Low power Wide area

A guide to making the right decisions about cellular LPWA connectivity

April 2024

Telia

The arrival of a new enabler

It's not news anymore — we know that a steadily increasing number of connected devices, machines, pieces of equipmentand vehicles are changing industries, the way business is done and how we go about our daily lives. The Internet of Things (IoT) has arrived and is here to stay.
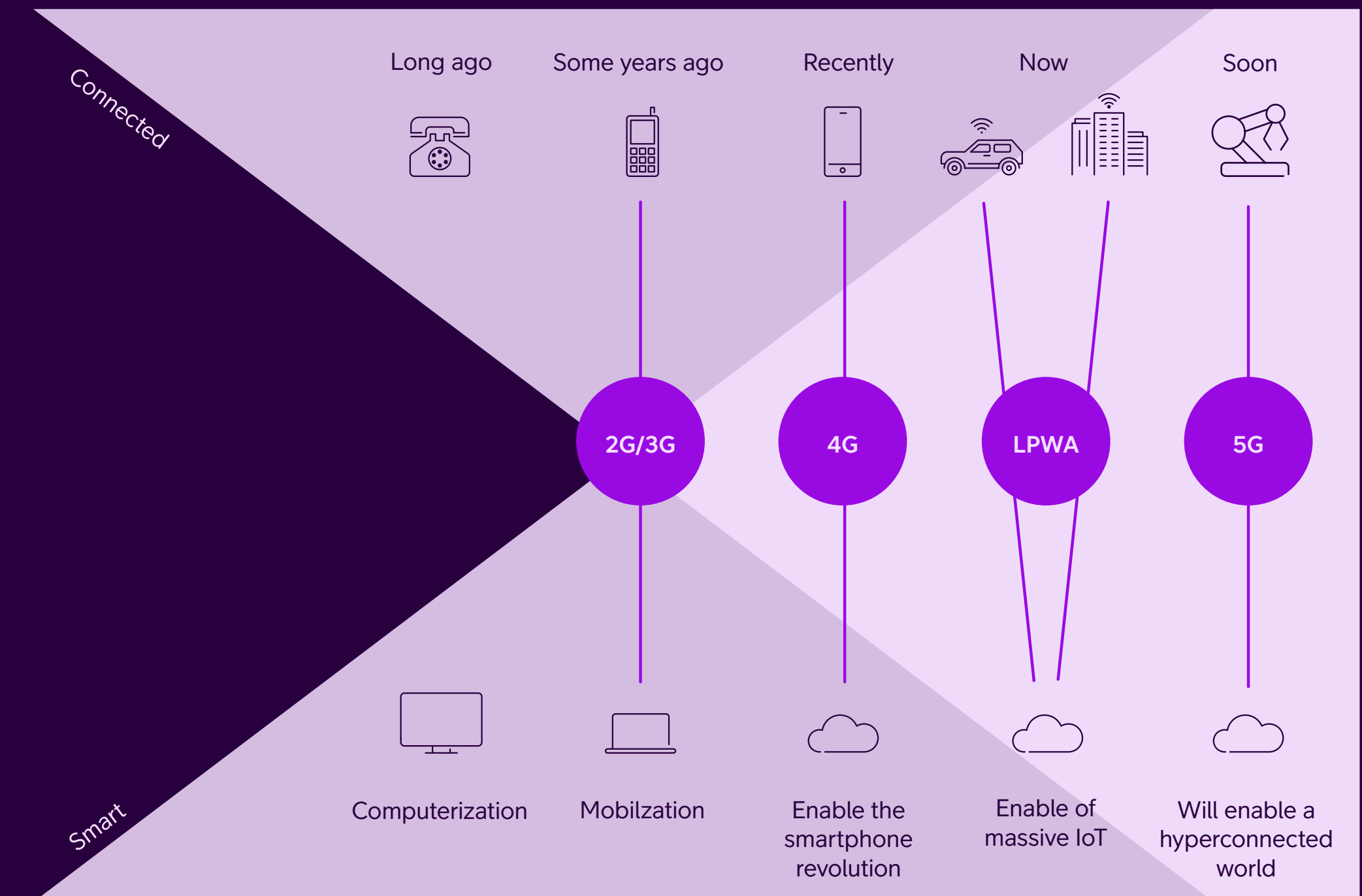
Leading digital transformation analyst firm Transforma Insights, which recently selected Telia as one of ten world-leading IoT players, estimates that the global IoT market will grow to 24.1 billion devices by 2030, generating USD 1.5 trillion in annual revenue1.

To grease the rails for this advance there is a technological concept that is particularly pertinent: Low Power Wide Area networks – LPWA. LPWA is one of the main enablers of IoT. That's because this concept, or rather these latest technologies – not only enable IoT solutions that were not possible before. They can also boost existing applications and allow for many processes to be run faster, at a larger scale and at lower cost. Naturally, LPWA is attracting a lot of interest – Ericsson expects that by 2026 these technologies will make up 45 percen of all cellular IoT connections2. With the

following information we want to support you in making even better-informed decisions regarding IoT connectivity. Telia offers two cellular low power wide area network technologies: Narrowband-IoT (NB-IoT) and LTE-M. Connectivity in general used to be a bit simpler. But today there are many new connectivity technologies that all create opportunities in IoT and in businesses. Organizations are pressed to choose the right alternative and then carefully plan for its development and long-term success.

While we are still at an early stage with LPWA, as mentioned above these networks are growing rapidly.

Figure 1: The landscape of cellular IoT connectivity

1) https://transformainsights.com/news/iot-market-24-billion-usd15-trillion-revenue-2030
2) https://www.ericsson.com/4adc87/assets/local/mobility-report/documents/2020/november-2020-ericsson-mobility-report.pdf

What is LPWA – and what's in it for you?

Low Power Wide Area is not one specific technology, but a network that runs on less power and across greater distances.

Simply put, LPWA supports IoT solutions that require low total cost, long battery life and the ability to operate in remote locations. Its efficiency comes from sending smaller amounts of data at defined intervals and then quickly powering down the transmitter in between. Let's take a closer look at cellular LPWA from Telia and the benefits for you. Both NB-IoT and LTE-M are developed

in accordance with 3GPP standards. Release number 13 came in 2016 and had all the latest specifications, and because the specifications are regularly updated to enable the best-performing networks, Telia will continuously add on new updates to make both pur networks and customers devices operate even mor efficiently.

Deeper penetration

Devices connected in a LPWA network can transmit from deep within buildings or underground. This superior indoor and underground coverage means that while other mobile communication technologies, such as 4G, offer excellent outdoor coverage, their reception inside buildings or underground is often limited. Many industrial, enterprise and municipal IoT use cases require reliable coverage inside buildings, underground or inside other enclosures.

NB-IoT achieves this deeper indoor coverage by concentrating radio transmissions into a narrow 180kHz carrier bandwidth. Additionally, its Coverage Enhancement (CE) feature offers the capability to repeat the transmission of a message, if needed, at a lower data rate. In fact, NB-IoT coverage offers a 20dB advantage compared to conventional GSM/GPRS, a multiple increase in coverage. In several tests throughout the development, Telia has shown that our NB-IoT works perfectly long after the traditional network signal has failed.
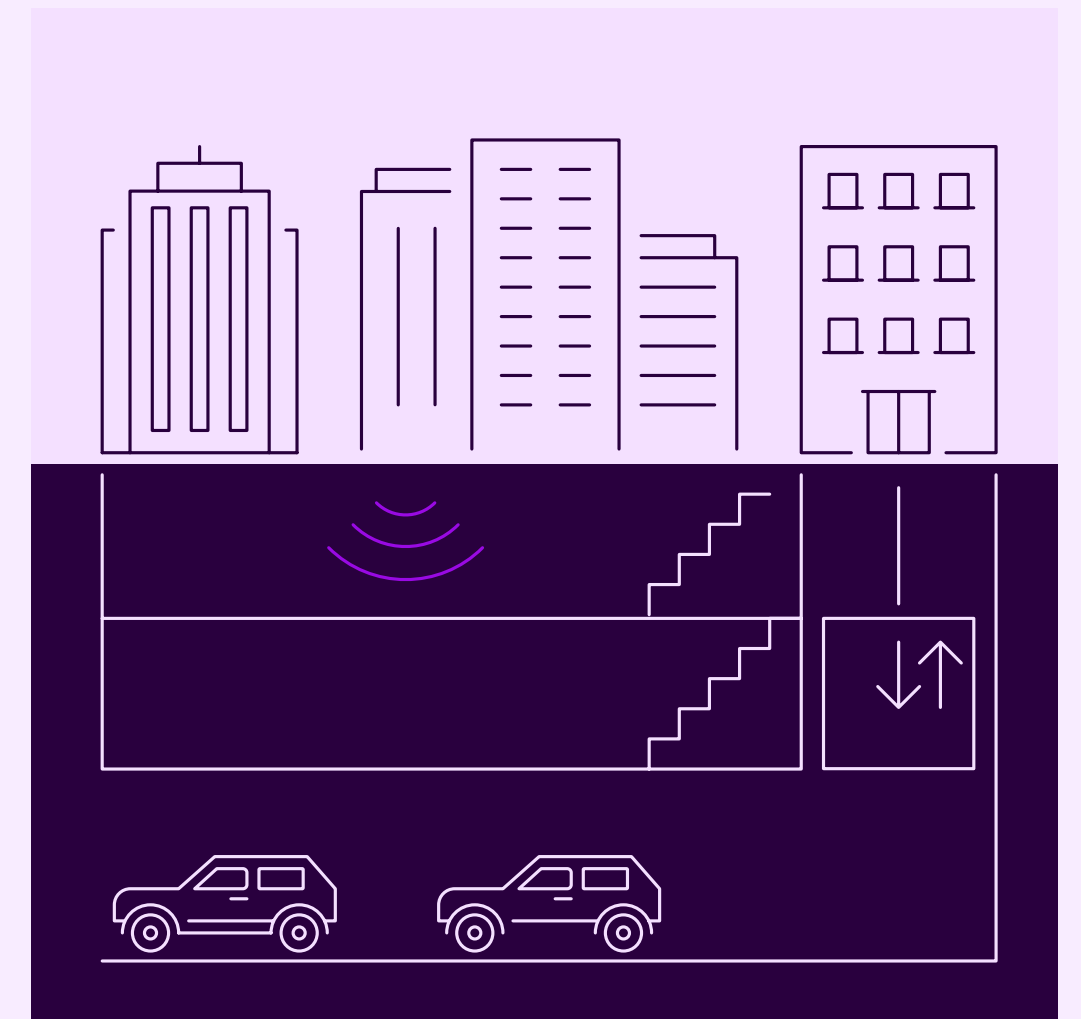
For example, our NB-IoT network has been shown to work without problems 80 meters down a bunker built for protection against military attacks, nuclear fallout or other crises. A regular mobile phone lost its signal after 20 meters. LTE-M also provides greater indoor coverage compared to other standard mobile technologies.

Case study

Aguardio: Reducing complexity and churn

Telia provides the connectivity platform for Aguardio, a company that helps reduce the amount of water and energy people use in the shower. Subsequently, with Aguardio's sensor devices building owners and facility managers can directly address three of the UN's Sustainable Development Goals by saving water and energy and reducing wastewater discharge.

"One of our biggest challenges was battery life and the complexities of managing different systems and languages when installing our solution

globally," says Aguardio co-founder and CEO Thomas Munch-Laursen. Telia has now helped us to move past these challenges."

With Telia's NB-IoT and LTE-M solution, Aguardio's devices can now run for longer between battery changes, and they can be used in locations where mobile coverage is scarce. As there are roaming agreements in place, Aguardio can also scale up and increase its reach to markets outside the Nordics and Baltics.

"We are now able to include connectivity from the start, as part of the complete solution, which enables us to provide an even more customer-oriented and easy-to-use service. Also, we don't have to rely on existing, power-draining Wifi connections which led to more support calls and customer churn because of issues like passwords and equipment updates and changes," Munch-Laursen says. Find out more here.

Cost efficiency

If you want to focus on the value that IoT can deliver, you shouldn't try to build your own network. Because building it is just the start. Managing an IoT network is a major undertaking that takes a lot of resources and effort.

Telia operates the largest and most advanced IoT networks in the Nordics, so you can be ready to deploy at any time. We have also harmonized our LPWA networks features across the Nordics and Baltics, for seamless connectivity and optimized deployment. Still, the cost efficiency of LPWA is about more than the networks, it's about the entire ecosystem around cellular LPWA.

The cost of IoT connectivity is comprised of the connectivity module cost and the connection cost. The low module cost can be achieved through strategic partnerships with module vendors and by eliminating a range of unnecessary LTE features from the modules. Without the need to support for example carrier aggregation, multi-stream transmissions, parallel processing, connected mode mobility measurements, turbo decoders, and inter- and intra-RAT handovers, the NB-IoT and LTE-M modules are produced more cost-effectively than regular LTE or GSM modules.

Long battery life

The long battery life is one of the biggest benefits of LPWA technologies. Modules can operate for several years on one battery charge. NB-IoT and LTE-M chipsets are optimized for low power consumption, focusing only on radio features relevant to the devices in use. Signaling overhead is reduced so that data is transferred more efficiently directly over the control plane — a feature referred to as Data over Non-Access Stratum (DoNAS).

Moreover, both NB-IoT and LTE-M technologies feature two power-saving capabilities that work together to maximize performance and efficiency: Power Saving Mode (PSM) and Extended Discontinuous Reception (eDRX). When a device is connected to the network, the network periodically sends paging messages to which devices listen and respond. Typically, these messages come at a rate of at least every few seconds, enabling the network to maintain accurate information about the devices connected to it.

This happens at the cost of battery life: the devices are effectively always tuned in. But the PSM allows for connected devices to be in a kind of sleep mode for several hundreds of hours at a time, only doing brief checks to update the network and scan for pages. The PSM puts devices into this mode while sending occasional tracking area update (TAU) messages to keep them registered with the network and to avoid the need to re-register.

In addition, the eDRX feature offers a longer lowpower paging mode that allows devices to receive downlink data from the server without sending.

Reliable performance

Telia's LPWA networks are secure, reliable and run in a dedicated and licensed spectrum to ensure no interference. This provides predictability and control. It also enables the efficient use of the spectrum to support massive volumes of devices.

For example, NB-IoT can be deployed in three different modes specified by 3GPP as "in-band" that uses resource blocks within a standard LTE carrier, as a "stand-alone" in a dedicated spectrum, or as implemented in an unused resource block with an LTE carrier's guard-band.
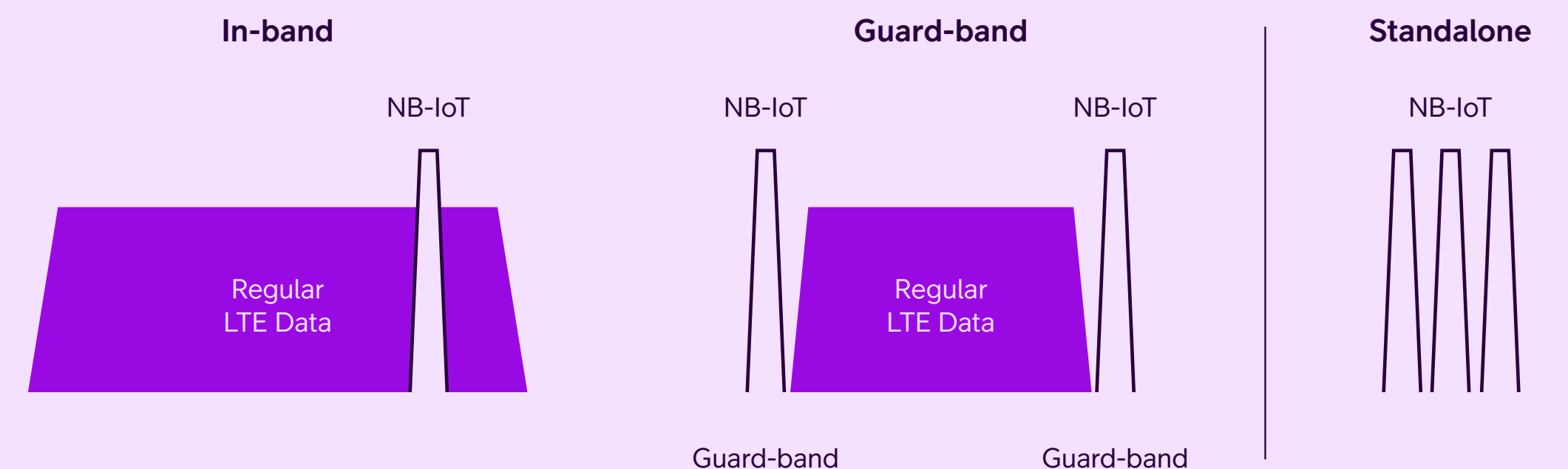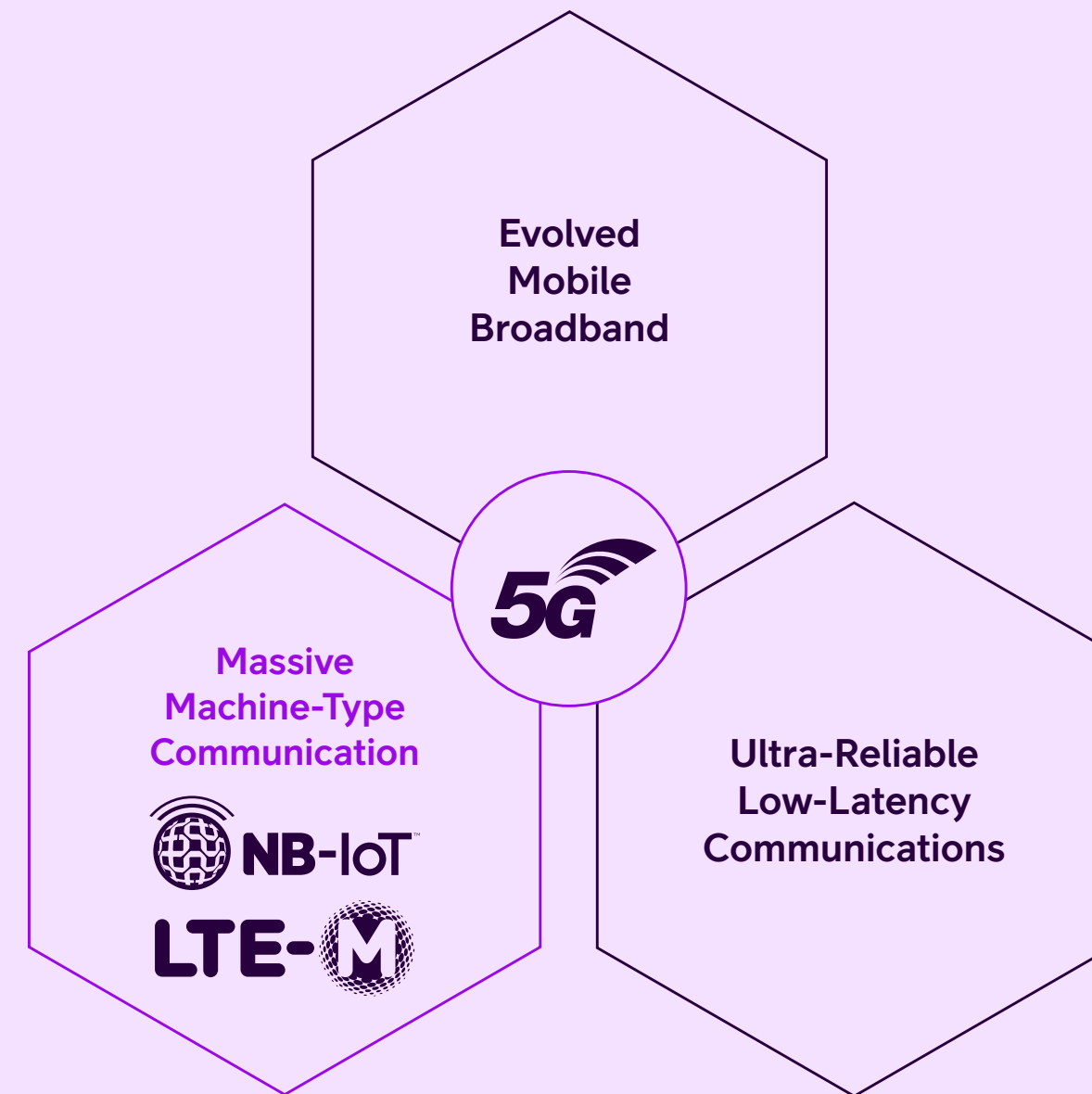

In-band

NB-IoT

Regular
LTE Data

Guard-band

NB-IoT   NB-IoT

Regular
LTE Data

Guard-band   Guard-band

Standalone

NB-IoT

Figure 3: The 5G standard

Evolved Mobile Broadband

5G

Massive Machine-Type Communication

NB-IoT

LTE-M

Ultra-Reliable Low-Latency Communications

Future-proof connectivity that evolves with you

LPWA networks are designed particularly for IoT applications. NB-IoT and LTE-M are both set to coexist with other 3GPP 5G technologies and will continue to develop under the 5G standards. In other words, the status of both NB-IoT and LTE-M as 5G standards has been confirmed and future-proofed.

The main advantage of 3GPP-standardized LPWA solutions, compared to proprietary technologies, is that they have the support of a huge ecosystem of operators and partners. This means that these technologies deliver a minimum level of performance, regardless of the vendor. Standardization also ensures interoperability

across vendors and mobile operators and helps in reaching scale due to the number of companies that implement the standards.

While 5G is characterized by higher data rates and lower latency, this aspect is mainly focused on the human user-enhanced mobile broadband and real-time control use cases. For the machine-related LPWA use cases, we are at the other end of the spectrum with low bit rates and a higher tolerance for latency. 5G systems can manage this variety by dynamically and accordingly allocating the network resources.

Instant coverage everywhere

Telia was the first operator to deploy both networks in the Nordic region and is now part of a fast-growing group of operators rolling them out around the world.

Telia's LPWA networks enable ready-to-use and widespread network coverage, even in remote areas. Because both NB-IoT and LTE are direct-to-network you can multiply the reach by the scale of our network for seamless connectivity across the Nordics.

To go outside of our Nordic and Baltic footprint, we are constantly working with securing roaming partnerships with other cellular LPWA operators around the world.

Link to GSMA's global map of LPWA connectivity

NB-IoT & LTE-M

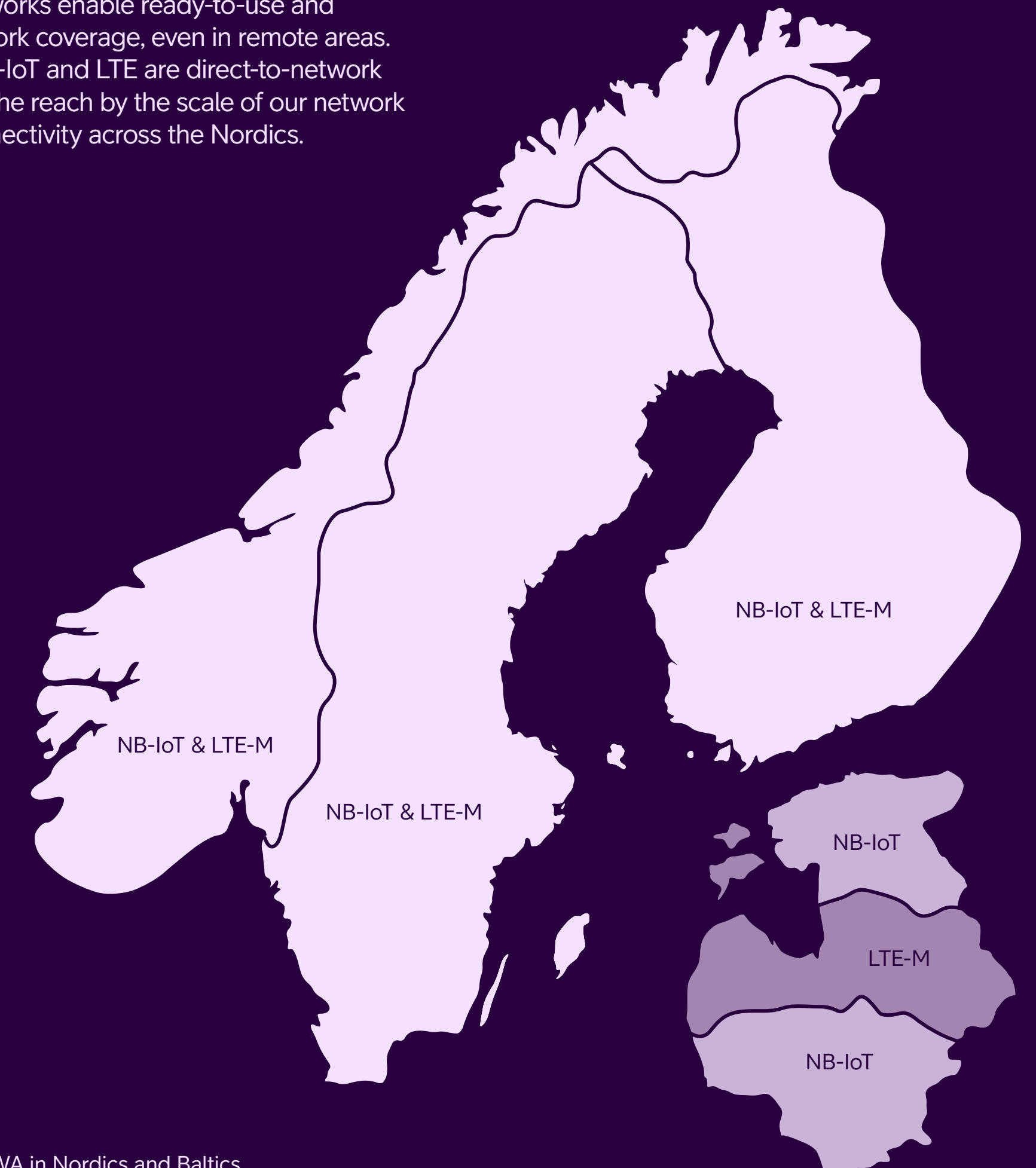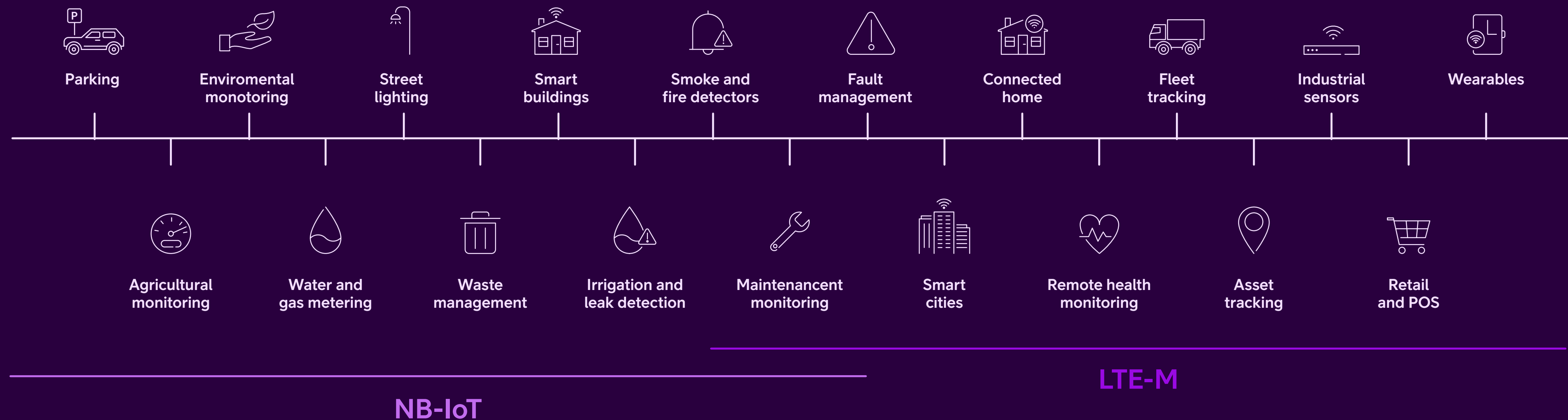NB-IoT & LTE-M

NB-IoT & LTE-M

NB-IoT

LTE-M

NB-IoT

Figure 4: Map of LPWA in Nordics and Baltics

Choosing one or the other: NB-IoT or LTE-M

Both LTE-M and NB-IoT are natural successors for 2G and 3G devices that need replacement. Both networks have several similarities such as deeper coverage and longer battery life, but there are also some differences between the two technologies. As a rule of thumb, a deciding factor when selecting your network of choice must always be your use case. What is the problem you want to solve or opportunity you want to take?

Figure 5: LPWA use cases

| Parking | Enviromental monotoring | Street lighting | Smart buildings | Smoke and fire detectors | Fault management | Connected home | Fleet tracking | Industrial sensors | Wearables |

| Agricultural monitoring | Water and gas metering | Waste management | Irrigation and leak detection | Maintenancent monitoring | Smart cities | Remote health monitoring | Asset tracking | Retail and POS |

LTE-M

NB-IoT

NB-IoT and LTE-M each have specific advantages – but it is possible to choose all of them by selecting a connectivity module that supports both NB-IoT and LTE-M.

NB-IoT

NB-IoT is optimized for low data transmission with maximum battery life and deep indoor and underground coverage. It is designed for IoT on a massive scale, with low bandwidth, small packets of data and a data rate of up to 250kbps, which make it ideal for stationary measure-and-report use cases.

Depending on the device settings it can offer up to ten years operation on a single battery charge which makes it well suited for hard-to-reach or remote locations. And due to its dedicated spectrum and frequency range it also ideal in high device density situations where interference- free connectivity is required.

LTE-M

LTE-M hits a sweet spot in terms of data speed, battery life, and coverage. Designed for low power wide area use cases that need more advanced capabilities it is the technology of choice when higher data rates and higher data volumes is needed.

Supporting data speeds up to 1 Mbps means LTE-M is flexible enough to support things like low to standard resolution video and soon also voice-over-LTE (VoLTE).

Case study

Heimdall Power: Real-time control

Together with partner Heimdall Power, Telia has connected sensors on powerlines to give grid owners real-time visibility of the capacity of different parts of the grid. This lets them increase the capacity of their lines by up to 25 percent. But just as important, it lets them prioritize any extra energy from wind and solar ahead of traditional power sources that rely on fossil fuels. This will play an important role in reducing emissions as more and more renewable energy sources come online.

Here, NB-IoT is used, with far greater reach than traditional IoT technologies, making it ideal for using in remote locations. And because Telia has the most extensive network infrastructure in the Nordics and Baltics, it's a perfect combination. Watch film about the case here.

Case study

SPM Instrument: New improved product

SPM Instrument is one of the leading developers of smart products for machine and equipment monitoring.

When one of SPM Instrument's customers needed a wireless vibration sensor, complete with a temperature measurement function that sends data about the machine's condition via a mobile network instead of using WiFi, gateways and so on, SPM Instrument turned to Telia.

The cooperation between the parties has made it possible to develop, design and manufacture sensors for real testing, and with very good results.

"Thanks to the excellent results from the pilot project, SPM Instrument now has a new and unique product to offer to our customers," says Tomas Årman at SPM Instrument. Read more about the case here.

All SIM form factors are available for both networks, except for eUICC, which is not available for Telia's NB-IoT networks. Existing SIM cards can be utilized for LPWA with a change of APN.

Main differences between NB-IoT and LTE-M

Mobility:
One of the main differences between the two technologies is that LTE-M is designed for mobility. Mobile use cases are better covered due to cell handover functionality within the LTE-M framework. Devices can move at high speed without fear of dropping data sessions. Coverage is very good, in the normal IoT range.

NB-IoT is better suited to static devices. Once established on the network, the device saves its settings and will not recalibrate unless forced to do so. This enables longer battery life.

Evolution and security:
The over-the-air (OTA) update capabilities and data capacity of LTE-M make it the better choice if your application is likely to develop over time. This is ideal where security is a priority: being able to update your devices quickly is essential when working with critical data. OTA updates also let you deploy fast and make timely enhancements.

NB-IoT is better suited to applications that will remain unchanged over a longer period.

Latency:
If responsiveness is a factor, LTE-M has the upper hand with low latency scenarios of 10 milliseconds to 3 seconds, depending on CE levels, compared to NB-IoT's latency of less than 10 seconds. The data capabilities of LTE-M allow for faster and more sustained response times, necessary for applications such as remote control or if human interaction is required.

NB-IoT is geared to sending smaller amounts of data less frequently. Transmitting larger amounts of data would be slow and lead to excessive power consumption.

Power:
Both technologies are very efficient when it comes to power, though NB-IoT has an advantage if used as intended. Performance depends on the transmitter powering down quickly and staying off most of the time. LTE-M tends to be active more frequently and for a little longer.

Figure 6: Main differences between NB-IoT and LTE-M

| NB-IoT	LTE-M
A stationary meter that only needs to report values a few times per day	A GPS tracker that sends frequent location data
Best for devices/solutions that: – Are simple – sensors & micro-controller – Will mainly remain stationary – Sends small amouts of data – Send data infrequently – May be deep indoors of underground – Prioritise battery life and lowest cost – Don´t need regular OTA updates – Only for data – No SMS enabled	**Best for devices/solutions that:** – Are smarter – sensors & processor – May be moved around – Send more data, faster – Send data frequently – Are within normal IoT coverage range – Prioritise higher perfomance – May need regular OTA updates – Simple voice use cases – Possibly to send SMS

Figure 7: Telia's specific LPWA parameter as of May 2021

	NB-IoT	LTE-M
Frequencey Band:	B20 (800MHz), B3 (1800 MHz)	B20 (800MHz), B3 (1800 MHz)
Duplex mode:	Half duplex	Half & full duplex
Signal Bandwidth:	180 KHz	1,4 MHz
Bidirectional data:	Yes	Yes
Min. Periodic Tracking Area Update Timer (T3412):	60 minutes	60 minutes
Max. Periodic Tracking Area Update (T3412):	12,91 days	12,91 days
Min. Active Timer (T3324):	0 seconds	0 seconds
Max. Active Timer (T3324):	186 minutes	186 minutes
eDRX cycle length:	No restrictions	No restrictions
eDRX Paging time window:	20.48 seconds	8.96 seconds
Paging Repetition timer:	12 seconds	2 seconds (6 seconds for delay tolerant devices)
Coverage extension:	EC0, EC1, EC2 up to 20dB, except for Denmark (only EC1)	CE Mode A 5-10dB
HLCom, High Latency Communication:	Buffersize of 2 packets. The first 2 packets will be stored, 3rd will be discarded, you cannot delete a packet.	Buffersize of 1 packets. The 1st packet will be stored, 2rd will be discarded, you cannot delete a packet.

The keys to long-term success

The choice of technology is at the heart of any IoT solution, but just as important is how your solution will be used over time. IoT will become a core aspect of your business and influence many parts of your operations. We have identified three steps towards your long-term success.
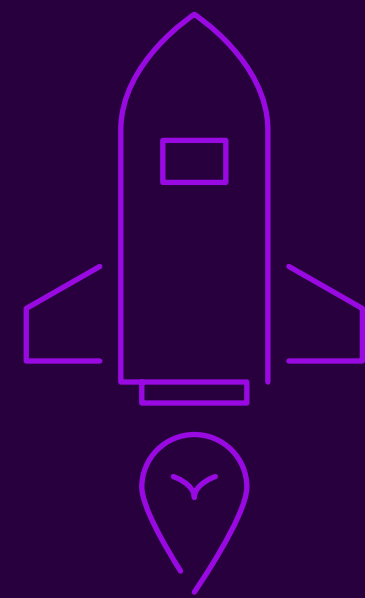
Firstly, you need to get it right from the start. Choose a partner that has experience and can let you design an IoT solution that will perform the way you want it to perform. We give you optimal conditions for predictable, trouble-free deployments. With Telia IoT Solution Optimizer, you can design your project in a few minutes and see if your design will live up to the expectations on its battery lifetime. And with identical performance across borders and the correct device settings from the start, you will be able to launch as planned.

Secondly, the solution needs to keep performing according to expectations. It simply needs to withstand the test of time. Unscheduled downtime or maintenance can impact profitability and the customer experience. As IoT is a core aspect of business, the consequences can be serious. Control and transparency are essential aspects of a consistent solution. Telia's connectivity platform makes it easy to monitor and manage devices remotely, and OTA security and feature upgrades reduce the need for hands-on maintenance.

Finally, there should be no barriers to expanding. Telia LPWA is designed for scalability. With extensive coverage in the Nordics and Baltics, and roaming agreements in several countries, you can easily expand into new markets. Furthermore, we have harmonized our network settings, for easy deployment across our footprint.

The harmonized network

The technological feature settings of the NB-IoT and LTE-M networks may differ from operator to operator. But it is crucial for any LPWA customer to know, and understand – the settings in each network. Only then can you maximize the efficiency of both new technologies.

Telia has harmonized its mobile networks for NB-IoT and LTE-M, giving them the same feature settings across the Nordics and Baltics. This way, our customers get a similar experience in all our networks and across our footprint, regardless of where they are. As a customer, you only need a Telia IoT SIM and some basic information, such as the Access Point Name (APN) and certain network parameters, and you are ready to use both our NB-IoT and LTE-M networks.
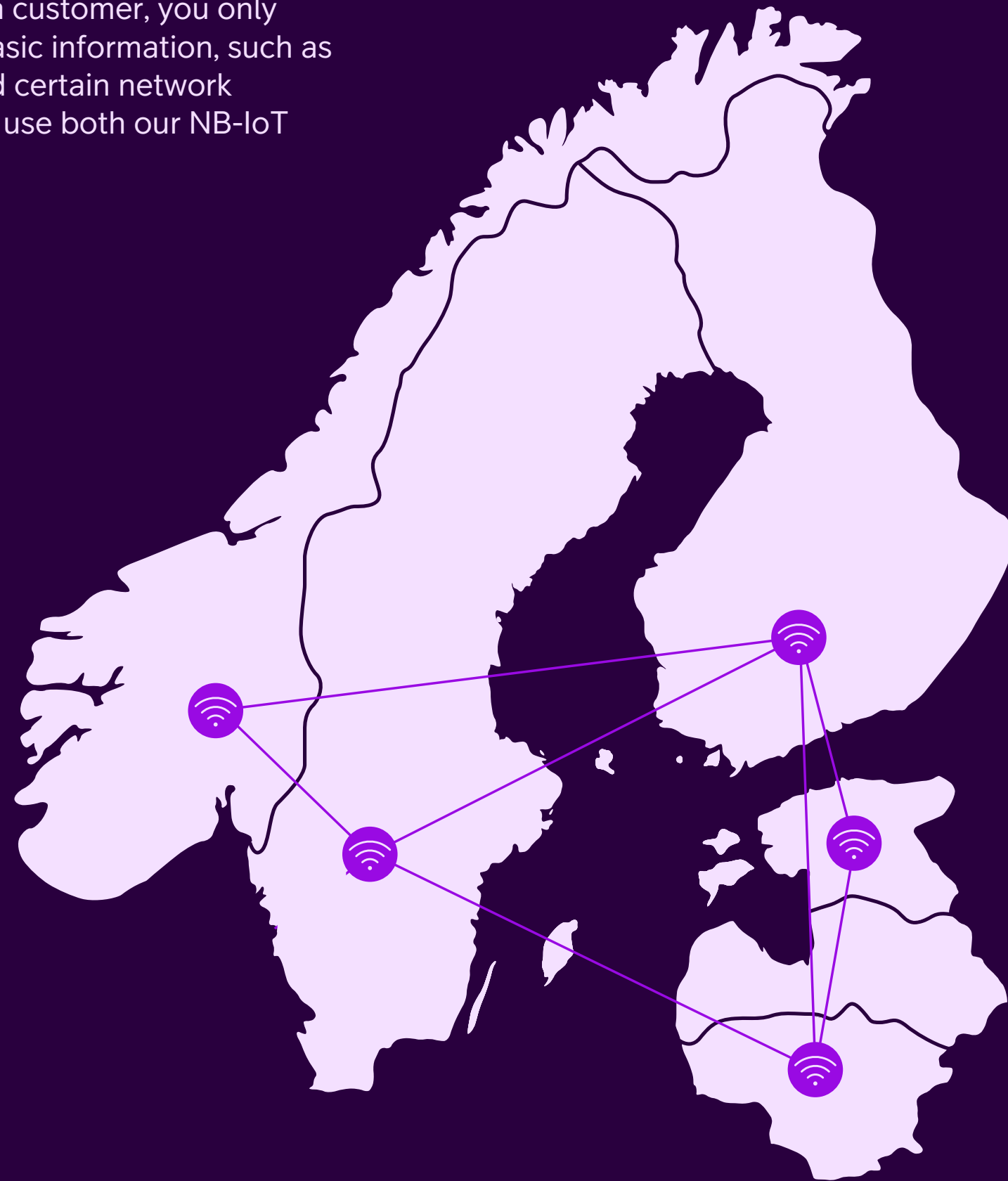
Roaming

The success of mobile LPWA devices will depend on the availability of global roaming agreements for NB-IoT and LTE-M. This will also depend on the adoption rate of LPWA between operators across the globe. The trend is that operators adopt a dual-technology strategy (NB-IoT and LTE-M), rather than sticking to one single technology, which is very promising.

Telia has already several roaming agreements with other operators in place, for both NB-IoT and LTE-M. The current ambition it to secure commercial roaming agreements across Europe and North America, and then extend further globally in the coming years.

Security

Telia's IoT solutions are secure by design, which means that security has been built in at several layers, from the SIM cards via the networks and encryption of data and all the way to protection of the devices. The starting point is the 3GPP-established industry standards LTE and GSM, thoroughly tested by the 700 members of the GSMA. Moreover, this means that both NB-IoT and LTE-M is supported within the existing LTE infrastructure, offering carrier-grade reliability and security. The standardization also means that there are set rules and specifications to follow, adding to the security benefits.

Dedicated Licensed Spectrum
Telia's cellular LPWA connectivity is provided in licensed spectrums bands dedicated to the specific connectivity. And because the management of the spectrum is done in accordance with regulatory authorities' standards, interference from other radio technologies is minimized while control is maximized. In other words, we control access to our spectrum. Once the device and the subscriber is authenticated, we set the rules relating to the spectrum. This eliminates congestion and other challenges of a shared spectrum with less reliability and control. With large numbers of devices connected to one cell tower, all devices compete for the same space causing interference and negatively impacting the ability for the device to transmit data.

Over the Air: OTA
Most IoT devices need to be updated from time to time. Software updates, security patches and regulatory changes all drive this need for updates. One of the key benefits of OTA updates is the ability to quickly react to security breaches or software bugs and to manage software updates or security patches remotely, without having to handle all the devices manually.

While Software OTA (SOTA) refers to updating software components in general, Firmware OTA (FOTA) is more specific. FOTA is about updating the main system software that controls the underlying hardware.

Another benefit of OTA is the possibility to add new software defined functionality to your products, extending the product life cycle.

IoT security needs to be addressed on many levels

SIM Security
SIM stands for Subscriber Identity Module and it contains highly secure integrated circuits to authenticate the devices accessing our networks and services.

Secure communications channels
With our VPN (Virtual Private Network) and advanced APNs, (Access Point Names) you can increase security on the network and access levels. VPN lets you separate your network from the public Internet. APN increases your control over who can access your data. It is also possible to utilize private APNs to further increase security levels.

Data over NAS (DoNAS)
Data over NAS (DoNAS) is a control plane optimization that means putting user data into signaling messages, well suited for low volumes of data and LPWA. It sends data via the MME (Mobility Management Entity) by putting it into NAS (Non-Access Stratum) signaling, which ensures high levels of protection as well as encryption of data and integrity protection.

Non-IP Data Delivery (NIDD)
Non-IP data delivery was introduced to send small amount of data more efficiently. It is used together with DoNAS to send data to the network without using IP. NIDD can transport data using a Point-to-Point (PtP) Serving Gateway interface (SGi) tunnel to the application server. It can also use the service capability exposure function (SCEF) to securely expose service and network capabilities through network application programming interfaces (APIs).

Encryption
NB-IoT and LTE-M encryption use the same encryption that is used in today's cellular networks. Additional encryption can be put on top of communications, depending on the device type and purpose.

DDoS protection
When deploying your IoT solution with Telia, devices and connections using LPWA have the option to be protected using Telia's DDoS (Distributed Denial of Service) protection that will mitigate the targeted attacks before they reach your servers.

Device Certificate Management
When deploying a large amount of LPWA connected devices, one of the security challenges is deploying Public Key Certificates to identify devices and protect communications. Telia offers its own Certification Authority to easily help manage the OTA deployment of certificates.

Identification of potential security breaches
Using Telia's LPWA network also means getting access to our expertise. Security scans and vulnerability assessments gives visibility to the status on connections and devices. Through Telia's Security Operations Center we can offer surveillance of potential security breaches and compliance with regulations in the Nordic and Baltics. Our platform also lets you visualize occurrences in a security analytics dashboard.

Taking the next step

At Telia we want to support you throughout the lifecycle of your solution – because IoT will become a core aspect of your business and influence many aspects of your operations. And while IoT essentially is more about business than technology, the choice of technology is still crucial. Factors like network quality and coverage are vital to efficiency and to the customer experience. We hope we have given you a clear picture of how we can support you along this evolution.

There are many scenarios and use cases where cellular Low Power Wide Area connectivity is an excellent choice, for instance when connecting IoT devices in the rural parts of the country, or connecting in downtown with high device density, or down below ground or in the ground. Devices that you don't want to update or change for many years. Connect a few or connect millions of IoT devices, the later is what LPWA was design for.

When is LPWA IoT Connectivity from Telia the choice for you?

1. You need full mobility and instant connectivity, instead of building your own network.

2. Your use case will evolve, and you need the possibility of OTA updates.

3. You will have many devices spread over a wide area and need a network with extensive reach.

4. You will deploy in an area with a high density of connected devices and need a robust network with dedicated spectrum.

5. Security is critical. You will need built-in mobile security, dedicated spectrum and OTA updates.

6. You want to shorten your time to market and evaluate your IoT solution immediately online.