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Guide to European Cellular Technology & Trends

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Introduction

According to IDC, worldwide spending on the Internet of Things (IoT) forecast to reach nearly $1.4 trillion in 2021[1]. A recent study by Vodafone claims that nearly one third (29%) of global organisations, across industries, have adopted IoT[2]. GSMA Intelligence forecasts that IoT connections will reach almost 25 billion globally by 2025[3]. The point is, IoT is making a massive impact on the world as we know it. From enabling the creation of new products and services, to introducing unprecedented levels of automation, to driving the Fourth Industrial Revolution, the IoT is truly transforming business practices and business models across industries.

Simply put, without connectivity - IoT would not be possible. It is powered by a broad range of network technologies that facilitate the transfer of data among devices and systems, and IoT application developers must select the option(s) that work best for their unique requirements. The options include Wide Area Networks (WAN), Local Area Networks (LAN), and Personal Area Networks (PAN) and vary greatly based on categories such as bandwidth, mobility support, and throughput – as well as many others. WAN accounts for the majority of business oriented IoT applications, cellular connectivity is the most widely selected network technology with an estimated 1.5 billion cellular IoT connections – set to rise to 5.2 billion in 2025[4]. Even when drilling down to the world of cellular networks, it is made up of numerous technologies (i.e. 2G, 3G, 4G LTE, etc.) offered from numerous operators throughout Europe and the rest of the world.

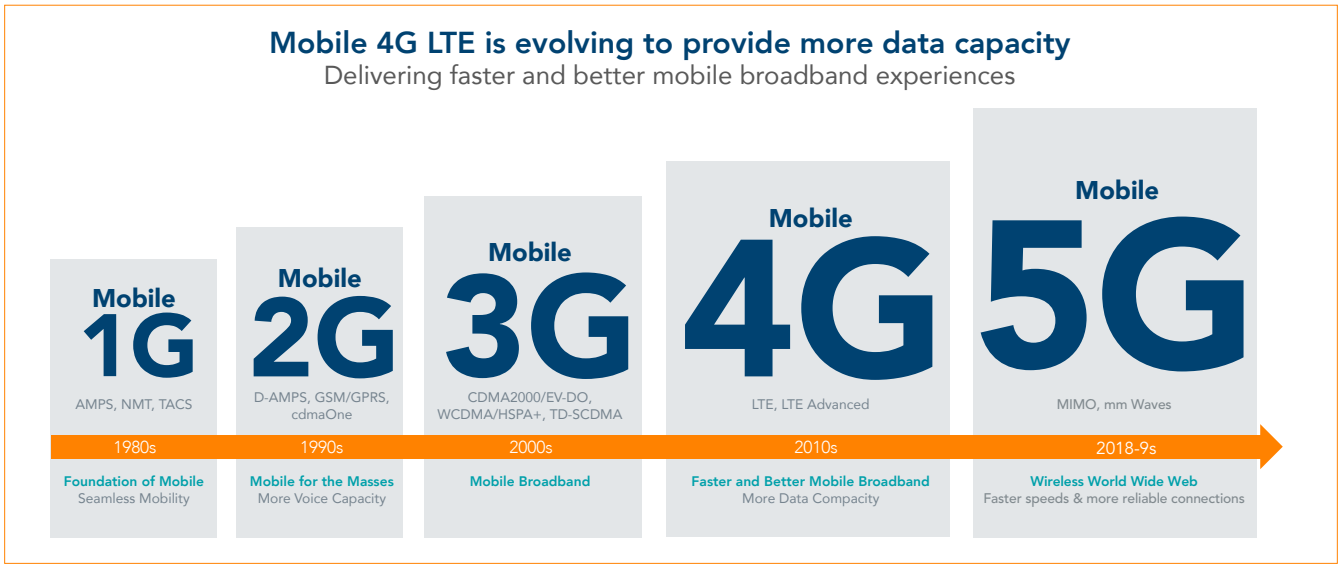
As the complexity of achieving customer's IoT goals ever increase with new use cases such as smart cities, connected health and more – we now enter an age of IoT sophistication. The 2019 Vodafone Barometer Report put together an IoT sophistication model that aims to benchmark organisations IoT progress against their peers and improve understanding of best practice. The IoT experience rating went from Band E: Still Considering to Band A: Most Sophisticated, and the results for EMEA from their survey was very interesting. Although 83% of IoT adopters said its crucial to the future success of their business - EMEA had the highest percentage of companies in Band E: Still Considering. Also in comparison with other regions, it had 'the lowest share of companies in the top three bands. This places EMEA at the bottom of the pile in terms of sophistication.'[2]

This white paper will explore key cellular technologies, trends, and use cases in the European marketplace, and future predictions for cellular IoT.

Simply put, without connectivity IoT would not be possible.

Key Cellular Technologies and Trends

When referencing cellular technology, the "G" in 2G, 3G, 4G, etc. is representative of the word "Generation", as each different number represents the next generation of wireless cellular technology. Each evolution builds upon the technology prior, adding new capabilities and supporting the expansion of the mobile experience. Here is a quick breakdown of key milestones in the mobile technology timeline:



2G – The first network technology to deliver mobile voice services to the masses, 2G enabled smaller and more cost-efficient digital components that delivered increased signal security. Its ability to more efficiently use spectrum resources, complemented by increased battery life in mobile devices, carried these advantages beyond consumer cell phone usage and powered the first Machine-to-Machine (M2M) applications. The simplistic data capabilities of 2G were perfectly suited for the minimal data requirements of traditional M2M solutions.

3G – Evolved from 2G networks, 3G delivered higher data rates, more capacity, and better mobile broadband experiences, ushering in the era of smartphones. In addition to higher throughput, 3G technologies reduced operator costs for data services and continued to build the foundation for progressive evolution of enhanced services.

4G LTE (Long Term Evolution) – 4G LTE provides faster, better mobile broadband experiences with increased data capacity for richer content and a higher number of connections. Contrary to common misconception, LTE is not a single technology but a range of technologies that fall under the LTE umbrella. Not all of these technologies are created equal, and different "categories" of LTE, as they are referred to, have been designed for specific purposes, with specific levels of performance, and require specific device makeups. These LTE categories are covered in greater detail in the following section.

5G - As with most previous cellular network evolutions, 5G has emerged from existing 4G networks as the next generation of cellular technology. Unlike previous evolutions, though, the expectations for 5G are much higher. 5G is more than a new generation of technologies; it denotes a new era in which connectivity will become increasingly fluid and flexible. 5G Networks will adapt to applications and performance will be tailored precisely to the needs of the user. Working closely with the mobile operators pioneering 5G, the GSMA is engaging with governments, vertical industries including automotive, financial services, healthcare providers, transport operators, utilities and other industry sectors to develop business cases for 5G.[5]

GSMA Goals of the 5G Era

1. Boundless connectivity for all – Co-exist with 4G LTE networks to provide borderless, high-speed, secure connectivity

2. Deliver future networks innovatively with optimal economics – Cost effectively deliver better quality networks either independently or through partnerships

3. Accelerate digital transformation of industry verticals – Establish the networks and platforms required to drive digitalisation and automation of industrial practices and processes

4. Transform the mobile broadband experience – Enhance mobile experience with up to 1 Gbps and <10 ms, providing a platform for cloud- and artificial intelligence-based services

5. Drive growth in new use cases for massive IoT and critical communications services – Support massive roll-out of intelligent IoT nodes, as well as widespread adoption of critical communication services

> *"The impact of mobile on our lives will be accelerated with the arrival of 5G in a few years. Wireless connectivity will go from something we experience through personal devices, to an integrated infrastructure of buildings, transport and utilities, providing unprecedented benefits for citizens, businesses and cities alike. This ubiquitous connectivity will help make energy grids more resilient, slash unproductive commutes and free up time in our over-stretched public services."*
>
> - Mark Evans, CEO, Telefónica UK

The GSMA forecasts that by 2025, 5G networks are likely to cover one-third of the world's population. The impact on the mobile industry and its customers will be profound[6]. With that said, 5G deployment is not without GSMA-identified challenges that must be managed by stakeholders to meet these expectations:

1. Business case – To maximise the 5G opportunity, the mobile industry must identify new services, market segments, and suitable business models to optimise the network investment[6].

2. Spectrum availability – Spectrum will continue to be a scarce resource, and the availability of spectrum, at which frequency bands, and at what costs will have a significant impact on the 5G business case[6].

3. Technological improvements and breakthroughs – To meet the technical expectations of 5G, both the laws of physics and current network layouts will be challenged, demanding major technological advancements in device and network design[6].

4. Fragmentation – Lessons learned from 2G, 3G, and 4G LTE deployments prove that mobile technology is more successful when fragmentation is limited. Operators must standardise from the beginning to avoid future issues[6].

5. Regulation – To rationalise the significant investment that 5G deployment demands, regulatory bodies must support transparent policies that encourage investment and innovation[6].

The innovation to 5G is significant, with estimates claiming mobile operators will be able to grow global revenues at a CAGR of 2.5% during the 5G era[6], it is important to note that 5G deployment must be a collaborative effort among key players in the mobile industry. The way that 5G is developed, managed, regulated, and commercialised will fundamentally establish how closely it meets expectations of innovation and economic growth.

eSIM: Single SIM – Global Connectivity

The eSIM (Embedded SIM), also known as an eUICC (Embedded Universal Integrated Circuit Card) is a type of technology that provides device users with significantly increased levels of flexibility through its ability to support multiple cellular carrier profiles on a single SIM card. Traditionally, a SIM card only contained the credentials or subscription required to access a single carrier's services – changing carriers required changing SIM cards. Through the use of eSIM, though, users can remotely provision their devices to switch between supported carrier profiles via Over-the-Air (OTA) updates. The eSIM represents a revolutionary change in the ways that cellular services are managed - eliminating the need for SIM swaps or even physical access to the device to change service providers.

The impact of eSIM on the world of IoT is expected to be significant, as GSMA predicts that half of all SIM card deployments will use the eSIM format by 2024[7].

Although eSIM solutions have technically been available for several years now, it has mostly been in proprietary solutions for very specific use cases (i.e. Apple iPads). In 2012, GSMA became involved in eSIM specifications and standardisation to ensure SIM cards, provisioning systems, and equipment – regardless of manufacturer – will function together. As these standards continue to be defined, cellular carriers, SIM card manufacturers, and other members of the eSIM ecosystem are already leveraging GSMA specifications to define their future eSIM offerings.

The impact of eSIM on the world of IoT is expected to be significant, as GSMA predicts that half of all SIM card deployments will use the eSIM format by 2024. Today, while the technology is advancing in its capabilities, the majority of cellular carriers are still making the necessary changes to network infrastructure, systems, and processes to prepare them for widespread eSIM adoption. With that said, eSIM is very much a near-future solution for IoT organisations to be aware of.

Expansion of LTE and Low Power Wide Area Networks (LPWAN)

Traditional M2M and now IoT applications have long relied on 2G and 3G cellular networks due to their low cost and high availability. The majority of IoT solutions are characterised by low bandwidth and low power requirements, and the increased speeds and higher bandwidth that come with traditional LTE technologies, such as Category 1 (Cat-1), Category 4 (Cat-4), are simply not needed. It should also be noted that for IoT companies, the high costs of these LTE networks present ROI challenges that render them a poor economic fit.

As cellular carriers today cater to consumer demand for high-speed LTE connectivity, they are faced with the challenge of finding a network solution that will continue to support the growth of IoT as legacy 2G and 3G networks fall victim to spectrum re-farming and eventually become extinct. The result: new low-power LTE technologies – Category NB1 (NB-IoT) and Category M1 (Cat-M1 or LTE-M) – have been specifically designed and deployed for IoT applications.

Both NB-IoT and Cat-M1 leverage existing cellular infrastructure, meaning devices on these technologies can easily be installed to current networks. Cat-M1 is a lower power and bandwidth variant of LTE, which still supports voice communications and full mobility, while NB-IoT is the lowest power and bandwidth variant but does not support voice communication or cell tower handoff. This means that NB-IoT is not typically a suitable option for applications that roam between towers.

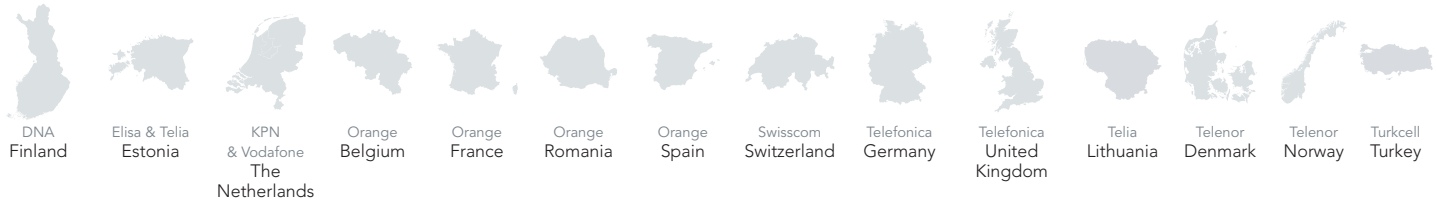
Common benefits of solutions deployed on LPWA LTE networks include:

- Very low power consumption with some applications boasting a battery life of 10 or more years
- Low cellular module costs leading to low device unit costs
- Indoor and outdoor coverage in previously unreachable locations
- Scalable technology with the ability to support a large number of devices over a wide geographic area
- End-to-end secure connectivity and support for authentication appropriate to the IoT application
- Future-proofed technology with no fear of network sunsets in the next 10 years

Predictions from Machina Research estimate that LPWA connections are set to exceed 2G, 3G, and traditional 4G LTE to become the leading technology for IoT by 2022. However, it must be understood that availability is still minimal today as a limited number of operators have commercially launched Cat-M1 or NB-IoT with many of them still in the planning or piloting phases.

GSMA list of commercially launched solutions[6]:

10 cellular operators have commercially launched Cat-M1 networks that are available across 14 European countries:



Licensed vs. Unlicensed

In addition to the aforementioned licensed, low power LTE technologies, there are also a number of proprietary LPWAN network options that operate in unlicensed spectrum such as Sigfox and LoRa. When using licensed spectrum, operators must apply for and obtain a license from local regulatory agencies, such as OFCOM in the United Kingdom, to own and operate spectrum in exchange for connectivity that is 99.999% interference-free. Unlicensed spectrum does not require any special permit or license to operate, but if multiple providers are operating in the same area unlicensed connections may be subject to interference[7].

Prior to the emergence of NB-IoT and Cat-M1, unlicensed networks were the only LPWAN solution for new IoT solutions requiring lower power, longer range, and longer battery life. Although the market is shifting towards licensed network technologies, there are still certain geographies and use cases where unlicensed connectivity is an adequate solution. The superior choice for network connectivity is dependent on each business' unique requirements.

	Licensed Spectrum			**Unlicensed Spectrum**	
	LTE-M	NB-IoT	SigFox	LoRa	RPMA
Coverage	160 dB	164 dB	149 dB	157 dB	177 dB
Bandwidth	1 MHz	180 MHz	100 MHz	125 MHz	1 MHz
Battery Life	10+ years	10+ years	10+ years	10+ years	10+ years
Throughput	1 Mbps	250 Kbps	100 bps	290bps - 50Kbps	624 Kbps
2-Way Data Tx	Yes	Yes	No	Depends	Yes
Security	3GPP (128-256bit)	3GPP (128-256bit)	16 bit	32 bit	AES 128 bit
Scalability	High	High	Low	Medium	High
Mobility Support	Connected & Idle mode	Idle mode	No	Yes	Yes
LBS Support	Requires GPS	Requires GPS	No	Yes	Requires GPS
Module Cost	$10	$5	$2	$12	$12

Cat-M1 and NB-IoT Use Cases

Cat-1 is the fastest, most expensive LTE technology that provides an appropriate solution for some IoT applications (Cat-4 is typically unnecessary for even the most robust IoT solutions). Its high bandwidth, high throughput capabilities make it best suited for applications such as digital signage, video surveillance, ATMs, and kiosks that demand low latency and high speeds.

Cat-M1

Cat-M1 fully supports IoT and M2M applications due to its ability to support voice communications and full mobility. Key use case applications include:

Tracking and Logistics - There are already many existing fleet and asset tracking M2M connections that exist as part of either 2G or 3G networks. Many logistical devices are not restricted by the same power limitations that devices in other LPWAN use cases have, meaning that battery life is not a primary concern. Due to the mobile nature of these applications, Cat-M1 is the optimal solution.

Remote Monitoring - For organisations that use sensors as part of their business practices to monitor things like temperature, humidity, or vibration, CAT-M1 is a good fit. Sensors in the field can be installed without battery life concerns, and mobile applications (cold chain monitoring, for example) are fully supported.

Consumer LPWAN - The market for consumer LPWAN will be driven primarily by wearables connected to a network by a Cat-M1 module. A number of LTE compatible wearables are expected to enter the market in 2018 and beyond, and the market for standalone wearables is expected to develop significantly with Cat-M1 likely to support the majority.

NB-IoT

As the lowest power and lowest bandwidth variant of LTE, NB-IoT does not support voice and has slower cell tower handoff, providing extreme optimisations for low-throughput, delay-tolerant use cases.

Smart Grid - The main spending drivers on LPWAN in this market will be to cut cost, improve operational efficiently, and introduce highly accurate customer billing. Due to its ability to support static assets with very low bandwidth requirements, NB-IoT fits the bill for smart grid applications.

Smart City - Similarly to smart grid applications, NB-IoT's ability to support static assets with low bandwidth requirements also make it a good fit for smart city use cases. Because it uses licensed spectrum, NB-IoT has better signal integrity and less chance of interference than unlicensed options that could be impacted by Bluetooth, Wi-Fi, or other technologies that are increasingly present in crowded urban regions.

Precision Agriculture - These application tend to be static and pass very little data. Extended battery life and low costs are favoured over latency, making NB-IoT a leading solution.

> *"We at T-Mobile see NB IoT as a game changer for the industry, the technology has all the potential of becoming the world's standard for LPWA."*
>
> - Robert de Vries, Senior Sales & Business Development Manager IoT, T-Mobile Netherlands B.V

Future Predictions

Smart Living

With the rise of city-based living, IoT solutions can help consumers and businesses navigate their congested lives. But, as IoT Now explains, it has to go beyond simple creature comforts like voice-enabled assistants and smart locks – we need to reduce our impact on the environment and leverage IoT for more sustainable solutions. Companies like U.S.-based Sagegreenlife have already made great strides by bringing sustainability and cleaner air into homes and offices through living plant walls.

For the EU, specifically, there has been much talk of EV charging stations and ways to make cleaner fuels more widely available. The number of interconnected devices is set to reach 33 billion in the next 3 years – there's ample opportunity to reduce our environmental impact through IoT solutions while also simplifying life for consumers.

There has also been a distinct movement from basics telematics to connected video technology as a way to boost fleet safety and efficiency. In-vehicle video solutions can provide near real-time alerts for driver distractions, unsafe road conditions, and vehicle status – allowing fleet operators to take action quickly and, ultimately, reduce their overall risk.

With each of these smart living advancements, the need for high-speed, IoT-specific network connections grows. Especially as solutions scale and deploy in more locations, there's an increased need for carrier flexibility and improved coverage. Expect to see higher adoption of low-power and narrow-band IoT solutions on a much larger scale.

IoT Security, 5G and Saying Goodbye to IPv4

The reality is that for many early M2M and IoT pioneers, adopting a holistic approach to securing communications and application data for devices in-field wasn't just afterthought, it wasn't really possible given the toolset available at the time. Security models and the associated plethora of tools were well established in protecting and securing traditional IT systems but attempting to shoehorn a remote deployment of 20,000 'dumb' endpoints into those various models didn't really work. And was it even necessary?

Fast forward 10 years and whilst the number of IoT devices deployed globally now significantly outweighs the number consumer mobile phones and the data transmitted being sometimes equally as sensitive, the focus on end-to-end security for

IoT deployments is primitive in comparison. Now 5G is here, coupled with the long-awaited – and somewhat reluctant – shift from IPv4 to IPv6, the traditional, rudimentary security methods employed to protect IoT solutions will be found lacking in this new age of modern, IoT-centric infrastructure and as the focus continues to intensify on IoT and the sheer scale of deployments, so will the evolution of IoT-specific security strategies.

As a result of that, we can expect to see the IoT security platform market grow significantly as it looks to provide a truly end-to-end approach to securing IoT deployments, from the SIM and the device all the way to the data-at-rest.

The Resurgence of MVNE

Mobile Virtual Network Enabler (MVNE) Service offerings are nothing new, but we see a sharp upward curve in this area, and we predict it will only grow. By the end of 2020, there are expected to be more than 9 billion active mobile cellular connections. And with this growth, Mobile Virtual Network Operators (MVNOs) have started to challenge traditional mobile network operators to provide SIM-only mobile subscriptions to consumers that have grown wise to overpriced mobiles and plans. As well as looking to address specific niche markets (with unique content offerings), thereby distinguishing themselves from the mass-marketing MNOs.

Launching a mobile virtual network should not be complicated and customers are now looking toward those fully managed offerings, where they can build their own propositions, offer tailor made connectivity services by creating their own rate plans and roaming footprint. The overall goal being to launch of mobile brands to the marketplace with minimum upfront investment - so they can focus on running their business.

Recommendations and Key Considerations for IoT Connectivity Provider Selection

In contrast to other global regions such as North America, where organisations have only a handful of carrier networks to choose from to power their IoT solutions, the European marketplace is much more competitive. Most EU countries are supported by multiple major carrier networks with varying capabilities that may or may not make them suitable for IoT. There are a number of key areas organisations should be evaluating when selecting an IoT connectivity provider:

Security

According to a recent study released by HP Security Research, it is estimated that up to 90% of IoT devices collect some form of personal information, meaning that it is critical for IoT applications to keep this information confidential. One of the most practical solutions to ensure secure data transmission is the use of a Virtual Private Network (VPN), which essentially uses end-to-end encryption to extend an organisation's private network out to cellular-connected IoT devices. Businesses should be asking providers if they provide private network solutions, what options are available, as well as estimated timeframes for implementation.

Coverage Requirements

Geographical coverage will vary drastically from carrier to carrier. Some are limited to in-country service, while others may enable roaming into

other countries at costs that vary at equally as drastic levels. It is important to understand the regions in which your IoT application will be operating to determine if a single carrier or multi-carrier approach will work best. If a multi-carrier approach is required, consider partnering with an IoT network provider that can grant access to multiple carrier networks via single relationship. Working with an organisation like this can also enable solution scalability into new regions without having to cultivate a new partnership.

Connectivity Management

The connectivity management requirements for IoT applications are much different than those demanded by consumers. While consumers typically manage one or two smartphones or other mobile devices, IoT companies are potentially managing hundreds of thousands of connected devices and require specific reporting, provisioning, analytics, and system integration capabilities. Ensure your provider has a connectivity management platform designed for IoT. It is also important to remember that if using a multi-carrier approach, you may have to manage multiple platforms, unless you partner with an IoT partner that can aggregate multiple networks into one.

Services Beyond Connectivity

Although network connectivity is one of the primary building blocks of any IoT application, there are a number of additional components that must be integrated to generate a functional solution (i.e. devices, applications, etc.). Even once the primary components have been selected, there are still secondary systems and services that must be implemented (i.e. staging and kitting, logistics' management, customer support, etc.) for a successful IoT deployment. Evaluate what complementary products and services your network provider can offer to simplify your IoT launch and accelerate time-to-market.

Reach out to KORE today to learn how we can help your business simplify the complexities of IoT to achieve transformative business performance.

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