**Internet of Things (IoT) – Day 2 – 08.09.2022**

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***Concepts***

* ***Communication in IoT systems based on the Bluetooth Low Energy standard Technology***
* *IoT structure and main requirements*
* *General information about Bluetooth and Bluetooth Low Energy (BLE) technologies*
* *Range and versions of the Bluetooth standard*
* *Basics of the BLE radio interface*
* *Application structure for BLE systems in Internet of Things systems*
* *Practical demonstration of the use of communication based on the BLE standard in a simple measurement application*

***Part 1: Introduction to Internet of Things***

***IoT – Internet of Things***

*System of electronic devices with sensors that can collect, process and exchange data through wired or wireless communication:*

* *Smart home devices (washing machines*
* *Industry*
* *Energy sector*
* *Medical devices etc.*

*The condition for the creation of IoT is the combability and capabilities of devices in terms of having appropriate sensors and modules responsible for mutual communication.*

*Due to the multiplicity of devices, it is necessary to unambiguously identify a specific device:*

* *IP addresses*
* *MAC addresses*
* *Product serial codes*

***Main requirements of the IoT application to the networks used***

*The main requirements of the IoT application to the networks used:*

* *Low energy consumption (large number of sensors deployed in remote locations)*
* *Low fees for using network*
* *Equipment used should be simple and cheap*
* *Long-distance transmission resistant to disturbances*
* *Large network capacity to support a large number of devices*
* *Adequate level of security of the communication network*

***Bluetooth***

*Bluetooth is a standard for short-range wireless communication between various electronic devices such as:*

* *Keyboards*
* *Computers, laptops*
* *Smartphones*
* *Wireless headphones*
* *And many others*

*More about Bluetooth:*

* *Open standard described in the IEEE 802.15.1 specification but no longer supported by the IEEE*
* *Currently managed by the Bluetooth Special Interest Group (SIG)*
* *SIG has more than 35,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics.*

***Bluetooth SIG***

* *Bluetooth SIG oversees development of the specification, manages the qualification program, and protects the trademark*
* *Each manufacturer must comply with the Bluetooth SIG standards in order to market their product as a Bluetooth device*
* *Technology applies to a network of patents that are licensed for each qualifying device (in 2021 the amount of Bluetooth chips produced was nearly 5 billion units)*

***The name Bluetooth***

* *The name “Bluetooth” was proposed in 1997 by Jim Kardach of Intel, one of the founders of the SIG*
* *Kardach was fascinated by the first Danish king Harald, who contributed to the unification of rival clans (just like the technology under development)*
* *King Harald was called Bluetooth*
* *Kardach proposed Bluetooth as the codename for the short-range wireless technology*
* *He chose the first character from the runic notation of King Harald’s nickname (*𐌁) *as the logo of the standard*

***Bluetooth development***

*In 1999, the Bluetooth SIG published a 1500-page specification for the first version of Bluetooth technology and is constantly working to improve it.*

*The current version of the specification has more than 3000 pages and covers the complete system, from the physical layer to the application layer*

***Bluetooth – Classic***

* *The Bluetooth Classic is a low power radio that streams data in the 2.4GHz (2.402 – 2.480GHz) unlicensed frequency band supporting point-to-point device communication.*
* *The spectrum of this band is divided into 79 channels, each of them has a 1MHz band.*
* *Bluetooth uses a radio technology called frequency-hopping spread spectrum. Bluetooth divides transmitted data into packets (parts) and transmits each packet on one of 79 Bluetooth channels. It usually performs 1600 hops per second, with adaptive frequency-hopping enabled.*
* *Each packet is sent on a specific channel, after which the air interface selects a new channel on which the next packet will be sent. Thanks to this process, the message is transmitted over the entire available frequency spectrum.*
* *For this reason, it is required that the transmitter and receiver are properly tuned so that the receiver knows the hop pattern and can receive the packets and then assemble them into a complete message.*
* *The Bluetooth network model is a proximity network-based communication model. Which means devices can automatically, spontaneously connect whenever they are in within range.*
* *They are based on the master-slave model, when devices are establishing a connection with each other, one is the master and the other is the slave.*
* *All slave devices that communicate with the master device create a piconet, where the number of active slaves cannot exceed seven.*
* *The Bluetooth Core Specification provides for the connection of two or more piconets to form a scatternet, in which certain devices simultaneously play the master role in one piconet and the slave role in another.*
* *All devices within a given piconet use the clock provided by the master as the base for packet exchange.*
* *Each Bluetooth device has a unique address provided by the manufacturer. Which excludes the situation that two different Bluetooth devices, e.g. a mouse and a keyboard, will stop connecting to the computer and start with each other.*
* *Receiver sensitivity is the measure of the minimum signal and strength receiver can interpret.*
* *Bluetooth technology specifies that devices must be able to achieve a minimum receiver sensitivity of -70 dBm to -82 dBm, depending on the physical layer used.*

***Bluetooth – Frame structure***

* *Access-code: Identifies the master for the slave device within the range of two master devices to which the transmission is to take place.*
* *Header: 54 bits, 18 bits of header repeated three times, on the receiving side, all three copies of each bit are checked.*
* *Data: Up to 2744 bits containing data (for a 5-slot frame). For a one-shot transmission, the frame contains 240 bits of the data field.*

***BLE – Bluetooth Low Energy (Bluetooth LE)***

*The Bluetooth Low Energy (BLE) radio, which is designed for very low power operation, uses the same 3.4GHz frequency band, but divides it into 40 channels with a width of 2MHz each.*

*The BLE is designed to operate with very low energy consumption. It supports multiple communication topologies:*

* *Point-to-point*
* *Broadcast*
* *Mesh*

*BLE now includes features that enable one device to determine the presence, distance, and direction of another device.*

*BLE greatly reduces power consumption by turning off the data transmission module when nothing is transmitted.*

*Contrary to the classic Bluetooth module, the transmission is carried out on the basics of intervals and not a permanent connection.*