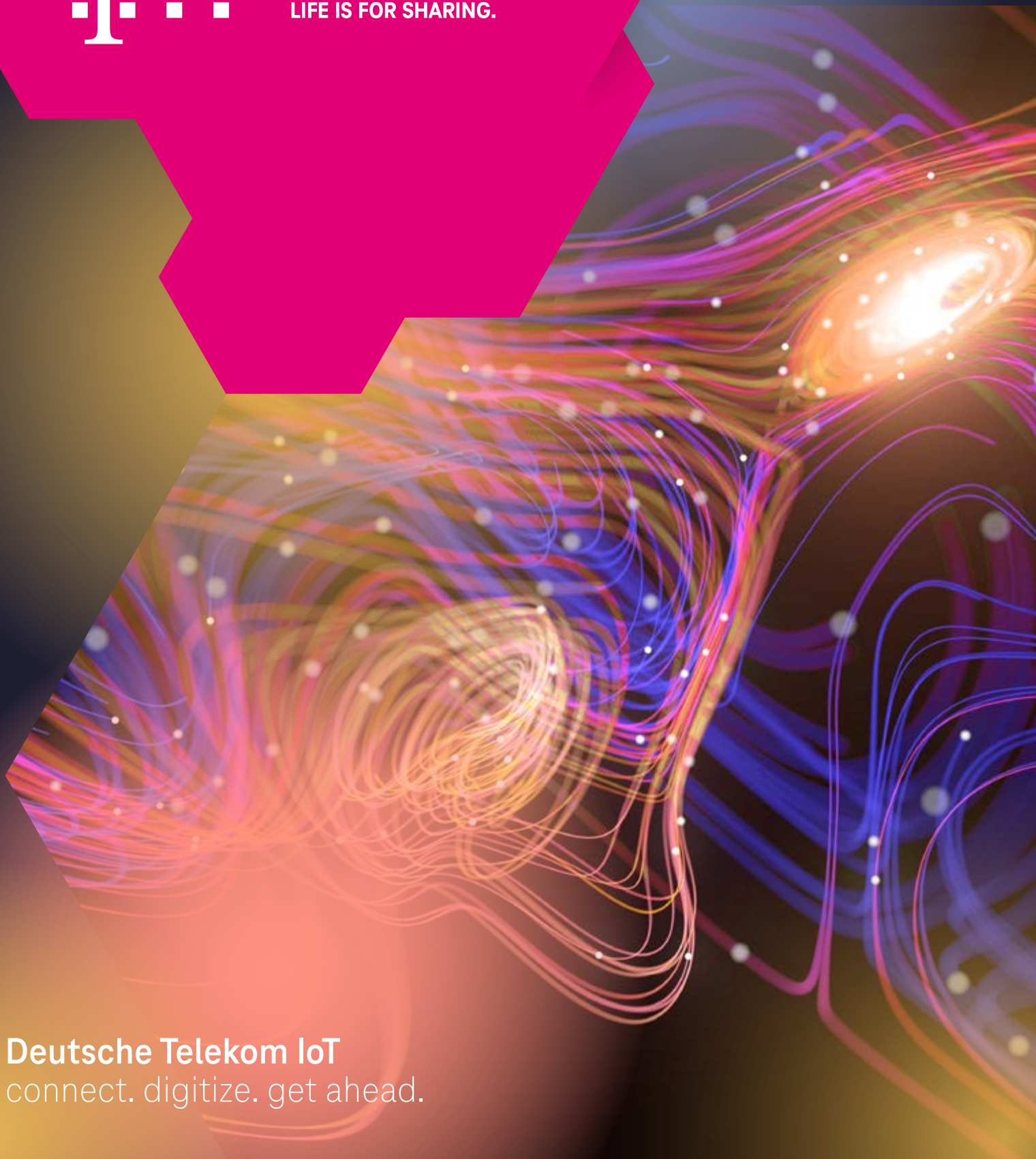
NB-IoT, LoRaWAN, Sigfox: An up-to-date comparison

LIFE IS FOR SHARING.



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NB-IoT, LoRaWAN, Sigfox:
An up-to-date comparison

"Low Power Wide Area" (LPWA) is a category of wireless networks – with a very self-explanatory name. Specifically designed for the Internet of Things (IoT), they manage to combine very energy-efficient devices with wide transmission ranges. LPWA wireless modules can run for years on standard commercial batteries and are nevertheless powerful enough to send readings to the Cloud from, say, basements, underground garages or spread-out shop floors.

Examples of LPWA use cases

- **Smart Metering**
  (connected utility meters, sensors in basements)
- **Smart Parking**
  (connected parking lots, sensors in the ground and basement garages)
- **Smart Waste Management**
  (connected municipal trash cans)
- **Asset Tracking**
  (such as countrywide tracking and tracing of cargo carriers like pallet cages, pallets and containers)
- **Connected Buildings**
  (sensors in bridges or tunnels measure temperature, humidity and corrosion and identify vulnerabilities long before visible damage occurs)
- **Condition Monitoring**
  (sensors in construction machinery and vehicles recognize malfunctions or theft)

LPWA technologies are suitable for IoT applications that rely on energy-efficient and thereby low-cost hardware for massive deployments on a wide range, potentially also within buildings (see box). Other common wireless technologies cannot serve these application areas or cannot do so satisfactorily:

- **NFC, QR, RFID** (low range, low/no energy consumption)
- **WiFi, Bluetooth, ZigBee** (low range, high energy consumption)
- **2G to 5G** (high energy consumption, limited indoor penetration)

In recent years a number of LPWA network technologies have established themselves in the market. They differ in adoption and availability, standardization and security, efficiency and effectiveness. That makes it difficult for companies to find the right technology for their IoT project, as we repeatedly discover in discussions with our customers. That is why this report takes a closer look at the three most widespread LPWA options:

- **NarrowBand Internet of Things**
  (NarrowBand IoT, NB-IoT, LTE Cat-NB)
- **Long Range Wide Area Network** (LoRaWAN)
- **Sigfox**

While LoRaWAN and Sigfox have been on the market for more than five years, the first NB-IoT networks were only launched in 2017. Many technology comparisons published to date are therefore based on theoretical aspects such as specification documents or laboratory measurements. It is therefore high time for an up-to-date comparison from the user's point of view with empirical values from practice in recent years.

Wireless IoT put to the test

Many differences between NB-IoT, LoRaWAN and Sigfox are due to their development history. LoRaWAN and Sigfox are proprietary technologies developed by individual companies, whereas NB-IoT is an open, global, LTE-based 5G industry standard. As such, it is supported by all the major network suppliers, telcos, and hardware and chip manufacturers. NB-IoT uses licensed LTE frequency bands and, unlike LoRaWAN and Sigfox, is always operated by wireless network providers. With LoRaWAN the user must also choose one of three deployment options (see box).

Three LoRaWAN operating modes

Local private network

(consists of own gateways and servers, access only by own devices)

- ⊕ Can be installed everywhere as required
- ⊕ Own control over network capacities and quality
- ⊕ All data stays in own network

- ⊖ Procurement and installation costs for LoRaWAN gateways and servers (or increased capacities for growing number of terminal devices)
- ⊖ Running costs for operation, maintenance and support
- ⊖ Requires network management knowhow

Network operator's public network

(requires a contract with a provider)

- ⊕ No investment in network infrastructure required
- ⊕ No running costs for operation and maintenance

- ⊖ Subscription fees for network utilization
- ⊖ No or no full countrywide network coverage
- ⊖ Too many users > loss of quality

Open community network

(access to community network, third-party access to own network)

- ⊕ Low investment in own gateways
- ⊕ Developer ecosystem providing support

- ⊖ Running costs for operation and maintenance
- ⊖ Limited data volume (with fair use policy such as with The Things Network)
- ⊖ Too many users > loss of quality
- ⊖ No countrywide network coverage
- ⊖ Security and data protection risks

1. Quality of Transmission

When assessing the transmission quality of the three main LPWA technologies, one should consider reliability, throughput, data rate and range. The observed variances in these four aspects are a result of several differences, like in signal modulation, bandwidth per channel, number of channels and spectrum used. First, it is important to understand that for LoRaWAN and Sigfox wireless transmission in the ISM band is subject to legal restrictions. The so-called **duty cycle** is defined as the maximum percentage of time during which an end device may occupy a channel – that's a significant constraint for networks operating in unlicensed bands. The duty cycle is 1 % in the uplink and 10 % in the downlink and leads, for example, to transmission time per participant and hour being limited to 360 ms for 1,000 LoRaWAN/Sigfox terminal devices per gateway.

With **NB-IoT** there is no duty cycle for either uploads or downloads. Twelve channels, each with 15 KHz of bandwidth, or 180 kHz in total, are fully available per resource block (several blocks can theoretically be used in the LTE frequency bands). **LoRaWAN EU** has to make do with eight 125 KHz channels and a 10 % duty cycle for downloads over all channels and with three 125 KHz channels and a 1 % duty cycle for uploads. **Sigfox** uses 192 kHz of bandwidth in which, due to the ultra-narrowband modulation, users each have only 100 hertz of bandwidth at their disposal.

Reliability:

How likely are connection setup and data transmission to succeed?

NB-IoT uses the licensed LTE frequency range of a mobile operator, preventing interference from other devices. LoRaWAN and Sigfox have to transmit via free and generally accessible ISM frequency ranges, running the risk of potential interference caused by other users. So the quality of transmission falls as soon as too much traffic on the LoRaWAN gateway or Sigfox base station increases the likelihood of message loss. With NB-IoT, in contrast, the provider can guarantee a predefined quality of service in the wireless network.

With NB-IoT messages can also be repeated very often by the network protocol – an advantage in unfavorable conditions such as in the basement of a building. With LoRaWAN and Sigfox the number of repeats is limited by law, thereby reducing building penetration (see table). In addition, an NB-IoT network operator has its own LTE spectrum at its disposal on a long-term basis, whereas regulations could change in future in the unlicensed ISM band. In a worst case scenario new legal restrictions of transmission frequency or power on open spectrum would necessitate the replacement of already installed IoT devices. Furthermore, LoRaWAN and Sigfox signal strength is limited by EU law to 14 dBm, whereas NB-IoT provides a transmission power of 23 dBm – a further advantage in terms of building penetration.

Facts & Figures

Technical Data	NB-IoT	LoRaWAN	Sigfox (EU)
Technology	open standard	proprietary	proprietary
Licensed spectrum	yes	no	no
Max data rate (gross)	27 kbit/s	5,47 kbit/s (SF7)	0,1 kbit/s
Worst case data rate (~144 dB link budget)	5–6 kbit/s	0,297 kbit/s (SF12)	0,1 kbit/s
Max. payload length (data per message)	> 1.000 B	51 B (EU) / 11 B (US)	12 B
Downlink capacity	unlimited	very low	very low
Link budget / max. path loss (Uplink)	164 dB	141–146 dB	163 dB
Link budget / max. path loss (Downlink)	164 dB	151–156 dB	158 dB

Source: Naumann H. & Oelers W.(2020)

Due to good channel quality in its licensed spectrum and to a optimized collision mechanism, NB-IoT also has very low packet losses (<5 %) even over long distances. LoRaWAN and Sigfox are influenced by interference and data traffic collisions in their unlicensed spectrum, leading to higher packet losses. That in turn leads to multiple data transmissions and higher energy consumption. An 80 % packet loss rate means, for example, that only one transmission out of five gets through.

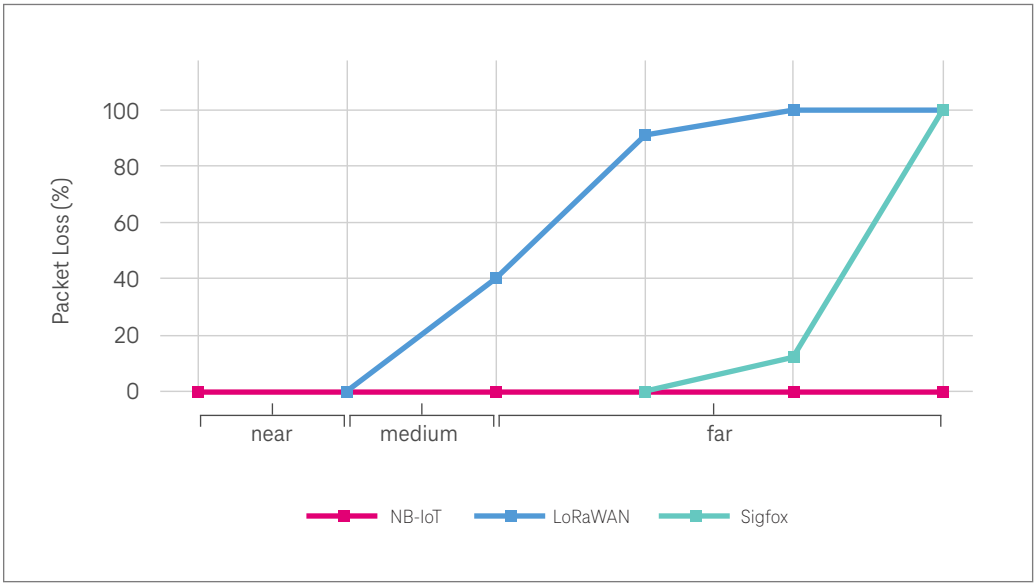
With LoRaWAN data packet loss increases significantly even over short distances (see chart). According to a survey by the University of Singapore a 40 % packet loss must be accepted when using LoRaWAN in urban environments over a distance of only three kilometers. It is to note that in Singapore a transmission power of 20 dBm, or 6 dBm more than in Europe, is permitted. In Europe this packet loss rate would be reached over much shorter distances.

So over larger distances 90 % of data packets would be lost. The repetitions to compensate the increasing packet loss rate over longer distances not only lead to higher energy consumption, but can also cause more collisions with other user traffic, resulting in a vicious cycle. With Sigfox packet loss only increases rapidly over longer distances (cf Offenburg and Singapure studies). NB-IoT, however, is steadily reliable over all distances.

Conclusion

Thanks to its reserved channels NB-IoT provides the most effective data transmission. LoRaWAN and Sigfox have less capacity at their disposal, leading to less reliable transmission.

Packet loss per transmission distance (near/medium/far)



Source: "Test and Measurement of LPWAN and Cellular IoT Networks in a Unified Testbed." Sebastian E. J, Sikora A. (2019)

Throughput:

How much data can be sent over a specified period?

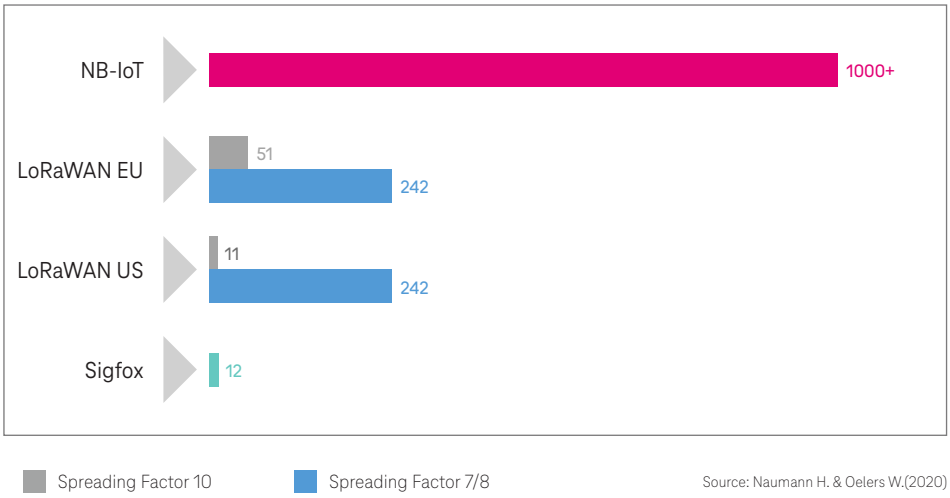
NB-IoT has no statutory or commercial limits to data throughput. Limits to the **volume of data** that can be **sent per day** (or per year) are set only by the wireless module's battery service life, unfavorable transmission conditions or the contractually agreed maximum data volume, as well as operator-side application development guidelines to safeguard cellular network quality (e.g. Deutsche Telekom's IoT Solution Guidelines).

The three technologies also differ markedly in **data volume per message** and **number of messages per day**. Most notably, for LPWAN technologies in the license-free band the legal duty cycle kicks in. Throughput is limited to prevent network overload.

Upload: With LoRaWAN and, especially, Sigfox the duty cycle imposes strict limits. A Sigfox data packet is limited to a 12 cycle byte payload. As a consequence, a Sigfox module has to split a longer message into several small data packets with a negative effect on energy consumption and duration of transmission. In addition, only four messages with acknowledgement can be sent per day (or six uplink-only messages per hour, i.e. 144 per day).

This limitation must be taken into account for use cases such as tracking, especially for devices using WiFi sniffing. In principle, NB-IoT and LoRaWAN modules permit upload (from device to server) transmission of longer messages. But with LoRaWAN the duty cycle can in less favorable circumstances (long distances, Spreading Factor 10) quickly reduce the theoretical best-case (i.e. short distances, Spreading Factor 7/8, see box) of 242 Bytes to 51 Bytes (EU) or even 11 Bytes (USA). As NB-IoT is not subject to technical or statutory limitations, payloads in excess of 1 kilobyte are possible (see chart).

Max. payload uplink (byte)



Source: Naumann H. & Oelers W.(2020)

Download: NB-IoT also enables downlink reception of larger data packets. As practice has shown, usual firmware updates (going beyond smaller parameter updates) are not a problem for the wireless module or the application on the terminal device. And for a very large firmware update of several megabytes common multimode wireless modules can switch briefly to 2G or LTE-M for a fast data transmission to save battery life. Realistically, Sigfox does not permit firmware updates; if anything, just short control commands. In general, message reception is only possible after transmission and is limited to 8 bytes each four times a day. With LoRaWAN, firmware updates, if they are possible at all in view of the low data rates, require a high level of energy consumption. So with both proprietary technologies downlink capacity is in general very limited when compared with NB-IoT.

Conclusion

For uploads, downloads, data volumes per day or per message or the number of messages per day, NB-IoT leads the field in every aspect of data throughput.

Spreading factor

With LoRaWAN the signal transmission can be spread over a wide frequency range. Bandwidth can be used optionally for either a high data rate or a robust transmission. The spreading factor (SF) and the bandwidth determine the data rate and the likelihood of reception. LoRaWAN networks use between SF7 (for optimal conditions) and SF12 (for bad coverage conditions).

Data rate:

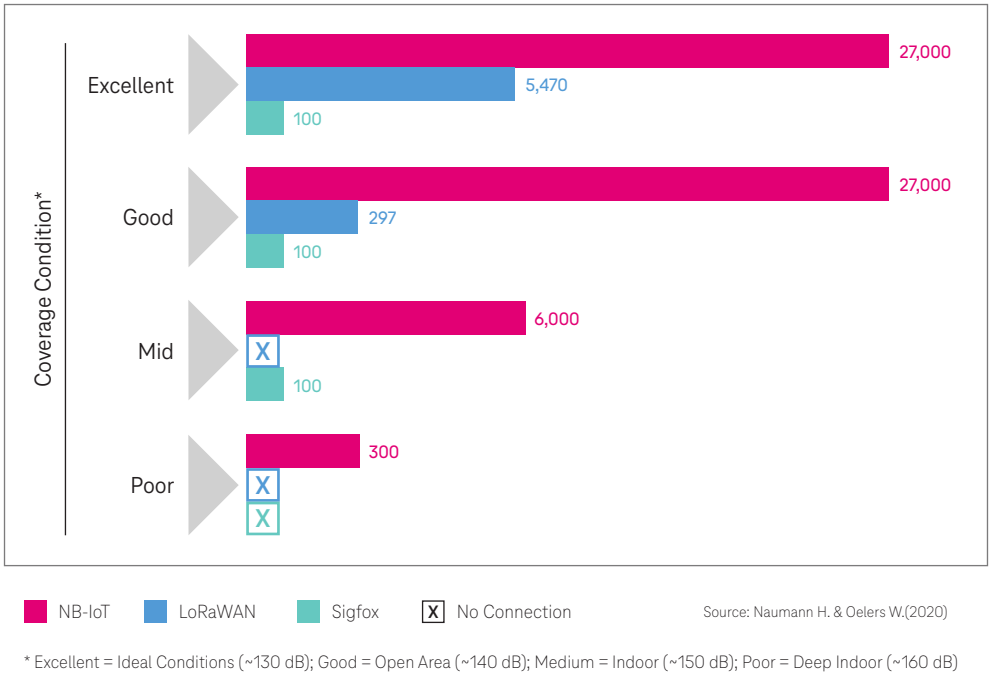
How fast can data be sent?

In some scenarios fast data transmission is important. As the chart shows, NB-IoT is the clear leader here, and not only in good transmission conditions. With LoRaWAN (EU), interference in the ISM band reduces the data rate that is theoretically possible under ideal conditions from 5470 bit/s (with SF7) to less than 300 bit/s (with SF12). Especially in difficult conditions only NB-IoT ensures fast and reliable transmission. Sigfox loses its connection in poor conditions while LoRaWAN does so even in moderate conditions. This advantage could come even more to the fore in the future because NB-IoT in principle also supports the multi-tone process, which would further significantly increase the current data rate.

Conclusion

For data rate NB-IoT has the greatest lead over Sigfox and LoRaWAN – in good and, especially, in worse conditions.

Typical data rate (bits per second)



Source: Naumann H. & Oelers W.(2020)

* Excellent = Ideal Conditions (~130 dB); Good = Open Area (~140 dB); Medium = Indoor (~150 dB); Poor = Deep Indoor (~160 dB)

Range:

How far can messages be transmitted in specified conditions?

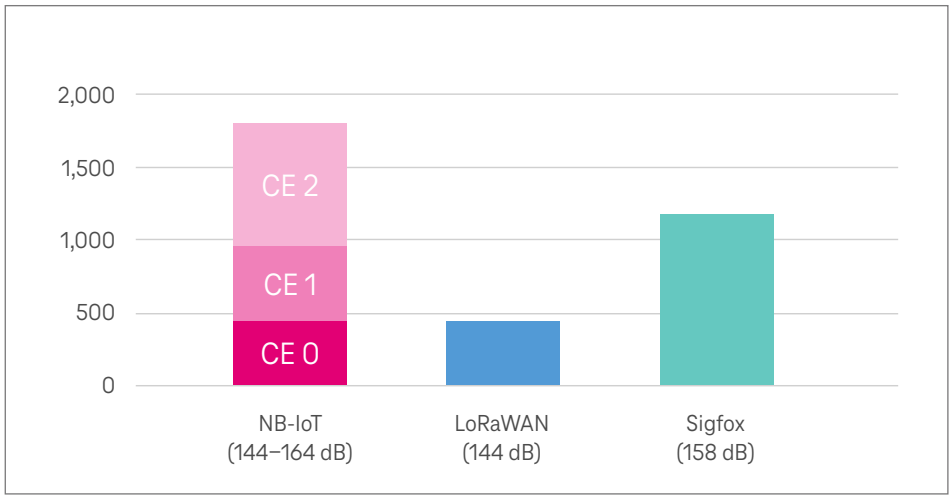
A study by the University of Aalborg shows that noise and interference are to be expected in the ISM band that LoRaWAN and Sigfox use. That can have a negative impact on both the sensitivity (the link budget with real noise) of the receiver and the range of the transmitter. In contrast, the NB-IoT network's inherent ability to send data as often as needed to reach its destination is a decisive advantage where range is concerned. The Okumura-Hata simulation model also shows that in a typical urban use scenario an NB-IoT or a Sigfox device can transmit much farther than a LoRaWAN device, on which interference from other users has a significant impact (see chart). Generally speaking, a link budget increase of 10 dB will double the transmission range, hence reducing the number of required base stations or gateways by a factor of four.

A field test by the independent consultancy P3 Communications (today: Umlaut) demonstrated in 2018 that NB-IoT modules at various indoor locations were able in 95 % of cases to establish a connection with the base station. Data transmission then always worked. No other wireless technology can deliver such a high level of reliability, especially in basements. LoRaWAN in particular is at a great disadvantage in this context due to strong interference caused by other users in, say, a shopping mall or a business park.

Conclusion

In the unlicensed ISM band noise and interference reduce the range, in particular in urban environments. While Sigfox compensates this with a high output power, the reach of LoRaWAN remains low. NB-IoT can improve its range and building penetration using the Coverage Enhancement feature on its licensed spectrum.

Max. range in city indoor (m)



Coverage Enhancement (CE) Levels: CE 0 = good CE 1 = medium CE 2 = poor Source: Naumann H. & Oelers W.(2020)

Scenario:

- Large/Medium City (Hata Propagation Model)
- One Wall between Basestation/ Gateway & Device
- 28 dB Loss (Penetration Loss, Fading)
- Basestation/Gateway Height: 30m
- Device Height: 1m
- Bidirectional transfer with acknowledgement (UL/DL)

2. Coverage

There are substantial differences in network coverage between the three technologies, but NB-IoT here enjoys a decisive advantage. It is based on the 3GPP LTE industry standard, runs on the same base station equipment and can therefore utilize existing LTE network infrastructures. In Germany, for example, around 60,000 LTE base stations – an estimated 20,000 per network provider – can ensure countrywide availability, especially with national roaming increasingly becoming common. For LoRaWAN and Sigfox setting up and operating a sufficient number of dedicated base stations (gateways) would not be viable. LoRaWAN provides public community networks in many urban locations but without any guarantee of quality. Much the same applies to international availability:

More than 100 mobile network operators in 54 countries (by the end of 2020) already operate **NB-IoT**, including all industrialized nations. For NB-IoT as a global 3GPP standard, cross-country, cross-network and cross-provider roaming is feasible and already live. In 2020 first commercial roaming agreements were struck and since then the extention of operator roaming footprints is steadily accelerating. In addition, to ensure global availability of wireless connections, many NB-IoT modules can fall back on 2G/3G or LTE-M wireless networks where NarrowBand IoT is not yet available.

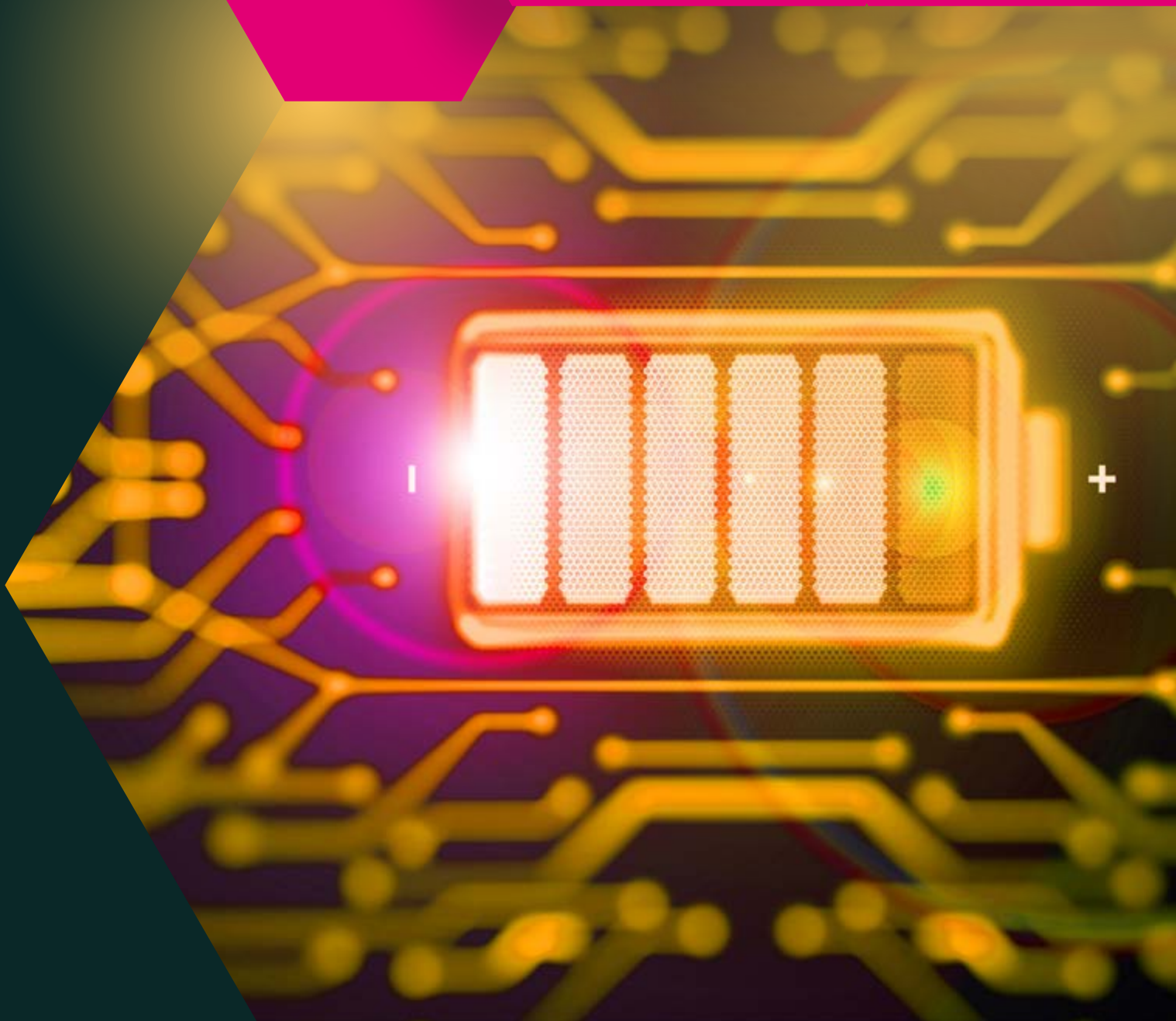
LoRaWAN networks are said by the LoRa Alliance to exist in over 160 countries, mostly as local installations. Roaming is difficult because a reliable contractual framework exists in only a few cases. Decentralized roaming between private, public and open networks poses reliability and security risks. Due to different frequency bands and national regulations (e.g. duty cycles), LoRaWAN modules are also not universally compatible between Europe, North America and Asia.

Sigfox is said on its website to be in use in around 70 countries. A globally centralized core network infrastructure facilitates the utilization of foreign networks, but due to the low number of base stations per country there is no reliable international (indoor) network coverage. And as at the end of 2020, there is stillwireless module with worldwide certification.

Conclusion

Anyone who runs IoT applications countrywide, or indeed across borders, will find that only cellular standards such as NB-IoT can offer the necessary coverage. Proprietary technologies on unlicensed spectrum lack international (indoor) network coverage and especially LoRaWAN lacks a secure and reliable roaming option.

3. Energy Efficiency



More data packets = More energy consumption

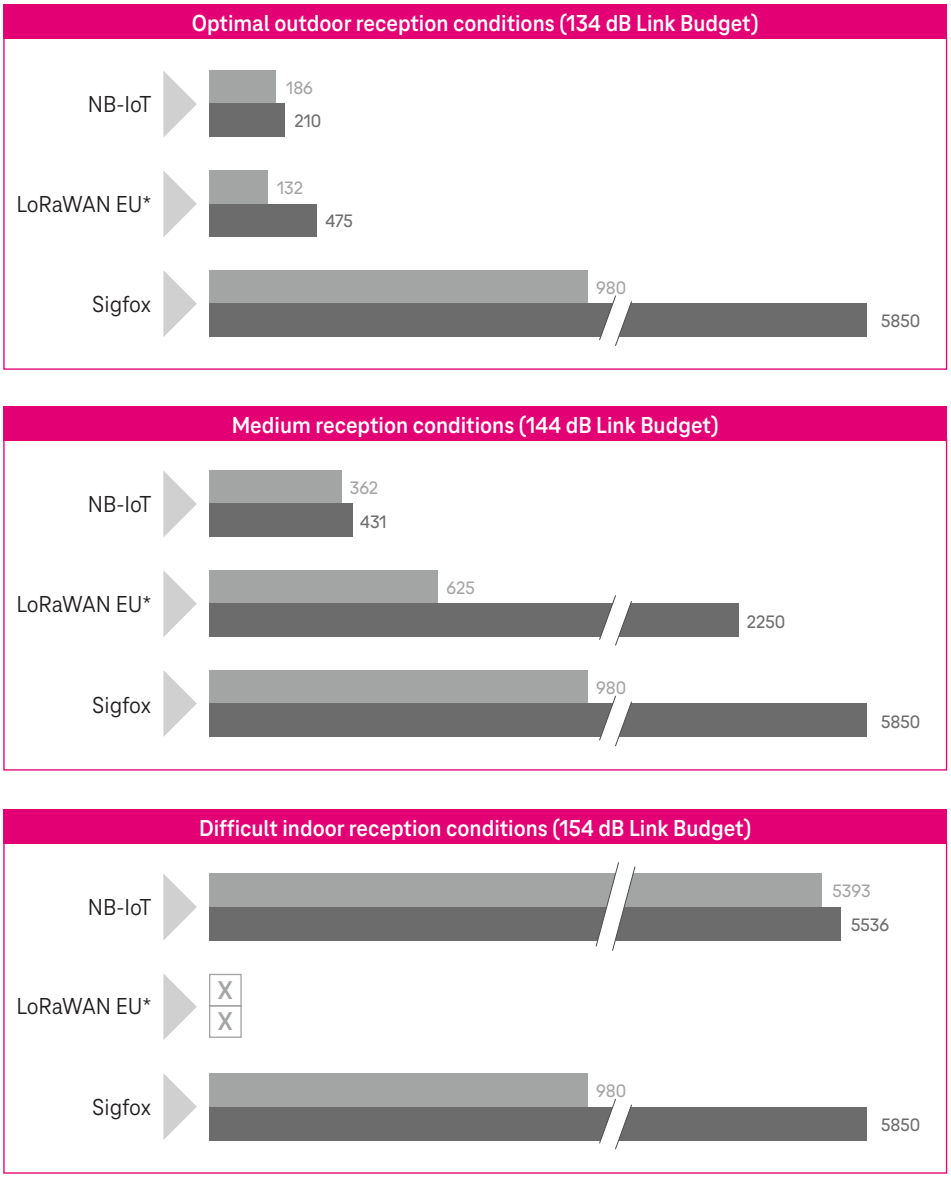
In an IoT scenario such as connecting parking lots, trash cans or trackers wireless modules must use as little energy as possible. That is the only way in which a module can run for a long time without maintenance of the battery. That not only makes the devices independent of a fixed power source such as a socket; it also keeps running costs low. Energy efficiency is therefore indispensable for mass usage of LPWA, such as in a Smart City.

In the past, many studies based their findings mainly on lab results using small data packets. That is why the Lübeck-based engineering company Triptec carried out practical tests in real conditions measuring 12-, 24-, 64- and 512-byte data packets. These were followed by a metrological examination in optimal (outdoor), mixed and difficult reception conditions in a basement (see chart).

These practical tests showed that, because many use cases can quickly require a message size of 200 bytes or more, NB-IoT devices benefit from being able to send such large data packets in one piece. Sigfox would in contrast need to split even a 64 byte message into six separate packets, requiring six times the energy to transmit. At almost 1,000 mWs each, energy consumption would be extremely high because Sigfox technology does not allow adjusting transmission power to reception conditions. Hence, frequent status or position reports are not compatible with a long battery life.

LoRaWAN is relatively economical in good coverage conditions and with very small amounts of data, but it fails if conditions deteriorate too much (see chart). Longer distances automatically lead to an increase in packet losses, requiring repetitions which increase the energy consumption.

Energy consumption for uplink data transmission (mWs)



Conclusion

If very low energy consumption is important for an IoT application, in most cases there is no alternative to NB-IoT. There are limits to Sigfox and LoRaWAN, especially for larger data packets and poor transmission conditions.

Using Deutsche Telekom's IoT Solution Optimizer developers can simulate and optimize the energy consumption of NB-IoT devices for various use cases and coverage conditions. (Link: https://iot.telekom.com/en)

An SMS text message as a transmission medium would – in terms of energy efficiency – not be a viable alternative to LPWA technologies. For its maximum range (144 dB) it requires 3,500 mWs, and even in an optimal case (134 dB) it would still use 450 mWs.

12 bytes (very small message) | 64 bytes (more usual case) | X no connection

*NB-IoT and Sigfox protocols have radio transmission repetitions built-in. For LoRaWAN these need to be initiated by the application to mitigate packet loss and collisions (increasing with transmission distance). Hence, to ensure a like-for-like comparison, two repetitions were assumed for 134 dB and three for 144/154 dB.

Source: Naumann H. & Oelers W.(2020)

4. Security

Viewed realistically, security still ranks lower on the list of priorities for developers and users than aspects such as technical reliability, energy efficiency or costs. It also seems obvious to assume that for a hacker attacking small, non-critical IoT devices would not be worthwhile, but that would be a dangerous fallacy. So security aspects should be taken into account at an early stage of development even if, generally speaking, they will only become a major focus of attention as the technology moves closer to maturity.

LoRaWAN for IoT: Vulnerabilities in v1.0

With LoRaWAN the security depends largely on which version is used. The new 2017 v1.1 architecture eliminates a number of vulnerabilities and security gaps in Version 1.0 such as that in end-to-end encryption of frame payloads the network server gains access to the key during the terminal device joining process. As of the end of 2020, however, the new Version 1.1 is not yet universally deployed.

Sigfox: Vulnerable to attacks

Sigfox, despite its integrated security mechanisms, is inherently more vulnerable to attacks due to its very small message sizes and its short 12-bit sequence number because simple brute force methods can wreak damage. Replay and DoS attacks have been simulated successfully on several occasions.

The most critical vulnerability of LoRaWAN v1.0 and, above all, Sigfox is to be found in their terminal devices. On cost grounds they do not, as a rule, have a secure element – a chip that stores cryptographic information such as secret keys securely. A hacker might therefore succeed in extracting secret keys or in flashing the device with compromised firmware. Using devices without a secure element can make even end-to-end encryption useless.

NB-IoT: Secure key exchange

NB-IoT in contrast benefits from LTE security features that have long proven their worth in practice. They include mutual authentication of terminal device and network, well-known cryptographic algorithms such as AES and secure key generation and exchange. On the network side NB-IoT's air interface is always encrypted. Another major advantage is that NB-IoT SIM cards are tamper-proof because they contain a secure element. That makes extracting the key very difficult and in most cases unlikely to succeed.

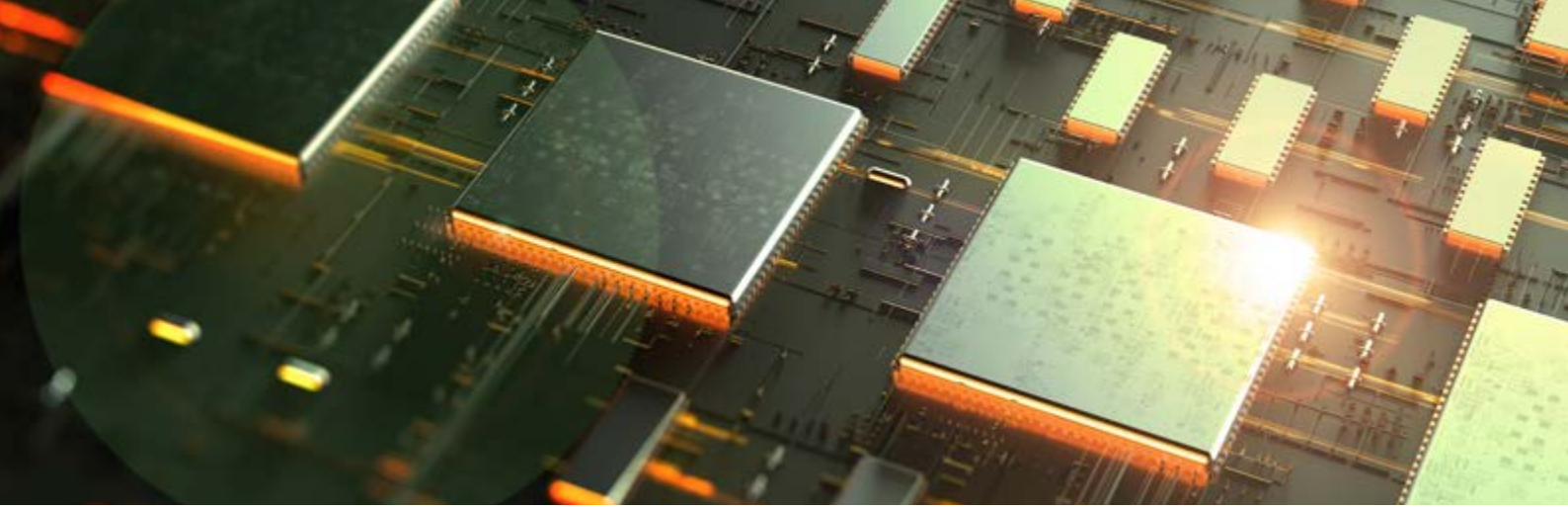
End-to-end encryption is not standard, but network operators can introduce a higher level of security by, for example, using a security tunnel between the core network and the application server. For roaming in NB-IoT networks additional security measures such as end-to-end encryption should be implemented. If, however, an NB-IoT use case takes place solely in the network operator's home network no additional security mechanisms are required during transmission.

Conclusion

If the planned IoT application is security-critical, LoRaWAN v1.0 and, in particular, Sigfox are not suitable. NB-IoT provides more security, especially because its SIM cards are tamper-proof. However, as the IoT market matures, the security mechanisms of all three technologies will certainly be continuously scrutinized and improved.

You will find a detailed comparison of the security mechanisms of NB-IoT and LoRaWAN in the Mobile IoT Security Comparison white paper.

5. Costs



The cost structure of setting up an IoT wireless network with LPWA technology depends to a decisive extent on the operating mode, i.e. whether one subcribes to a network operator or chooses to deploy and operate own network infrastructure (see table). Sigfox devices and wireless modules are currently (as of 2020) the least expensive, partly because they use by far the simplest technology. LoRaWAN modules have been on the market since 2015 and therefore had a starting advantage of about two years over NB-IoT. But the prices of NB-IoT hardware are falling rapidly due to high production volumes (especially in China) and constantly increasing sales figures with the result that the original price target of $ 4 per wireless module was undershot only a few years after the first NB-IoT networks were set up.

Usage fees vs. investment costs

The cost of SIM cards (or of SIM profiles for integrated SIMs such as nuSIM) is negligible in relation to the cost of devices. Annual usage fees per device (*) – usually single-digit for NB-IoT, double-digit for Sigfox and operator-managed LoRaWAN – make a big difference, however, especially in long-term projects.

Setting up a private LoRaWAN network may eliminate usage fees but will require investment in network infrastructure such as the purchase and installation of local gateways and network servers (although the latter can also be bought as a cloud service). Maintenance and operation, gateway site rent and electricity must also be financed. Alternatively, all of these costs are included in the variable usage fees charged by a provider-operated network and are therefore better to plan (per device).

Conclusion

For most IoT use cases the total cost of ownership (TCO) is lower for NB-IoT than for LoRaWAN and Sigfox. So the longer an IoT application is scheduled to run, the greater the cost benefit of NB-IoT. However, there might be cases where a local private LoRaWAN network might be the better choice.

Cost factors for deployment

	NB-IoT	LoRaWAN		Sigfox
		Own local network	Subscription with operator	
Devices incl. radio module	€	€	€	€
SIM cards	€	–	–	–
Subscription fees*	€	–	€	€
Own network infrastructure	–	€	–	–
Network ops & maintenance	–	€	–	–
Application (server)	€	€	€	€

(*) Please check providers' websites for the latest prices

6. Future Viability

Apart from considerations around technical quality or cost, as elaborated in the previous chapters, any company developing or using IoT applications and devices should think about the sustainability and future viability of their chosen technology. In particular, the following general questions should be asked:

- Is it assured that my deployed IoT devices will still work for their entire lifetime? Will my provider still exist and operate the network? Could there be any future regulatory restrictions forcing me to replace my devices?
- For future production batches and device generations, will the prices for hardware and subscriptions decline or grow? Will there be enough players in the market to ensure tough competition for best quality and prices or will I become dependent on one single vendor?
- Will there be enough resources for and investment on the continuous enhancement of the technology? Will there be regular updates to further improve quality and performance and fix any new security threats?
- Is there an active developer community to support me in application development and troubleshooting?

Sigfox is its own company and sets its own standards. It demands certification (at cost) of any products to be used on the Sigfox network. Over the past years a wide choice of hardware and software has emerged, but mostly consisting of smaller players. The developer community is centrally organized by Sigfox.

LoRaWAN is dominated by Semtech, who owns the patents on the LoRa modulation technique. The LoRa Alliance, an open, nonprofit association with more than 500 members, has managed to foster a large, vibrant ecosystem developing LoRaWAN-based hardware and software. However, semiconductors are still available only from Semtech or its licenses. Also, while there is already an impressive choice of ready-to-deploy devices, it is fair to say that the vendor landscape for LoRaWAN semiconductors, devices or gateways features rather smaller players compared to typical suppliers for cellular 3GPP industry standards such as NB-IoT or LTE(-M). The LoRaWAN developer community is decentralized and diverse, with most notable communities run by Semtech, The Things Network and Actility.

Despite its rather late market entry compared to LoRaWAN or Sigfox, unlike these proprietary technologies NB-IoT is an open industry standard developed by the 3GPP, a global standardization organization with more than 500 members, covering various cellular telecommunication technologies. As a result, NB-IoT users benefit from the fact that the hardware they use is globally consistent and compatible, e.g. different frequency bands can be handled by multiband modules. Companies can choose freely from the products of different major manufacturers and providers and they run no risk of a hardware vendor lock-in. Although there are not yet as many different device models on the market as for LoRaWAN, the number of commercially available radio modules is arguably already at par. The developer ecosystem is decentral and rapidly evolving, with Deutsche Telekom offering diverse useful resources and community support via iotcreators.com. Being the integral component of the 5G standard for Massive IoT use cases, together with LTE-M, NB-IoT is consistently usable worldwide and safe choice long-term.

Conclusion

Given that the market environment is changing rapidly, a definite answer to the above questions cannot be provided herein. In the end, it is an individual choice whether to invest into established proprietary technologies like Sigfox or LoRaWAN, both of which still benefit from their head start, or to go for NB-IoT, which benefits from being a cellular IoT industry standard (and part of 5G), supported by the international mobile operator community.

In short:
Which LPWA technology is the best match for my IoT project?

As we have seen in this report, the three technologies perform very differently in the most important categories, with NarrowBand IoT mostly the winner in direct comparison (see list).

Companies must consider which criteria an LPWA network must definitely fulfill – and which may be a secondary consideration. Overall, in discussions with our customers network coverage and quality of transmission currently appear to be most important for enterprises.

In view of the disadvantages of Sigfox and publicly operated LoRaWAN on precisely these issues there are only two options for enterprises that are looking for a reliable, secure and powerful LPWA network for their IoT projects (see table below).

So, if your aim is to connect a larger number of IoT devices securely at one corporate site with inadequate cellular network coverage, and if the amounts of data and number of messages are limited, LoRaWAN can be used as a local IoT network. In all other cases, such as if countrywide or even international coverage is required, data throughput, range and quality of transmission must be high while energy consumption and costs must be low, NarrowBand IoT is your LPWA technology of choice – currently and above all for the future.

NB-IoT's key benefits

1. **Best quality of transmission**
   Licensed radio spectrum, unlimited usage, best building penetration, highest data rate and throughput, good downlink transfer
2. **Best national and international coverage**
   Runs on existing LTE infrastructure and roaming frameworks
3. **Best energy efficiency**
   Lowest energy consumption in most reception scenarios because transmission can usually be in one data packet
4. **Securest network**
   LTE-based security mechanisms, least vulnerable to attacks, secure key storage on SIM
5. **Lowest total costs**
   In most cases, lowest overall costs (TCO) from a user perspective – no own network infrastructure, operation and maintenance required
6. **Future-safe choice**
   Global 3GPP industry standard for 5G Massive IoT, backed by all large network operators and manufacturers (no risk of vendor lock-in)

Conclusion: Which IoT network for which purpose?

Consider **NB-IoT**, if ...	Consider local private **LoRaWAN**, if ...
→ **Countrywide/international** coverage necessary	→ **Local area** that has no (stable) cellular network
→ **Multiple locations** of devices	→ Sufficient number of devices at **one location** to justify operation of own gateway(s)
→ Critical to have reliable quality **(no data lost in transmission)**	→ Tolerant for **occasional loss of data** in transmission
→ **Higher throughput** is required	→ **Lower throughput** is fine (up to 1.6kb/day)
→ **Moderate latency** of up to 10 seconds is required	→ **Latency is no concern**
→ Data transmission across **network operators acceptable**	→ Data must not leave **own network**

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