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IOT DIGITAL ASSIGNMENT 1

AIM: To compare the various communication protocols using the given parameters.

CRITERIA	Zigbee	6LowPAN	Bluetooth Low Energy	802.11ah
Data rate	It works in the 802.15.4 standard and its data rates vary from **20 Kbits/s** (868 MHz band) to **250 Kbits/s** (2.4 GHz band).	For different frequency bands, the data rates are different. Maximum data rate for 2.4 GHz band is **250 Kbits/s**, **40 Kbits/s** for 915MHz band and **20 Kbits/s** for 868.3 MHz band.	Devices using Bluetooth 4.0+ (BLE), send low volumes of data (i.e. a few bytes) infrequently. BLE has a data rate of **250 Kbits/s**. With Bluetooth 5.0, BLE's raw data rate is now **1 to 2 Mbit/s**.	The maximum data rates achieved using Wifi HaLow is **78 Mbits/s** when used in 16 MHz bandwidth in Sub-1 GHz. Compared to other technologies, it is indeed a very high data rate.
Transmission power	During transmission of data, the Zigbee module consumes **36.9 mW** of power.	During transmission of data, 6LowPAN consumes **15 mW** of power.	During transmission of data, the Zigbee module consumes only **10 mW** of power.	During transmission of data, 802.11ah can use upto **122mW** of power.
Energy efficiency	**Sleep–wake strategy** is used to enhance energy efficiency. Power consumption is low, thus the energy efficiency is high.	In 6LowPAN **neighbour discovery strategy** is used to enhance efficiency. Thus, since the power consumption is low, the energy efficiency is high.	The BLE device is mostly kept in **power-down mode**. Thus, the power consumption is ultra-low, and the energy efficiency is very high.	802.11ah employs concepts of **TIM, DTIM, TWT** for energy efficiency. The energy efficiency is moderate for Wifi-HaLow.
Frequency	It operates in **2.4 GHz** Industrial, Scientific, and Medical **(ISM) band** as well as Sub-GHz band: 784 MHz in China, 868 MHz in Europe, and 915 MHz in the USA and Australia. ZigBee uses 16 x 2 MHz channels separated by 5 MHz. Also, there is **ZigBee PRO** 2017, a mesh network capable of operating in the 2.4 GHz and 800 - 900 MHz ISM frequency bands together.	6LowPAN follows the **2.4 GHz** frequency band worldwide, while in Nothern America **902-929 MHz** band is used. 6LoWPAN combines IPv6 and Low-power WPAN(LoWPAN). 6LoWPAN can communicate with 802.15.4 devices and also devices on an IP network link WiFi.	BLE operates in the **2.4 GHz** Industrial, Scientific, and Medical (ISM) band and is suited to the transmission of data from compact wireless sensors or other peripherals where fully asynchronous communication can be used.	Launched in 2017, Wifi HaLow, uses the **Sub-GHz 900 MHz** license exempt bands to provide extended range Wi-Fi networks.
Max no. of devices connected	In Zigbee the node address is the physical device (the radio). Each physical device can contain up to 240 logical devices	Referring to a site of Texas Instruments, a 6LowPAN can handle **1000 nodes in a mesh network**.	Although, there was no restriction on the number of slaves as in the original protocol developed, the BLE dongles available have	The network size of 802.11ah can consist of **upto 8000 nodes**. Thus, 802.11ah outperforms the classic 802.11a/ac

	(endpoints). So **technically** you can have roughly **15 million** (2^16 * 240) logical devices on a network. **In practice**, Zigbee networks that reach the **1000s of node** ranges tend to hit technical limitations, but this comes down to the placements of the physical devices relative to each other. Zigbee works best with nodes connected within a **range of 10 – 100 metres**. It works on **mesh topology**.	**Theoretically**, the maximum number of nodes is a very large number, but practically, anything upto 1000 is feasible. Transmission **range** for 6LowPAN is **10-100 metres**.	a restriction of **only 8 slaves connected to a master at once.** However, **three to four devices** is a **practical limit**, depending on the types of devices and profiles are used. Bluetooth 4.0+ has a range of **50-150 metres**. Bluetooth 5.0 has **improved range by up to 4x** compared with the previous version.	protocol when it comes to the network size requirements. Maximum **range** for Wifi HaLow, without repeaters is **1000 meters or 1 kilometer.**
Pros and cons	**PROS:** Uses mesh topology- no single point of failure Network physical coverage is high Suitable for many end nodes at one physical location. **CONS:** Although it has more potential on a larger scale, for smaller projects it can be way overly complicated to set up. Incompatibility between some device vendors who implement non-standard network stacks. These devices have limited interoperability.	**PROS:** 6LowPAN is massively scalable networking as it is IPv6. While the other technologies are bound by different radio standards, 6LowPAN is applicable to any low power, low rate wireless radio device. **CONS:** 6LoWPAN also offers a secure and non-secure mode but the overall security in 6LoWPAN is a work in progress. When it comes to the hardware stack and support, others technologies like Zigbee are ahead.	**PROS:** Simple- Mode of operation can be managed by a small protocol stack Low power- The radio spends nearly all of the time in power-down mode, drawing a negligible current Frequency hopping scheme makes a BLE radio highly resistant to interference at its 2.4GHz licence-free band. **CONS:** BLE can be used for transmitting 'state' data, not for streaming content. In practical scenarios, 1 master node can have only 4-5 slave nodes.	**PROS:** Since it uses the sub-GHz spectrum, there will be less congestion, which means better penetration. Uses a hierarchical network organization with a large number of associated stations (STAs), to improve simplicity and scalability. Has a very large range and can support a considerable number of devices. **CONS:** Has wider range but consumes a huge amount of power when compared to other alternatives.