. For example, RFC 2464 defines how an IPv6 packet is encapsulated in an Ethernet frame. The same is also used for IEEE 802.11 Wi-Fi. For 6LoWPAN, RFC 6282 defines how an IPv6 data frame is encapsulated over an IEEE 802.15.4 radio link.

The packets in 6LoWPAN have small data transmission range from 10m to 30m at the rate of 20 kbps to 240 kbps, with very constraint node memory of 16 kb RAM and 128kb ROM [5] [6]. Permissible packet size, short transmission range, limited memory, constraint energy are some compatibility issues between IPv6 and LoWPAN (IEEE standard 802.15.4). To remove these compatibility issues for efficient transmission of packets, an adaptation layer is placed between network and data link layer of TCP/IP stack.

The adaptation layer is the main component of 6LoWPAN. The first major function of this layer is the TCP/IP header compression. TCP/IP headers are too large for 802.15.4, which has a maximum packet size of 128 bytes; instead IPv6 header size is 40 bytes, UDP and ICMP header sizes are both 4 bytes, TCP header size is 20. Without compression, 802.15.4 is not possible to transmit any payload effectively.

A second major function of the adaptation layer is to handle packet fragmentation and reassembling. IEEE 802.15.4 has a maximum frame size of 128 bytes, while IPv6 requires a maximum transmission unit (MTU) of 1280 bytes. This mismatch has to be handled in the adaptation layer.

The third major function of the adaptation layer is routing. The border nodes of the WSN should be able to route IPv6 packets into the WSN nodes from outside and route inside packets to outside IP network. Different routing protocols of adaptation layer are shown in table. There are other functions of the adaptation layer on networking related things like neighbor discovery and multicast support.

5. Routing

Routing is the ability to send a data packet from one device to another device, sometimes over multiple hops. Depending on what layer the routing mechanism is located, two categories of routing are defined: mesh-under or route-over. Mesh-under uses the layer-two (link layer) addresses (IEEE 802.15.4 MAC or short address) to forward data packets; while route-over uses layer three (network layer) addresses (IP addresses) as shown in the below figure 1.3.

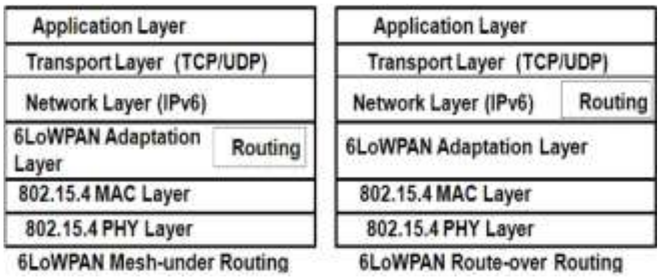

Figure 1.3: Mesh under and route over routing

In a mesh-under system, routing of data happens transparently, hence mesh-under networks are considered to be one IP subnet. The only IP router in such a system is the edge router. One broadcast domain is established to ensure compatibility with higher layer IPv6 protocols such as duplicate address detection. These messages have to be sent to all devices in the network, resulting in high network load. Mesh-under networks are best suited for smaller and local networks. In route-over networks the routing takes place at the IP level as described above, thus each hop in such networks represents one IP router. The usage of IP routing provides the foundation to larger and more powerful and scalable networks, since every router must implement all features supported by a normal IP router such as DAD, etc. The most widely used routing protocol for route-over 6LoWPAN networks today is RPL (pronounced "ripple") as defined by IETF in RFC 6550. Compared to mesh-under, route-over features the advantage that most of the protocols used on a standard TCP/IP stack today can be implemented and used as is. RFC 6550 specifies the IPv6 routing protocol for low-power and lossy networks (RPL), which provides a mechanism whereby multipoint-to-point traffic from devices inside the 6LoWPAN network towards a central control point (e.g., a server on the Internet) as well as pointto-multipoint traffic from the central control point to the devices inside the 6LoPWAN are supported. Support for point-to-point traffic is also available. However, RPL is not the optimum choice for such traffic, since the data in many cases needs to be transported via the edge router.

RPL supports two different routing modes; storing mode and non-storing mode as shown in the below figure 1.4.

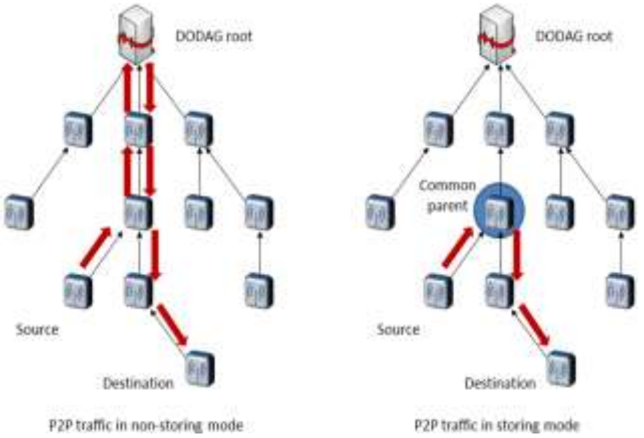

Figure 1.4: Non-storing and storing mode

In storing mode, all devices in the 6LoWPAN network configured as routers maintain a routing table and a neighbor table. The routing table is used to look up routes to devices, and the neighbor table is used to keep track of a node's direct neighbors. In non-storing mode the only device with a routing table is the edge router, hence source routing is used. Source routing means that the packet includes the complete route (or hops) it needs to take to reach the destination. For example, when sending data from one device to another device inside the same 6LoWPAN network, data is first sent from the source device to the edge router, the edge router in turn makes a lookup in its routing table and adds the complete route to the destination in the packet. Storing mode imposes higher requirements on the devices acting as routers (i.e., they need to have resources enough to store the routing and neighbor tables), while using non-storing mode the overhead increases with the number of hops a packet needs to traverse to reach the destination.

6. Conclusion

Accent Lighting is the sagacious application of light to achieve some aesthetic or practical effect. Advances in technology have stimulated significant research and development of intelligent control algorithms pertaining to automated lighting control systems. In this paper, by using DALI protocol, a movable spot is controlled. The presented method can be extended for zoom control by adding zoom motor configuration and also the system grows to be a complete lighting solution, if the control console is improvised by integrating the system with a mobile app.

7. Acknowledgment

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References

[1] SusanG Varghese, Dr.Ciji Pearl Kurian, Dr.V.I George, "A study of Communication Protocols and Wireless Networking Systems for Lighting Control Application", 4th IEEE International conference on Renewable Energy Research and Applications, 2015.

[2] Yuan Ma and Darold Wobschall, "A Sensor Network for Buildings Based on the DALI Bus", IEEE Sensors Applications Symposium San Diego, California USA, 2007.

[3] Francisco Jose Bellido-Outeirino, Jose Maria Flores-Arias, Francisco Domingo-Perez, Aurora Gil-de-Castro, Antonio Moreno-Munoz, "Building Lighting Automation through the Integration of DALI with Wireless Sensor Networks", IEEE Transactions on Consumer Electronics, Vol. 58, No. 1, February 2012.

[4] Yufang Zhong, Huadong Li, Mingguang Wu, "Research of Feedback Control of Lighting System Based on DALI", 7th IEEE International Conference on Industrial Informatics, 2009.

[5] Yuejun Zhang, Ping Zhou, Mingguang Wu, "Research on DALI and Development of Master-Slave module", IEEE, 2006.

[6] P. F. Hein, "DALI – A Digital Addressable Lighting Interface For Lighting Electronics", IEEE, 2001.

[7] Mary Ann George, Srutishree Choudhary, Divyang Sahay, Tejaswini Yerra, Ciji Pearl Kurian," Digitally Addressable Wireless Interface for Lighting Control System", Texas Instruments India Educators' Conference, 2013.

[8] Wei Wu, Mingguang Wu, and Yanpeng Liu, " A Design of Embedded DALI Controller", IEEE International Conference on Industrial Informatics, 2006.

[9] Shun-Chung Wang, Yi-Hua Liu, Yuan-Lin Chen, Jyun-Yan Chen1, "Development of DALI-Based Electronic Ballast with Energy Saving Control for Ultraviolet Lamps", IEEE, 2010.

[10] Jyh-Ching Juang, and Hung-Chi Wang, Chun-Lin Lu, Wen-Ming Chen, and Ching-Wen Hsu, "A Touch-Dim Network for the Dimming Control of Lighting System", IEEE International Conference on Computational Aspects of Social Networks, 2010.