The Issue of LPWAN Technology Coexistence in IoT Environment

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***Abstract*—This paper discusses Low Power Wide Area Network technologies. The purpose of this work is a presentation of these technologies in a mutual context in order to analyse their coexistence. In this work there are described Low Power Wide Area Network terms and their representatives LoRa, Sigfox and IQRF, of which characteristics, topology and some significant technics are inspected. The technologies are also compared together in a frequency spectrum in order to detect risk bands causing collisions. A potential increased risk of collisions is found around 868.2 MHz. The main contribution of this paper is a summary of characteristics, which have an influence on the resulting coexistence.**

Keywords-Coexistence; IQRF; Low Power Wide Area Network; LPWAN; LoRa; Sigfox

I. Introduction

The invention of Low Power Wide Area Network (LPWAN) came from an idea of Machine-to-Machine (M2M) communication, which was created for a transmission of information in a network, especially, without a human interaction [1-4]. LPWAN networks are the part of the Internet of Things (IoT), which can help end users with a wide range of applications.

It has been published several papers on the topic of LPWANs, which describe problems from various views. The paper [5] describes techniques and methods of carrier sensing to be suitable for LPWANs. The paper [6] presents a different kind of application scenarios and their requirements. Measurements of interference by IEEE 802.11 (WiFi) to IEEE 802.15.4 (WirelessHART) are described in [7]. The paper [8] proposes a distributed scheduling scheme for IoT wireless devices to maximize a bit rate of the network. The paper [9] presents a description of opportunities and threats that arise from a new comprehensive system of IoT in individual sectors.

Some text analyses possibilities of specific technologies such as [10], which shows differences of several existing wireless technologies to LPWAN technologies and describes their possibilities. It also shows concrete examples of LPWAN technologies. The paper [11] describes details of Ultra Narrow Band (UNB). It presents specifically a channel access including Time/Frequency Aloha, which is a random access scheme adapted for UNB. The paper [12] refers to their own experiments with LoRa, which are conducted in the city of Oulu, Finland, to find out real-life characteristics in 868 MHz for the mentioned technology. A design of a new narrowband M2M system built from existing LTE functionalities for LPWAN systems is described in [13].

This paper describes fundamental characteristics of LPWAN and shows a description of the three technologies, which are the part of LPWANs. It compares technologies from a view of their parameters and especially a frequency spectrum. It also presents a division of other technologies in a spectrum.

The rest of the paper is organized as follows: Section 2 describes fundamental characteristics of Low Power Wide Area Network and unlicensed bands, section 3 and 4 present detailed information of frequency spectrum, section 4 and 5 describe probability of occurrence and collision on the channel, section 7 presents capacity of the number of device on the channel. Conclusion is described in section 6.

II. LPWANs and Unlicensed Bands

The Low-Power Wide Area Network is a basic name for a wireless technology in wide networks, concretely type of WAN. Each specific technology is in charge of private subjects. These are basically development groups from all over the world, which test their own inventions. These network technologies involve a connection of devices with a low bandwidth and focus on energy and transmission efficiency. Low-Power WAN technologies are designed according conditions of networks using M2M communication.

Nowadays it is known a big progress in this branch, especially because of the fact, that LPWANs manage lower power requirements, a signal coverage in the area of units and tens of km and a lower bandwidth than the existing mobile networks. That is why LPWANs can use a modified bi - directional communication and also work with lower financial expenses than the mobile networks.

Some current technologies in the Internet of Things environment are proper for a usage for end users such as Bluetooth, ZigBee and Wi-Fi. Whereas LPWAN technologies are much more useful in industry, civil and commercial areas, where the main effort is to improve a communication from side of an efficiency and power requirements. Therefore, it can be stated that LPWAN technologies have a big financial and technical potential into the future [14].

Additional expenses are also payments for licensed bands, which every network provider have to pay. However, mayor technologies mentioned in the next sections work in unlicensed

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bands defined by European Telecommunications Standards Institute (ETSI) [15] and International Telecommunication Union (ITU) [16], which are represented for instance by Industrial, Scientific and Medical (ISM) bands. There is no payment for a usage of the ISM band [5].

Specifications of technologies Main characteristics of the three deputies of LPWAN technologies are summarized in the Tab. 1.

TABLE I. MAIN CHARACTERISTICS OF LORA, SIGFOX AND IQRF TECHNOLOGIES [17-23]

	LoRa	Sigfox	IQRF
Frequency bands	868 MHz (Europe) 915 MHz (N. America) 433 MHz (Asia)	868 MHz (Europe) 915 MHz (USA)	868 MHz (Europe) 915 MHz (N. America) 433 MHz (Asia)
Maximum range	15 - 20 km	30 - 50 km (countryside) 3 - 10 km (urban)	Hundreds meters
Data rates (DR)	0.25 - 50 kbit/s	100 bit/s	1.2 - 115 kbit/s Typical 20 kbit/s
Topology	STAR	STAR	MESH
Modulation	FSK s FEC	UNB (DBPSK)	FSK
Payload	2 - 255 B	Max 12 B	Max 128 B
Transmitted power	10 – 18 dBm	0 – 14 dBm	Optional Max 11 dBm

A. LoRa Technology

Long Range WAN alias LoRaWAN or simply LoRa is a complex of specification for LPWA networks. It was made by association LoRa® Alliance, which is concerned with the IoT, M2M communication, Smart cites etc. Main producers of LoRa devices are companies Semtech and Microchip.

LoRa is wireless network using on physical layer techniques direct sequence spread spectrum (DSSS). It enables to communicate on signals with a low value of power and uses frequency-shift keying (FSK), which changes a carrier wave according to a value of a modulated signal. In the case of using forward error correction (FEC) it is possible to demodulate also signals 20 dB under a noise level. It is much lower signals than in traditional FSK systems and it makes a sensitivity up to -148 dBm [6].

The technology has many possible data rates, payloads and bandwidth according to LoRa specification [18]. This options are chosen along the specific application. The most used bandwidths are 125 and 250 kHz. These devices work in the global free unlicensed frequency bands such as 868 MHz for Europe, 902 MHz for North America and 433 MHz for Asia. The LoRa system enable to set between the end devices and the central note several frequency channels and data rates, where the most important channels using JoinReq messages for joining the network are summarized in Tab. 2. However, LoRa can work on the channels with almost any frequency from 863 to 870 MHz.

TABLE II. DEFAULT CHANNELS AND CHANNELS FOR TRANSMITTING JOINREQ MESSAGES FOR LORA DEVICE [18]

Modulation	BW [kHz]	Channel Frequency [MHz]	FSK bitrate / LoRa bitrate	Nb. Channels	Duty cycle
LoRa	125	868.10 868.30 868.50	0.3-5 kbps	3	≤ 1.0 %
LoRa	125	864.10 864.30 864.50 868.10 868.30 868.50	0.3-5 kbps	6	≤ 0.1 %

The devices use channels also for a reverse transmission. LoRa provides two downlink windows, which are specified in a documentation [18]. The same channel as for the previous uplink is used for the first window and the default channel 869.525 MHz with the data rate 250 bit/s is used for the second one [17, 24].

B. Sigfox Technology

The Sigfox technology is a name of a network technology, which was developed by a group from France with the same name. It is another representative of networks, which enable to become the part of the IoT.

The Sigfox technology uses on the physical layer a technique of the Ultra Narrow Band (UNB), apart from LoRa system and DSSS technique. Important characteristics of UNB are big flexibility with antennas, which could be chosen for a given situation, and a tiny bandwidth only 100 Hz, which makes a better security against an influence of an interference. The Sigfox devices allow also to demodulate signal with a small received power, sensitivity is up to – 142 dBm. Sigfox network is setting in the star topology, which reduces construction expenses and others.

The network works in the global free unlicensed frequency bands such as 868 MHz for Europe, 902 MHz for USA. It depends also on other regulations of the state. Sigfox spectrum in 868 MHz is divided into 400 channels from 868.18 to 868.22 MHz. It is shown in the Fig. 1. The channels with numbers 181 and 219 are reserved for a future usage. Frequencies for reverse transmission are situated 1 MHz higher and with the data rate 500 bit/s [19, 20, 26].

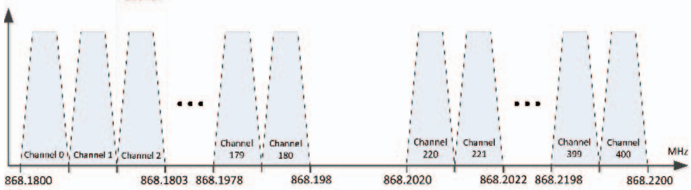

Figure 1. Fixed defined channels 0 - 400 by 100 Hz in range 868.180 – 868.220 MHz [25].

C. IQRF Technology

The IQRF technology is one of wireless technologies, which aim at IoT applications. It is involved in the group of LPWAN technologies, but it has some differences to the common mentioned representatives. It was developed by IQRF Alliance with a residence in Písek, Czech Republic.

IQRF technology works with radio transceivers (TR) with a microcontroller (MCU), which has own operating system. The whole system implements the mesh topology instead of the star topology, which is the biggest difference to other LPWAN technologies such as LoRa and Sigfox. It uses own IQMESH protocol to provide easier all advantages of the mesh topology.

The technology is specified for the unlicensed frequency bands 868, 916 and 433 MHz. It uses a specific amount of channels in these bands, which is different for each band. In 868 MHz band it is defined 62 fixed channels, which are in a range from 863.15 to 869.25 MHz. Each channel has 100 kHz bandwidth. The detailed schema of channels is placed in channel maps [21]. The default channel number 52 working on 868.35 MHz is used really often and operates with the most common data rate 19.836 kbit/s [21, 27].

III. Coverage of LPWA Technologies in the Spectrum

The spectral distribution and the channels of all the three mentioned technologies are shown in Fig. 2. The channels for downlink are not displayed, because they are situated higher than 869 MHz in the spectrum and don't overlap one each other. Figure 2 shows also only the most important default LoRa channels for sending JoinReq messages. However, LoRa can work on the channels with almost any frequency from 863 to 870 MHz.

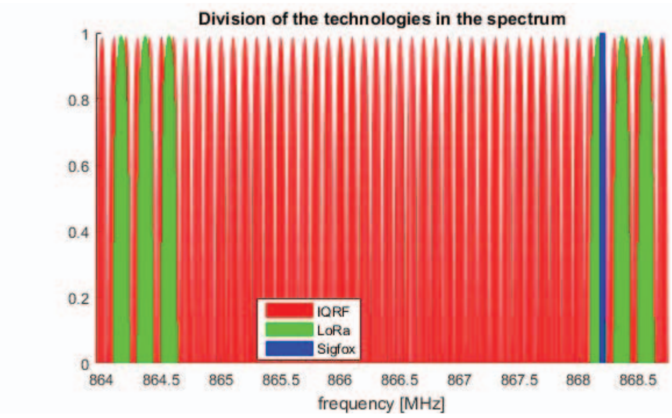

Figure 2. Division of LoRa, Sigfox and IQRF technologies in range 863.95-868.75 MHz.

It is mostly obvious that IQRF covers all shown frequency range because of used channels. LoRa works with the channels using the wider bandwidth than IQRF and their maximum number is not precisely specified. Otherwise Sigfox covers really the tiny part of the spectrum, what corresponds with UNB technique. The channels of Sigfox look like one line in this figure, because it results from their small bandwidth only 100 Hz.

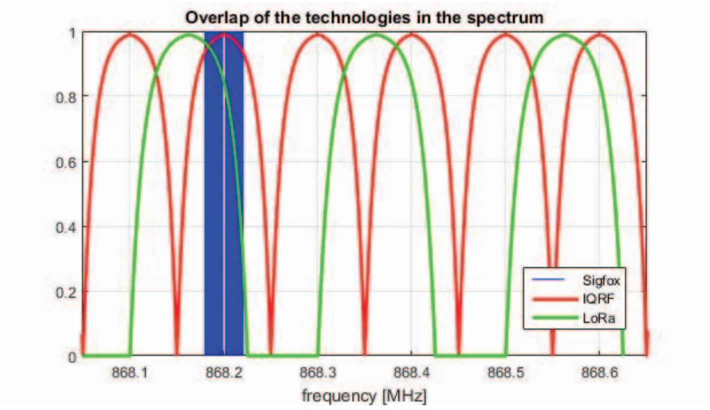

Figure 3. Division of the technologies in smaller range 868.05-868.65 MHz.

Figure 3 shows the same frequency spectrum with the technologies more in detail. It shows just this part of the spectrum around 868 MHz, because of an appearance of all the three technologies. LoRa has here 3 main channels with bandwidth 125 kHz, which occur in every LoRa device. IQRF has in this section 6 channels and one of them is default channel number 52 beginning on 868.35 MHz, which is used often in his devices and Sigfox has situated all channels around 868.2 MHz.

The spectrum in a range 868.10 – 868.25 MHz is depicted in Fig. 4. This spectrum part contains the main channels, which have a big importance in the problem of potential collisions and a final coexistence. It results from the situation that more technologies, which overlap one each other, are situated in this part of spectrum. These are LoRa with the channel starting in 868.1 MHz, IQRF with the channel starting in 868.15 MHz and Sigfox technology with all channels.

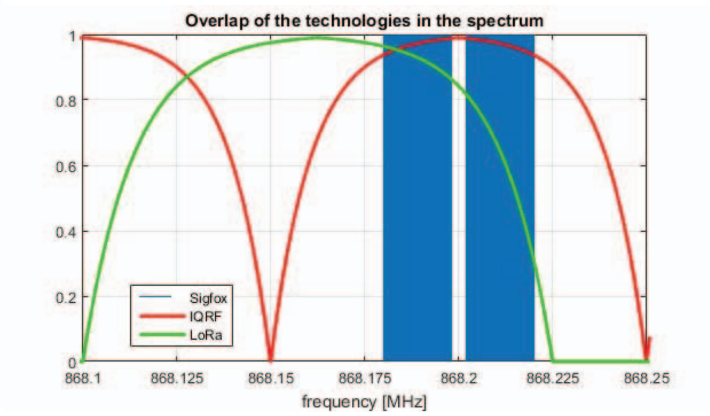

Figure 4. Division of the technologies in range 868.1-868.25 MHz.

This part of the spectrum especially around 868.2 MHz could be problematic, because here could happen accidentally collisions, which could interfere and interrupt communication. The probability of collisions is in this part much higher than in others. Finally, the higher amount of devices, which is expected, also increases a chance of collisions [18, 22, 25].

IV. OTHERS CONFLICTING TECHNOLOGIES IN THE SPECTRUM

Many others technologies exist in the world, which are used for various purposes and operate in many frequency bands. Because the whole frequency band is shared medium for all and also limited, it is necessary to keep in mind these technologies for a possible coexistence with LPWANs.

Possible complications can rise especially in technologies, which are frequency conflicting with ranges of LPWANs. Because of this reason it is chosen the main six technologies working in the similar frequencies such as Personal Mobile Radio (PMR), Wireless voice transmission, Mobile networks etc. LTE and GSM mobile networks are very popular and the correct division of 800 or 900 MHz frequency bands according defining documents is well known. They cover a big amount of frequencies in 800 MHz band except security intervals of the mobile networks. More details are presented in Tab. 3.

TABLE III. OTHER TECHNOLOGIES CLOSE IN FREQUENCY TO LPWANS [28-30]

	Alarm devices	**Wireless voice transmission**	**Radio Frequency Identification (RFID)**
Frequency bands [MHz]	868.60 – 868.7 869.20 – 869.4 869.65 – 869.7	863 – 865	865.0 – 868.0 865.6 – 867.6 867.6 – 868.0
	Security intervals of mobile networks	**Mobile networks LTE and GSM**	**Personal Mobile Radio (PMR)**
Frequency bands [MHz]	862 – 863 870 – 872	832 – 862 876 – 880 (GSM-R)	870 – 876

The first of three conflicting technologies in the spectrum is for alarm devices, which use a radio communication for an alarm indication that can happen in a far place. The technology has specified a small duty cycle and a really small usage of the spectrum, which help to improve reliability.

The next technology for wireless voice transmission is defined for a hearing aid, wireless microphones, speakers, headphones and devices for listening-in. The Radio Frequency Identification (RFID) technology uses radio transceivers and generally passive “tags” fixed on all kind of things. RFID technology is instrumental to identification and monitoring objects and to avoid thefts etc. These two technologies have not defined duty cycle, because the devices work in the mode Listen Before Talk (LBT).

Question is if these technologies will affect someway the final coexistence in the band 863–870 MHz used by LPWANs. The biggest barrier could be the mobile networks according their width and character, but they don’t overlap with LPWANs. It is very probable that developers of LPWANs chose just this band, because of an absence of the mobile networks. Other mentioned technologies already overlap with LPWANs, but they are not hazardous aspects as the mobile networks, because of the different character of the technologies.

The technology for alarm devices does not create a big risk for the coexistence using a slim part of the spectrum and a small duty cycle, although alarm devices use a global communication range. Otherwise RFID and Wireless voice transmission technology have a radius of communication much shorter. It is possible to say that these technologies could be found only in small areas on concerts or around security gates and occur occasionally. This minimizes rapidly possibilities of potential problems with the parallel operating technologies [24-26].

V. THE PROBABILITY OF OCCURRENCE ON THE CHANNEL

All calculations and considerations of time distribution and probability of technologies Lora, Sigfox and IQRF are made assuming that all technologies are working on overlaping frequency channels. It is only a single possible combination of channels for these technologies, Fig. 2. It includes Lora channel starting at 868.1 MHz, IQRF channel no. 50 starting at 868.15 MHz and all Sigfox channels due to its bandwidth. These channels are shown in detail in Fig. 4.

According this assumption, the timing of individual technologies and their resulting statistics and probabilities, which suggest a possible mutual coexistence on the same channel, can be considered. Individual variants with the greatest load time on the channel, so in terms of time it is the worst possible option, are selected for calculation of the resulting probability. It includes Lora DR0 (DataRate0) and IQRF low datarate [18], [21]. Sigfox technology offers only one variant.

Table 4 shows the comparison of these technologies. One transmission period is calculated from the data rate and the message size. Lora Modem Calculator tool is used for LoRa devices.Time of occurrence for each of variants during 24h in order to better comparison is also mentioned. A prerequisite for all technologies is a broadcast of 140 messages per day, which is the maximum value defined for the technology Sigfox. A part of that time is also period of retransmission messages occurring in Sigfox devices and transmission times for the downlink, which are differently defined for each technology. The resulting time, when the devices are active, are shown and graphically compared in Fig. 5.

TABLE IV. TIME AND TRANSMISSION DATA OF SELECTED VARIANTS OF TECHNOLOGIES

	LoRa DR0	**Sigfox**	**IQRF low DataRate**
Bit rate [bit/s]	250	100	1200
Maximal payload [B]	59	12	64
One transmission period [s]	2.30	2.00	0.85
Occurance on the channel during a day [s]	378.28	840.00	119.47
Occurance on the channel during a day[%]	0.4378	0.9722	0.1383
Probability of occurrence on the channel [-]	0.004378	0.009722	0.001383

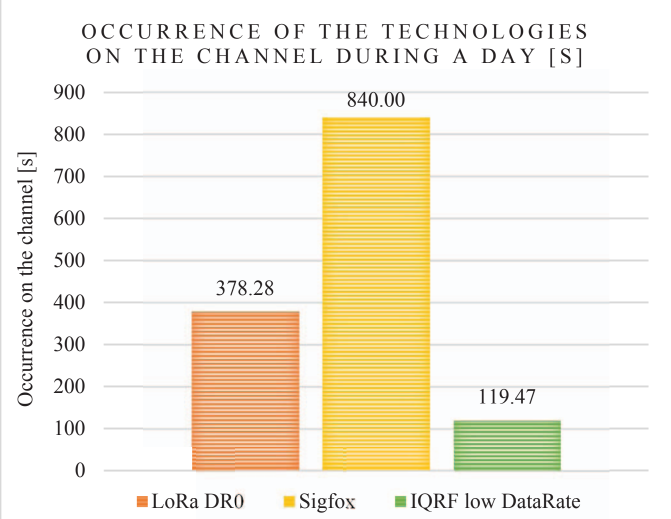

Figure 5. Time of occurrence of devices on the channel during a day.

According to the previously mentioned parameter time load, the variation Sigfox is with a bit rate of 100 bit/s and max. payload 12 B the worst. It is primarily due to the fact that Sigfox sends each message three times. They are broadcasted on different frequencies, but their position interferes still with the mentioned problematic zone. Lora DR0 and IQRF low datarate are more time saving. Reasons for such a large difference is in the structure of the technology, which is in using techniques UNB, low bandwidth, low bit rate and a small volume of data. Sigfox therefore chose other priorities in its policy such as long range and longer battery life at the expense of speed or security against transmission errors.

VI. The Probability of Collision on the Channel

The issue of the probability occurrence of discussed technologies or even directly their collisions is a crucial issue for potential coexistence of these technologies in the world because of necessary coexistence also with other technologies.

It is considered and calculated with the "worst possible" variants. This type of selection is quite intentional that it is possible subsequently to estimate what is possible potential of coexistence for the mentioned technologies. This idea exists in order to estimate the approximate amount of equipment of each technology so that the probability of collision is adequate for proper functioning of all processes.

From these mentioned reasons, the propability of occurrence of each technology determines the amount of time they spend on the channel. These values are expressed in Tab. 4, which are also analyzed and shown in Fig. 5. The probability during one day is based on the ratio of time when the technology uses the channel to the total time. The probability of occurrence is the main inherent value that can be compared with others or used to calculate the probability of collisions.

The specifications of the general authorization no. VO-R / 10 / 05.2014-3 [28] defines maximum allowable duty cycle, which determines the percentage of time the device may be active on the channel. All mentioned technologies fulfil this condition, although Sigfox with ratio 0.009722 fits under limit 0.01 only with a small margin as shown in Fig. 6. The calculated probability of collision describes a situation in which two or more different devices on the channel collide at the same time. It is seen that the probability of this is very low and therefore much smaller than the probability of occurrence of individual technologies. But it will significantly increase the probability with the growing number of devices and the limit will inevitably near certain probability 1.

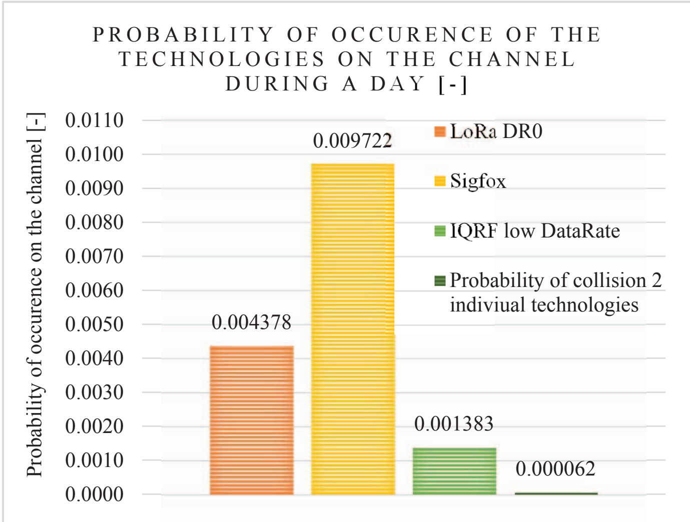

Figure 6. Probability of occurrence of devices on the channel during a day.

A. *Calculation the Probability of Collision*

Problems of coexistence of technologies for a greater number of devices are very important for the subsequent determination of possible limits. The limit of the amount of devices should not be exceeded to avoid deterioration in the quality or availability of services running on these technologies.

Problems calculating collision probability for a larger number of devices from each of these technologies is considerably complicated. Problematic states of collision are defined for two or more simultaneously active devices. The complexity of calculation is getting worse, because number of the probabilistic states increases with the number of n devices according to:

$$S = 3n + 1 \qquad (1)$$

$S \ldots$ *number of the probabilistic states*
$n \ldots$ *number of devices from each technology*

Calculation the probability of collision in case of higher number of using devices from each technology is defined as:

$$\mathrm{P}(N \leq n) = 1 - n(P_L + P_S + P_I) - P'_0 \, [-], \qquad (2)$$

where each parameter describes probabilities specific states as described below. These unknown are calculated from the already known values of probability of occurrence, which are written in Tab. 4. Here is used complement to express opposite event, which is labeled C in superscript. A prerequisite is that the number of devices n is the same for all technologies.

N *... number of devices from each technology during collision*

$$P_L = P(L)\ P(L^c)^{n-1}\ P(S^c)^n\ P(I^c)^n\ [-]$$

... one active LoRa device

$$P_S = P(L^c)^n\ P(S)\ P(S^c)^{n-1}\ P(I^c)^n\ [-]$$

... one active Sigfox device

$$P_I = P(L^c)^n\ P(S^c)^n\ P(I)\ P(I^c)^{n-1}\ [-]$$

... one active IQRF device

$$P'_0 = \left(P(L^c)P(S^c)P(I^c)\right)^n\ [-] \qquad \text{... all inactive devices}$$

The resulting dependence of the probability of collision on a channel is after substituting into the original (2) intolerably long and difficult to understand, therefore it is divided into sub-sections, which clearly illustrate their usage. Results of calculating the probability of collision for the increasing number of devices are discussed in the following chapter.

B. Distribution Function of the Number of Devices

Distribution function (4) shown in Fig. 7 is based on (2). It depends on increasing the total number m of devices, which is the number n of devices from each of the three technologies (3).

$$m = 3n \tag{3}$$

$$\mathrm{F}(m) = 1 - \frac{m}{3}(P_L + P_S + P_I) - P'_0\ [-] \tag{4}$$

It is obvious that it is not a linear function of the process, which might seem like the easiest solution for the growing number of devices, Fig. 7. Nevertheless, it can be approximated by a polynomial curve at least 4th order. The function starts at zero and it is one in the limit, which is an expected limit given the nature of calculation.

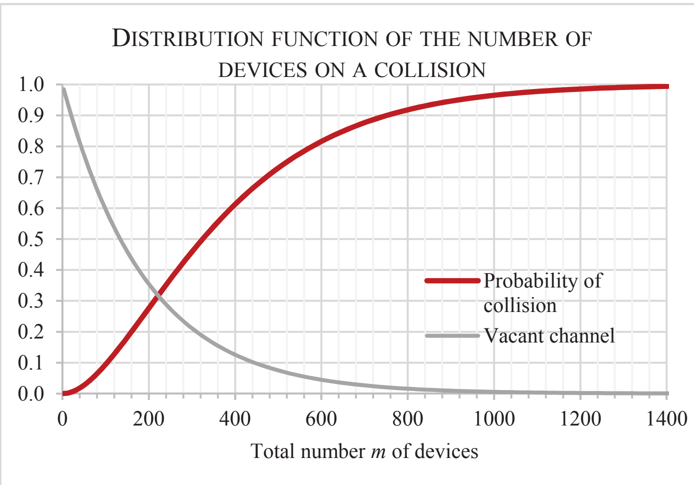

Figure 7. Distribution function of the probability of collision 2 or more devices.

Figure 7 also shows the curve of probability of unoccupied channel, which is initially one due to the absence of any device on the channel. The course of the curve exponentially decays to zero with the square of the number n of devices from each technology. This course is calculated from:

$$P'_0 = \left(P(L^c)P(S^c)P(I^c)\right)^n\ [-]\ , \tag{5}$$

where the unknows are defined in the previous chapter.

VII. Capacity of the Number of Devices on the Channel

The issue of coexistence depends on two main pillars, which have their limits, i.e. the frequency distribution and time distribution. Time division is composed mainly of the probability of occurrence of individual technologies and thus the probability of collisions on the channel. From these findings, it can be assumed additional conditions or limits in these transmission systems. One of the main limits is the potential maximum capacity of the number of devices operating on the channel. It is based on the utilization of the channel, i.e. how much are devices burdening. In other words, it expresses the borders, in which it is possible to operate the system without any significant deterioration in the quality or availability of operated services. Certain parameters determining the quality of services are also Quality of Service (QoS) and Quality of Experience (QoE).

Capacity number of devices on the channel is a vital thing that is important to the contractor of public and private networks. They have to dimension its network in accordance with just the maximum predetermined possible capacity of a channel as well as with regard to other possible technologies on the same frequencies. They also really often have to respect the planned Availability of service according to the document SLA (Service-Level Agreement), which is arranged and drawn between the service provider and the user. This document including the Availability of services is obligatory.

Accurate sizing of number of devices on the channel, however, is not entirely possible. It depends on many factors describing how channel status, and the quality and availability of used services. One of them is also the probability of collision with multiple devices on the channel, which is discussed above. It is the term describing the true state of the channel with a certain number of connected devices, Fig. 7. It is possible from the Fig. 7 to purely approximately estimate what could be the maximum channel capacity. It also depends on other parameters of individual operating services such as Avaibaility of service and a way of implementation of QoS and QoE parameters for reserving and managing data flows.

The QoS and QoE parameters are indicators of a level of quality, and therefore just their protocols would react if conditions deteriorated due to, for example, higher number of devices on the channel than the determined maximum capacity. In case of such deterioration in the network, the Availability of service can fallen below the threshold of SLA document, which is a violation of their terms and it is often followed by financial penalties. The threshold is typically set around 99%, which goes also for technology Sigfox. Therefore, it is important for the ideal and the proper functioning of the entire network, not to exceed the maximum channel capacity. It is even difficult to find the limit without experimental trials on the channel with concrete technologies and services.

VIII. Conclusions

The paper describes the various aspects of LPWAN technology coexistence in IoT environment. There is specified LPWAN term with the representatives of LoRa, Sigfox and IQRF, which are one of the main pioneers in this area. Their typical characteristics, topology is inspected in order to express the closer problem in IoT technologies.

A frequency distribution of the LPWAN technologies, i.e. LoRa, Sigfox and IQRF, is presented in detail. It describes predefined channels or areas of transmitting to a mutual context in order to show a well-arranged total distribution in the spectrum. These are placed purposely in the area of the unlicensed bands, which enable to transmit only on the basis of standard for Short Range Devices (SRD) defined by ETSI.

Potential risk bands and differences between LoRa and Sigfox are shown well on the total distribution of the technologies. The reason of the differences is in a concept of the physical layer. In these risk bands the most frequency channels are overlaying and the bands are the most inclinable to possible collisions between devices. The most risk band is set around 868.2 MHz. The context of the other technologies, which work in the similar frequency bands, is also described. The total distribution is very important element during exploring a rate of the technology coexistence in IoT environment.

With the assumption that all LPWAN technologies operate on the same frequency, the paper also explores behavior of these technologies in a time domain. It discusses the duration of activity of the various technologies on the channel during the day in order to determine the potential maximum channel capacity in their coexistence. Occurrence on the channel during a day of Sigfox technology is more than twice higher than LoRa and more than seven times higher than IQRF technology. It is caused by a different choice in policy such as long range and longer battery life at the expense of speed or security against transmission errors. Probability of occurrence of devices on the channel during a day is further calculated, which confirms all technooogies fulfill the condition of maximum allowable duty cycle. Distribution function of the probability of collision 2 or more devices shows it is closed to 1 for more than 1000 simultaneously active devices, if the the variant with the longest technologies occurrence in order to find a "worst case" status on the channel is used.

Nowadays it is still a small amount of the active devices constructed on the basis of LPWAN technologies. It should be changed in close future, because LoRa and Sigfox promise a big development and more than thousands of placed devices. Then the problem of LPWAN technology coexistence becomes more than actual.

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