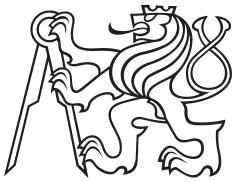


České
vysoké
učení technické
v Praze

F3

Fakulta elektrotechnická
Katedra telekomunikační techniky

Low power wireless sensor network

Tomáš Hyhlík

Vedoucí: Ing. Bc. Marek Neruda, Ph.D
Školitel–specialista: Ing. Bc. Lukáš Vojtěch, Ph.D
Obor: Elektronika a komunikace
Studijní program: Elektronika
Říjen 2019

Poděkování

Prohlášení

Abstrakt

Účelem této práce je...

Klíčová slova: sensor network

Vedoucí: Ing. Bc. Marek Neruda, Ph.D

Abstract

The purpose of this work is...

Keywords: sensor network

Title translation: Low power wireless sensor network

Obsah

Obrázky

Tabulky

0.1 List of Abbreviations

BLE ..... Bluetooth Low Energy

I2C ..... Inter-integrated Circuit

IoT ..... Internet of Things

IPv6 ..... Internet Protocol version 6

ISM ..... Industrial, scientific and medical

M2M ..... machine to machine

RF ..... Radio Frequency

RPMA ..... Random Phase Multiple Access

SDK ..... Software development kit

SF ..... Spread factor

SPI ..... Serial Peripheral Interface

Kapitola 1

Low power wireless network technologies

In the appendix is table where all widely used low power wireless technologies are compared. This chapter additionally provide a brief description of all these technologies, but the main parameters are only in the table. All these technologies use license-free ISM bands.

1.1 IQRF

This technology aims to make it easy to implement wireless solutions. It enables peer-to-peer, star and mesh network communication modes. The IQRF alliance provide IQRF transceivers for $15-20 with a few serial interfaces such as SPI, I2C, UART etc. and they also provide open source SDK which makes it very easy to use IQRF modules. The SDK is based on Java so it's compatible with various platforms such as Linux and Windows [1] [2] [3] [4].

1.2 Wireless M-bus

"Wireless Meter Bus has its origins within the Meter-Bus standards. This is a field bus standard aimed at applications for collecting meter data for gas, electricity, water, etc." [5] It supports a few application modes for differing applications.

- S1 Unidirectional, data are transmitted only a several times a day.
- S2 Bidirectional version of S1.
- T1 Unidirectional transmission of data with a period of a few seconds of minutes.
- T2 Bidirectional version of T1.

- C1 Unidirectional transmission of bigger amount of data.
- C2 Bidirectional version of C1.

Usually one M-bus device support only a few of these application modes [5] [6] [7] [8].

1.3 Zigbee

Zigbee, developed by zigbee alliance is usually used for mesh sensor networks because of its short range. This technology is standardized since 2003, so there is many available nodes at the market by now [10] [11] [12].

1.4 Bluetooth

Bluetooth has the big advantage, taht it's built in almost every mobile phone, tablet or laptop so there are more options to control the network. The Bluetooth 4.0+ also called BLE (Bluetooth Low Energy) aims to low power wireless sensor networks. It can be used for point-to-point, broadcast or mesh network topology [13] [14] [15] [16].

1.5 LoRa

The name LoRa stands for "Long Range"wireless communication with low data rate and power consumption. The protocol enables to modify SF which affects the communication range and data rate. The 1.1 shows this dependence.

Spreading Factor (125kHz Lora)	Bit rate(bps)	Range (varies on propagation conditions)	Time on air(ms) (10 bytes payload)	0.1% of Time on air waiting time	1% of Time on air waiting time
SF7	5470	2 km	56 ms	1 min	6s
SF8	3125	4 km	100 ms	1 min 40s	10s
SF9	1760	6 km	200 ms	3 min 20s	20s
SF10	980	8 km	370 ms	6 min 10s	37s
SF11	440	14 km	740 ms	12 min 20s	1 min 14s
SF12	290	20 km	1400 ms	23 min 20s	2min 20s

Obrázek 1.1: LoRa spread factor options [24]

This technology is very attractive for its long range capability and easy to connect nodes. It's complicated to build a full-capacity gateway which is capable of receiving packets at all frequency channels and SF in parallel. The transceiver for this application costs about $130. Although it's also possible to build single-channel gateway which is way too cheaper, but it can receive packets at only one frequency channel and SF at once [17] [18] [19] [20] [21] [22] [23] [24].

1.6 Sigfox

This technology focuses on short message and long range communication applications [25] [26].

1.7 Z-Wawe

Z-Wave is intended for wireless connectivity for all possible smart home products, controlled by PC, phone, voice, etc. It's based on mesh network topology so every non-battery powered device works as a router to enhance the network range so the more devices are connected in one network, the stronger the network is [27] [28].

1.8 Thread

This technology based on IPv6 was developed for home network controlled by smartphone, tablet or PC [29] [30] [31].

1.9 RPMA

The "Random Phase Multiple Access"developed by Ingenu designed for M2M and IoT applications [32] [33] [34]. *"RPMA has been deployed for the Machine Network, but can also be rolled out as a private network installation. It is highly suitable for regions, where the rollout of 3GPP LPWA technologies is lagging, where cellular coverage is generally weak, or where users would like to exert full control over their network deployments."*[33]

Kapitola 2

The design of the sensor network

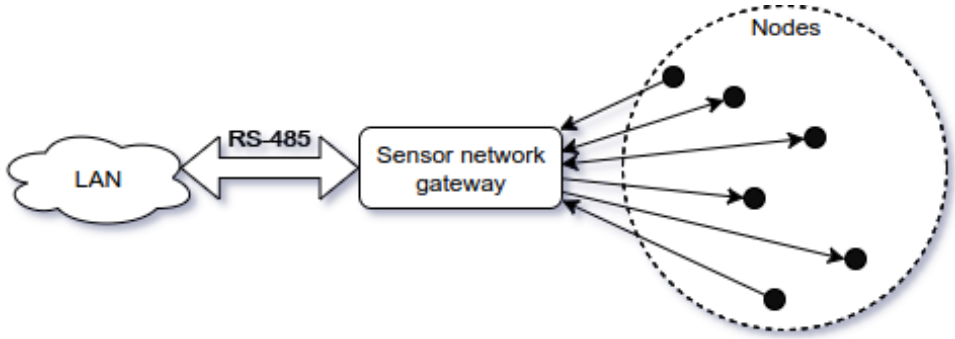
2.1 Block diagram

2.1.1 Node

The node as an any device that transmits data in the network. In the star network topology it could be only a sensor or an actuator accessed by the gateway, because there are no routing devices or other. [35].

2.1.2 Gateway

The gateway handles the communication with all the nodes and transmits the data to other network or device [35]. In this case the gateway is accessed by the LAN through RS-485 interface.



Obrázek 2.1: The block diagram of the sensor network

2.2 The requirements for the wireless technology

The main requirement for the designed network is ability to add many various nodes which are available at the market to the network, so we don't have to make our own nodes for every kind of application. The other requirements are price, power consumption, range etc.

2.3 The final choose of the low power wireless technology

From all the compared technologies in the table in appendix is chosen LoRa, because its nodes are easy to implement to the network with no restrictions. For example there is also many BLE nodes available at the market, but many of manufacturers say that their nodes are compatible only with their own network gateway so it may not be possible to add the node to our designed network. To make it simple and cheap only single channel gateway is used which means that all the devices in the network must be configured to one predefined channel and SF.

Literatura

[1] *RF.* IQRF Alliance.
[Online]. Available: https://www.iqrf.org/technology/rf [Accessed: 9-Jun-2018].

[2] *IQRF SDK.* IQRF Alliance. [Online]. Available: https://www.iqrf.org/technology/iqrf-sdk [Accessed: 9-Jun-2018].

[3] *Transceivers.* IQRF Alliance.
[Online]. Available: https://www.iqrf.org/products/transceivers [Accessed: 9-Jun-2018].

[4] *IQRF SDK.* IQRF Alliance. [Online]. Available: https://www.iqrf.org/technology/iqrf-sdk [Accessed: 9-Jun-2018].

[4] *Three security levels in new IQRF OS 4.0.* IQRF Alliance. [Online]. Available: https://www.iqrfalliance.org/news/117-three-security-levels-in-new-iqrf-os-4-0 [Accessed: 9-Jun-2018].

[5] *Wireless Meter Bus, WM-Bus Technology.* Radio-Electronics. [Online]. Available: http://www.radio-electronics.com/info/wireless/wireless-m-bus/basics-tutorial.php [Accessed: 9-Jun-2018].

[6] *Wireless M-Bus in Industrial Wireless Sensor Networks.* Radiocrafts. [Online]. Available: https://radiocrafts.com/technologies/wireless-m-bus-technology-overview/ [Accessed: 9-Jun-2018].

[7] Radiocrafts: *WirelessM-Bus in Industrial Sensor Networks.* [Online]. Available: https://radiocrafts.com/uploads/AN024_Using_Wireless_M-BUS_in_Industrial_Sensor_Networks_1_0.pdf [Accessed: 9-Jun-2018].

[8] Silicon labs: *WIRELESS M-BUS SOFTWARE IMPLEMENTATION.* [Online]. Available: https://www.silabs.com/documents/public/application-notes/AN451.pdf [Accessed: 9-Jun-2018].

[9] Compass security: *Wireless M-Bus Security Whitepaper Black Hat USA 2013.* June 30th. 2013, v1.01. [Online]. Available: https://www.compass-security.com/fileadmin/Datein/Research/Praesentationen/blackhat_2013_wmbus_security_whitepaper.pdf [Accessed: 9-Jun-2018].

[10] *Zigbee.* Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Zigbee [Accessed: 9-Jun-2018].

[11] Xueqi Fan, Fransisca Susan, William Long, Shangyan Li: *Security Analysis of Zigbee.* May 18, 2017. [Online]. Available: https://courses.csail.mit.edu/6.857/2017/project/17.pdf [Accessed: 9-Jun-2018].

[12] *The Zigbee Alliance.* Zigbee alliance. [Online]. Available: http://www.zigbee.org/zigbee-for-developers/about-us/ [Accessed: 9-Jun-2018].

[13] *Bluetooth sensor network.* mikroelektronika. [Online]. Available: https://www.mikroe.com/blog/bluetooth-sensor-network [Accessed: 9-Jun-2018].

[14] *Dispelling Common Bluetooth Misconceptions.* Sans technology institute. [Online]. Available: https://www.sans.edu/cyber-research/security-laboratory/article/bluetooth [Accessed: 9-Jun-2018].

[15] *Bluetooth radio interface, modulation, & channels.* Radioelectronics. [Online]. Available: http://www.radio-electronics.com/info/wireless/bluetooth/radio-interface-modulation.php [Accessed: 9-Jun-2018].

[16] Kianoosh Karami: *BLE Packet.* Punch through. November 07 2016. [Online]. Available: https://punchthrough.com/blog/posts/maximizing-ble-throughput-part-2-use-larger-att-mtu [Accessed: 9-Jun-2018].

[17] *LoRa Wireless for M2M & IoT.* Radioelectronics. [Online]. Available: http://www.radio-electronics.com/info/wireless/lora/basics-tutorial.php [Accessed: 9-Jun-2018].

[18] *LoRa Network: LoRaWAN.* Radioelectronics. [Online]. Available: http://www.radio-electronics.com/info/wireless/lora/lorawan-network-architecture.php [Accessed: 9-Jun-2018].

[19] *Understanding the Limits of LoRaWAN.* IEEE. Communications Magazine. January 2017 [Online]. Available: https://arxiv.org/pdf/1607.08011.pdf [Accessed: 9-Jun-2018].

[20] BRIAN RAY: *Use Cases and Considerations for LoRaWAN.* Link-labs. June 20, 2016. [Online]. Available: https://www.link-labs.com/blog/use-cases-and-considerations-for-lorawan [Accessed: 9-Jun-2018].

[21] *LoRa Physical Layer & RF Interface.* Radioelectronics. [Online]. Available: http://www.radio-electronics.com/info/wireless/lora/rf-interface-physical-layer.php [Accessed: 9-Jun-2018].

[22] Kianoosh Karami: *BLE Packet* Punch through. November 07, 2016. [Online]. Available: https://punchthrough.com/blog/posts/maximizing-ble-throughput-part-2-use-larger-att-mtu [Accessed: 9-Jun-2018].

[23] *Build your own gateway.* The things network. [Online]. Available: https://www.thethingsnetwork.org/docs/gateways/start/build.html [Accessed: 9-Jun-2018].

[24] *LoraWAN in Europe.* Match X. [Online]. Available: https://matchx.io/community/eu/12-lorawan-in-europe [Accessed: 9-Jun-2018].

[25] Ian Poole: *SIGFOX for M2M & IoT.* Radioelektronics. [Online]. Available: http://www.radio-electronics.com/info/wireless/sigfox/basics-tutorial.php [Accessed: 9-Jun-2018].

[26] *SIGFOX for white paper security.* Sigfox. February 2017. [Online]. Available: https://www.sigfox.com/sites/default/files/1701-SIGFOX-White_Paper_Security.pdf [Accessed: 9-Jun-2018].

[27] *Z-Wave.* Z-wawe Alliance. [Online]. Available: http://www.z-wave.com/about [Accessed: 9-Jun-2018].

[28] *Z-Wave.* Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Z-Wave [Accessed: 9-Jun-2018].

[29] *What is thread.* Thread group. [Online]. Available: https://www.threadgroup.org/What-is-Thread [Accessed: 10-Jun-2018].

[30] *Thread (network protocol).* Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Thread_(network_protocol) [Accessed: 10-Jun-2018].

[31] *Experimental Study of Thread Mesh Network for Wireless Building Automation Systems.* EXAMENSARBETE INOM ELEKTROTEKNIK. STOCKHOLM. SVERIGE 2016. [Online]. Available: http://www.diva-portal.org/smash/get/diva2:1040491/FULLTEXT02 [Accessed: 10-Jun-2018].

[32] *RPMA TECHNOLOGY.* Internet of things. [Online]. Available: https://theinternetofthings.report/Resources/Whitepapers/4cbc5e5e-6ef8-4455-b8cd-f6e3888624cb_RPMA%20Technology.pdf [Accessed: 10-Jun-2018].

[33] *RPMA.* Ublox. [Online]. Available: https://www.u-blox.com/en/rpma [Accessed: 10-Jun-2018].

[34] *RPMA TECHNOLOGY.* Ingenu. [Online]. Available: `https://www.ingenu.com/technology/rpma/` [Accessed: 10-Jun-2018].

[35] *What Is a Wireless Sensor Network?* National Instruments. 24.8.2016. [Online]. Available: `http://www.ni.com/white-paper/7142/en/` [Accessed: 14-Jun-2018].