Wireless connectivity for the Internet of Things

Internet of Things (IoT) products require a lots wireless connection. Bluetooth LE, ZigBee and Z-Wave are common protocols. This essay discusses their communication methods, transmission methods, network topology, data throughput, transmission range, hardware requirement and applications.

Explanation of terminologies:

Direct Sequence Spread Spectrum (DSSS) and Frequency Shift Keying (FSK)

DSSS is a common technique to reduce overall signal interference. By wide spreading the signal through multiplying it with a Pseudo Noise Code (a pseudorandom sequence of 1 and -1 with much higher frequency than the signal), the wideband channel becomes noisier, thus it can resist interference [1]. FSK represents a logical 1 or 0 with a shift of 115 kHz higher or lower of the carrier signal [2]. The reason for using frequency shift is that this modulation system is relatively immune to noise as the noise affects the amplitude of the signal the most [3].

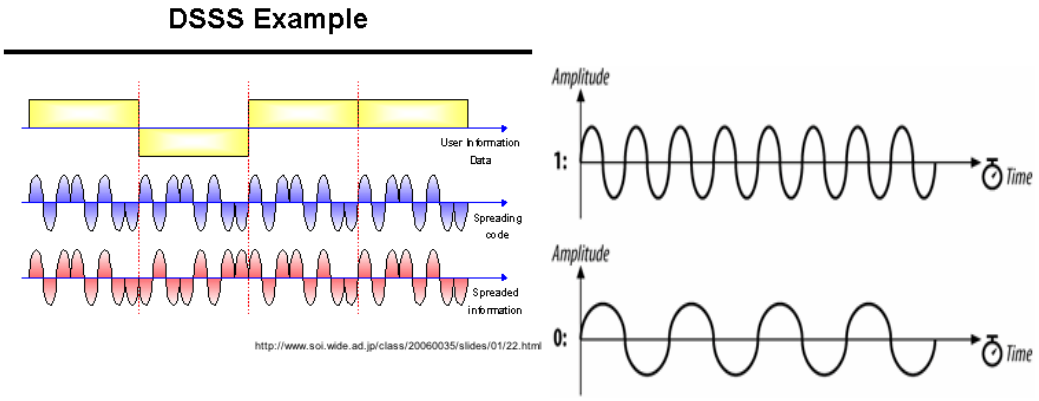

Figure 1 and 2 (DSSS and FSK) :

from https://www.eeweb.com/quizzes/dsss-jamming-margin and [3]

Mesh network and Scatternet

Mesh network is the most common network topology that is used in IoT applications. Each IoT device is a node. Each node in the network acts as both a wireless data source and a repeater. Information from a node hops between nodes until the

transmitted signal reaches the gateway. The main advantage is that the network is very dynamic, so that we can easily add or remove devices from the network. However, mesh networks usually have higher latencies, due to the bottlenecks when several nodes try to send data through a single node.

Scatternet is the network topology of Bluetooth. Each wireless network can contain up to 8 active devices, and this is called the Piconet. Larger network can be formed by combining Piconets to form the Scatternets. In the network, only one device which is the master can be the coordinator to transmit data at the same time. Devices that cannot control other devices are slaves.

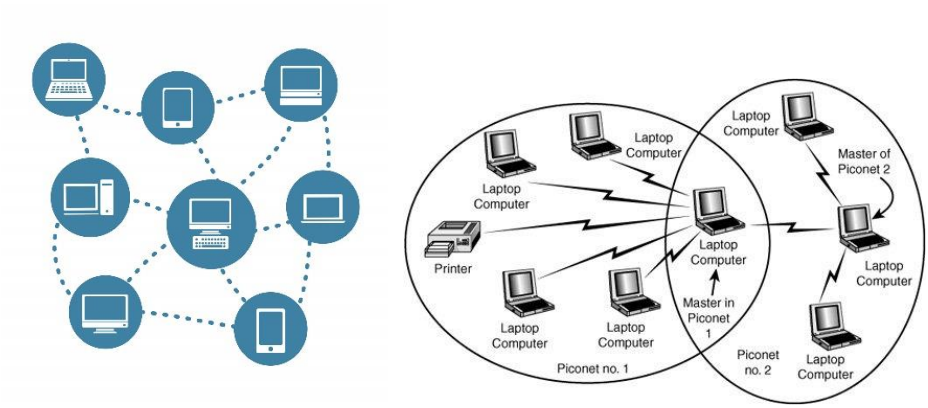

Figure 3 and 4 (mesh network and Scatternets):

From http://www.entcengg.com/bluetooth-architecture-layers-bluetooth/

And http://bestwirelessroutersnow.com/eero-vs-luma/

Protocols:

Bluetooth LE

Bluetooth is a ubiquitous standardized technology that uses the 2.4GHz unlicensed frequency band for communication. Bluetooth LE has come to market in 2011 as Bluetooth 4.0. It uses DSSS for transmitting data and Scatternet as its network topology [4].

Its throughput is designed to be no more than 0.27Mb/s since it is not necessary to send huge amount of data in a small amount of time for IoT applications [5]. Also, it

remains in sleep mode except when a connection is initiated. Therefore, it has low power consumption and thus it is not needed to replace the batteries for long period. The maximum transmission range is same as standard Bluetooth, which is around 100m.

Zigbee

Zigbee is an open technology which also uses 2.4 GHz ISM frequency band for communication, so it may be influenced by Bluetooth or Wi-Fi. It uses DSSS for transmitting data, Mesh network as its network topology and IEEE 802.15.4 low-rate personal area network protocol. The main advantage is its network can contain vast number of nodes. Another advantage is that the transmission range is larger, which is three times of Bluetooth [6]. This leads to a disadvantage of higher power consumption. Its data throughput is up to 0.25 Mbps, which is similar to Bluetooth LE. It is used in security systems, urban smart grid controllers, home automation and lighting controls. However, it is also difficult to setup Zigbee product since it is originally designed for commercial uses, not for residential uses.

Z-Wave

In contrast, Z-Wave is designed for home automation so it is more user friendly, even person with less technology knowledge can easily set-up the IoT product. Since it is a closed technology, product that equipped with Z-Wave is usually more expensive. It also uses mesh network and IEEE 802.15.4 low-rate personal area network protocol, but it uses 915MHz ISM band (in the U.S.) and the 868 MHz RFID band (in Europe), therefore there will never interference with Bluetooth or Wi-Fi that use 2.4GHz frequency band [7] . Another difference is it use frequency shift keying modulation(FSK) rather than DSSS. Its data throughput is 0.1 Mbps, which is slower than Bluetooth LE and Zigbee [8]. The disadvantage is that it requires a Z-Wave hub that serves as the network's controller, so we need more hardware to set up the

network than Bluetooth LE and Zigbee.

In summary, if we need low power consumption, choose Bluetooth LE; if we need longer transmission range and low price, choose Zigbee; if we need the product to be user-friendly, choose Z-Wave.

References

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[7] https://www.link-labs.com/blog/z-wave-vs-zigbee

[8] Mikhail T. Galeev (2006-10-02). "Catching the Z-Wave | Embedded". embedded.com. Retrieved 2015-07-26.