2G and 3G switch-off:

What network evolution means for IoT

Dec 2022

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Executive summary

Mobile network operators (MNOs) around the world are going through a process of migrating from old legacy networks, specifically 2G and 3G, to newer more capable and efficient technologies in the form of 4G and 5G. In some countries, such as Australia, Japan and the United States this process has been under way for a decade or more. In Europe, in contrast, it is a relatively recent development, with the first migrations happening in just the last two years, but with almost all operators now setting roadmaps for switching off in the next decade.

The process involves the 'refarming' of spectrum which was previously used for the older generations, for use with the new generations. There are several reasons why MNOs are going through this process. In some cases, there are regulatory requirements to do so. But in most cases, the drivers are that 4G and 5G network have much greater capabilities for delivering data services and make more efficient use of spectrum with lower operational overheads. This translates into better and cheaper experiences for customers as well as being more sustainable.

The consequent sunsetting of the old 2G and 3G networks can have some significant implications for organisations that have relied on these networks for their IoT deployments. The extent to which it will have an impact depends on a number of factors:

- How critical are the IoT connections to your operation?
- Have you already deployed the devices and what technology are they using?
- Where are your devices deployed?
- What is the lifespan of your devices and their natural replacement rate?
- How easy is it to upgrade units?

Based on the answers to these questions, this White Paper identifies five possible implications for enterprises: no action necessary, roadmap change, accelerated roadmap change, accelerated replacement rate and proactive switch-out. Depending on which of the possible scenarios applies, there are likely to be costs for any enterprise involved in the need to migrate to 4G or 5G. This might involve hardware replacement and the logistics costs implicit in any 'truck-roll' to replace old devices.

However, it should also be stressed that there are significant benefits for enterprises in migrating to these newer generations. For instance, the new NB-IoT and LTE-M technologies offer superior data throughput, reduced power consumption and improved coverage, and promise to be future-proof for decades. There are numerous other benefits, including the ability to upgrade the whole protocol stack, adopt new functionality such as eSIM, and introduce more management features. Beyond this, the upgrade will often allow access to cheaper tariffs. Overall, the new technologies are more sustainable due to reduced power consumption from the devices, more efficient data delivery from 4G and 5G, and the reduced need for MNOs to continue to operate multiple networks.

Having decided to upgrade from 2G and 3G there are numerous technology options within 4G and 5G, all of which have different capabilities. These range from the 'Low Power Wide Area' (LPWA) technologies NB-IoT and LTE-M to ultra-high bandwidth 5G, plus several options in between.

This White Paper fulfils a number of different purposes. The introductory sections explain the rationale amongst MNOs for making these network changes, and a guide to where and when 2G and 3G sunsetting is occurring in the Nordic/Baltic region and beyond. It goes on to examine how 2G and 3G switch-off will affect different organisations, as well as the potential costs and benefits. Then it examines the technology options that are available to organisations that are going through the upgrade from 2G/3G, including LTE, NB-IoT, LTE-M, and 5G. Finally, it offers a set of recommendations about how enterprises should act when considering upgrading from 2G/3G.

This White Paper has been compiled by IoT industry analyst firm Transforma Insights, in collaboration with Telia Company and Ericsson.

Why are the operators doing this?

MNOs around the world are going through a process of network evolution which is seeing 2G and 3G networks coming to the end of their natural life and reusing the spectrum (known as ”refarming”) for 4G and 5G networks. There are several reasons why the MNOs have made this decision.

Richer services demand 4G and 5G

Older technologies, in the form of 2G and 3G have been superseded by newer 4G and 5G which can deliver far superior services. 2G and 3G were about delivering voice, data and some limited data services, including machine-to-machine (M2M) connectivity for early IoT devices. It really required the arrival of 4G and its higher data speeds to support the app economy that we know today. Tinder, Uber, WhatsApp, and numerous other data services have only really become viable with the arrival of 4G.
As has the idea of mobile working, web browsing, collaboration tools, using video-conferencing, and other office applications while out of reach of Wi-Fi.
In IoT the arrival of 4G permitted higher bandwidth applications such as connected cars, video cameras and consumer electronics. With 5G this trend becomes even more pronounced, as it enables capabilities such as real-time augmented reality, autonomous vehicles and industrial process automation. The applications enabled by the next generation of technologies are much richer, and the old 2G and 3G networks are simply unable to deliver them.

More efficient use of spectrum

The radio spectrum that is used by mobile networks is scarce and each mobile operator only owns a limited amount. The old 2G and 3G technologies do not make very efficient use of this spectrum compared to 4G and 5G, which can support more users delivering higher bandwidth services over the same resources. Ultimately this means that switching from using a piece of spectrum for 2G or 3G to instead delivering 4G, and even more so 5G, means better services for end users at lower prices.

Operational overheads

It is very inefficient to continue to maintain lots of different networks. While there is some overlap in the infrastructure used to deliver 2G, 3G, 4G and 5G - most notably in terms of using the same masts for transmitters - most of the infrastructure used to deliver each of these technologies is separate. This is very inefficient, with MNOs needing to maintain lots of 2G and 3G network infrastructure to support rapidly declining numbers of users. It should be noted that this is less the case with 4G and 5G which do interoperate quite well. Rationalising the number of networks that the operators need to maintain reduces costs considerably, providing financial benefits which can be passed on to end users.

Regulation

In some markets, for instance in Singapore, there has been, or will be, an agreed shut-down date or the end of a licence period, after which the MNOs are obliged to cease operating their networks.

Sustainability

Another angle on efficiency is that by delivering more data more efficiently, networks are effectively becoming more sustainable. The power used to deliver a byte of data falls dramatically as networks evolve from 2G to 3G to 4G to 5G, thanks to features such as network load balancing, beam-forming, which narrowly focuses network resources, and the greater dynamic adaptability of the network, for instance to turn off sites during off-peak hours. Furthermore, removing the requirement to continue operating empty 2G and 3G networks also has a positive sustainability impact.

We have to be a little careful here, as the trend has been for the volume of traffic to expand to fill the capacity available. It’s doubtless greener to view one funny cat video over 5G versus 2G GPRS, but 5G also allows a user to indulge their love of funny cat videos to a much greater extent, resulting in much larger volumes of data and therefore potentially a larger carbon footprint. What we can certainly say is that on a like-for-like basis, the use of data applications becomes much more sustainable, and that the use of increasingly valuable data services is delivered in an increasingly sustainable way with 4G and 5G.

Where and when is it happening?

Many MNOs around the world have plans in place for migrating both their 2G and 3G networks to 4G and 5G. This is particularly true in the more developed markets in North America, Asia and Europe.

Japan was the first country to begin to switch off its 2G networks and has had no support for 2G devices since 2011. Similarly in South Korea, there have been no 2G networks active since 2011, while Australian operators closed 2G networks between 2016 and 2018. In all three countries 3G persists. North American operators have also been quite proactive in network rationalisation. There was limited 2G network availability in Canada or the US after 2021. Although 3G switch-offs have been announced, coverage remains an issue for many operators and more remote areas are still served by 3G networks as opposed to newer generations.

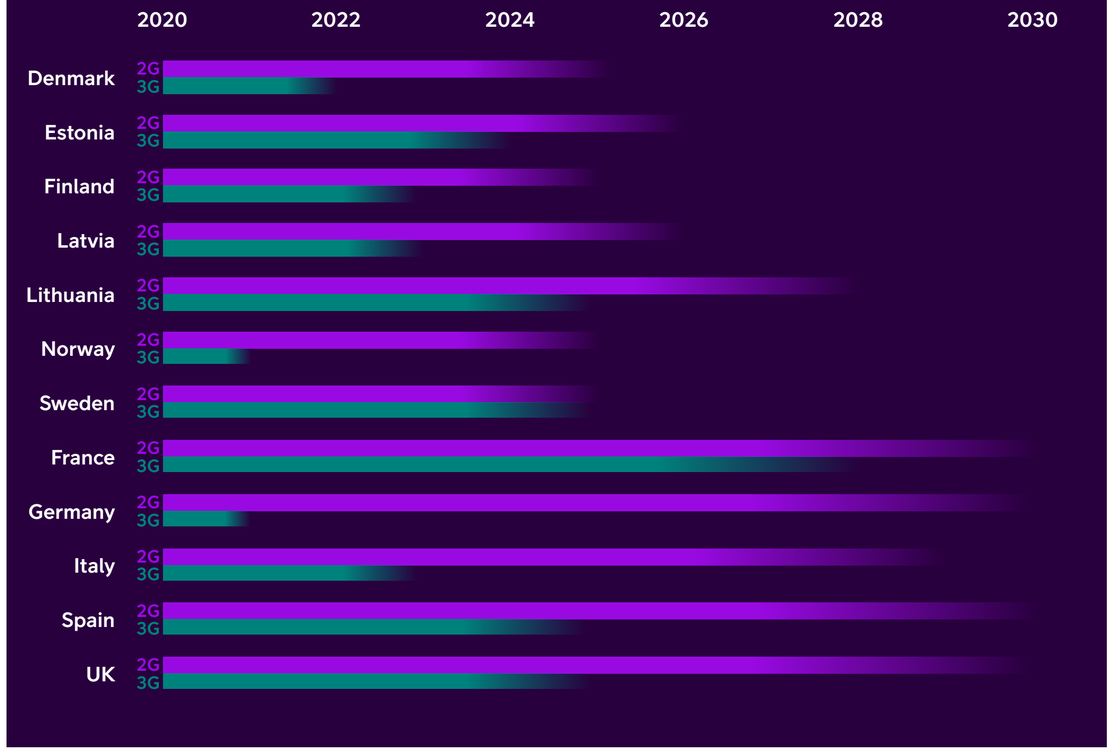
Europe has seen a diverse range of approaches and timelines. It might seem counter-intuitive, but in many countries, including most countries in Europe, it has been established as common practice to switch off 3G networks first. The reason is simply that 3G typically has more limited coverage than 2G for delivering basic voice and data, and 4G networks for delivering mobile broadband data. In Germany, for instance, 3G networks were shuttered in 2021, well ahead of the same process for 2G, for which several operators have still not yet set a switch-off timetable. A similar situation exists in Italy, the Netherlands, and the UK, amongst others, where the most common approach is to establish well defined plans for 3G migration but maintain 2G for longer.

The general approach in the Nordic region is the same as the rest of Europe. Norway has followed the 3G-first approach with 3G networks all closed down in 2021. Denmark will follow suit and plans to close 3G during 2022. In Sweden there is a slightly more mixed picture, with all but one operator switching off 3G in 2023. In Finland 3G switch-off is scheduled for 2023. Exact dates for 2G switch-off across the region are less clear, but most operators are likely to do so around 2025. In the Baltic states, there are a few operators with stated plans for 2022 or 2023 switch off for 3G, and with 2G 3-4 years after that.

There is some complexity to tracking 2G and 3G migrations. In some cases it is switch-off with a specific end date - as is the case with Sweden for 2G in 2025 - whereas for others it is a gradual scale down, as seen with Sweden's 3G migration. This means that network coverage and capacity for the outgoing technologies may be gradually degraded over a few years, without disappearing entirely. In some cases, legacy network coverage for 2G or 3G remains from some operators, even where it is only very limited and not advisable to select for new deployments.

Upgrade paths will also see very different timelines for different MNOs. For instance, the majority of MNOs in a market may have made the decision to switch networks off, but there may be a single MNO that elects to maintain its network for a variety of reasons. For example, in Sweden, three operators have stated plans to close 3G networks in 2023, whereas a single operator plans to continue maintaining 3G past 2025. Furthermore, the planned timings are often affected by delays caused by a variety of factors, from the logistics of closing the networks to regulation requiring the continued support of certain services, such as the eCall emergency crash notification service which currently relies on 2G and 3G.

Figure 1: 2G/3G availability for selected countries in Europe
[Source: Transforma Insights, 2022]



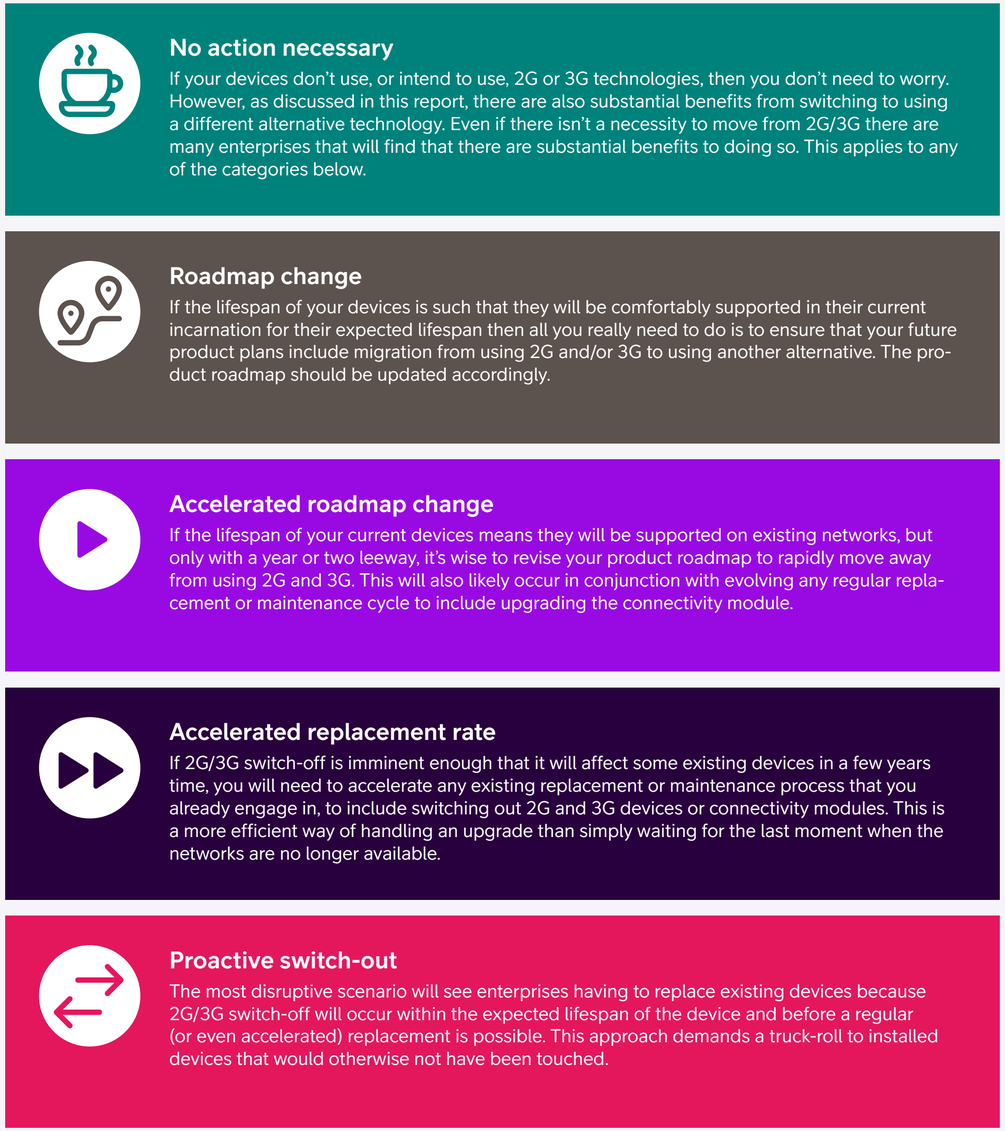
How will this affect my organisation?

The impact on any given organisation of 2G and 3G switch-off will vary substantially depending on that organisation's specific circumstances. For some enterprises it will necessitate some substantial changes, whereas for others it will be largely irrelevant.

The impact on any organisation will depend on a few factors:

- How critical are the IoT connections to your operations? Organisations with core mission-critical applications running on 2G and 3G will clearly need to focus on what to do more than organisations where IoT is less critical.
- Have you already deployed your IoT devices and what technology are they using? If you already have 2G and 3G devices in the field, they (or the connectivity modules within them) will eventually need to be upgraded, unless they have another technology to which they can fall back (many IoT devices are multi-mode, comprising a combination of 2G, 3G, 4G and other technologies). The timing will depend on which markets they are in and the operators to which they are connected. For devices that have not yet been deployed you will need to consider adapting your product roadmap to use a different technology for future products.
- Where are your devices deployed? The future availability of 2G and 3G networks will be highly geographically specific. You will need to understand which operators in which countries are planning to switch off 2G and 3G networks and with what kind of timeline.
- What is the lifespan of your devices and their natural replacement rate? Some MNOs have been very good at signposting their plans for 2G and 3G switch-off, giving many years notice before ceasing operation. If your devices are only expected to be used for a few years before they become redundant and the associated network switch off is a decade away, then clearly there is no need to switch out your existing devices. Of course, some adaption of the product roadmap will be necessary in the intervening years to ensure future-proofing. →

Figure 2: The 5 possible implications for enterprises of 2G/3G switch-off
[Source: Transforma Insights, 2022]

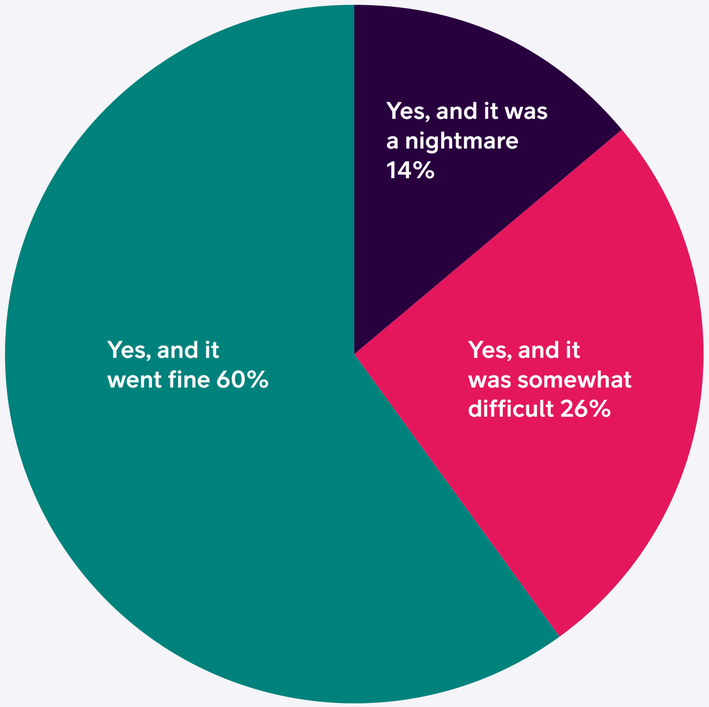


- How easy is it to upgrade units? Some IoT devices are 'attended', with a person directly in contact with that device. Others are unattended, for instance a remote monitoring device located many kilometres from the nearest person. The former will be generally much easier to upgrade (i.e. by swapping out either the whole device or replacing a connectivity module) than the latter. For instance, it may be as simple as sending out a replacement 4G payment terminal to a store to replace the existing 2G version. Or the connectivity module might be an integrated element of, for instance, a smart meter, which would require an engineer's site visit.

Based on the variable potential impact on any enterprise, there are a few possible implications of 2G/3G switch off for any enterprise, as illustrated in Figure 2, below. These range from 'no action' (e.g. in the scenario where the lifetime of the device is less than the lifespan of the networks), through to 'proactive switch-out' (e.g. where there is a large installed base of devices that will require a truck-roll to replace them otherwise they will lose connectivity).

The experience of companies that have gone through an upgrade from 2G/3G has been mixed, and generally relatively good. In the recent Transforma Insights Enterprise IoT Connectivity Survey, we asked what the experience was of companies that had been through such a process. A strong majority (60%) said they navigated the process relatively easily. Just over a quarter (26%) said they had some challenges with the process. The remaining 14%admitted that it was a 'nightmare'.

Figure 3: Enterprise experience of 2G/3G upgrades
[Source: Transforma Insights Enterprise IoT Connectivity Survey, 2022]



Question: Has your company been through a migration of devices from 2G or 3G to 4G/LTE or another technology (i.e. w here your existing device estate needed to have connectivity units sw apped out)? n=1,018

Automated Meter Reading (AMR) upgrade

New EU regulation requires the upgrade or replacement of 5.4 million smart meters, both domestic and enterprise, across Sweden by 1st January 2025.

In 2019, Telia won the tenders from several utility companies to upgrade almost half of those meters, and today a major part has already been completed. The scale and complexity of this upgrade process has been significant and there have been some key learnings from these projects that will be valuable for other major IoT deployments, covering preparation, testing and deployment.

The initial preparatory work is critical for laying the foundations for a successful roll-out. This involves identifying how devices, networks and servers will work together, creating a robust architecture on paper.

The next step is a rigorous testing phase, which turns up issues with the hardware, network compatibility, and the server solution, all of which are managed by different stakeholders. Success depends on documenting test cases, each defined by factors such as load, location, and position underground and comprehensive documentation of deviation reports, tracking meter behaviour to understand patterns that might be seen in the deployment phase.

Another major lesson from deployments is the requirement for post-deployment changes and upgrades. The specifications of the various elements, including the meter, module and network evolve over time. This necessitates the use of software-over-the-air (SOTA) and firmware-over-the-air (FOTA) updates to upgrade the systems to remove known errors, support new features and functionality in the hardware and networks, and provide support for the deployment throughout its lifetime. One example, as seen in this project, was the implementation of a fix to ensure that smart meters do not all attempt to report data at the same time. This can create unmanageable load, but is resolved by introducing randomised reporting, i.e. each meter waiting a random number of seconds before sending a message.

Involving the network operator early was also a critical success factor. With a variety of devices operating on different networks, the utilities inevitably need to implement some specific configuration for each deployment, and even some customization. For instance, in the type of fixed deployments required for smart meters, some adaptation of design is required to adapt to the available coverage, which can be done with the addition of extra cables and antennas.

It's impossible to ignore the internal factors. Experience and expertise varies significantly, with many utilities needing to implement new training regimes and/or increase the size of the work-force. For instance, some had their own resources for troubleshooting and analysing deviation reports, while others needed to build those capabilities. Managing this process requires an early start to planning for the whole upgrade project.

Finally, the upgrade involves the replacement of lots of hardware, all of which needs to be recycled.

The key learnings from the project were to start early and plan resources and training of staff, involve the operator early, document test use cases and deviation reports, use tools for remote management and monitoring and have a strategy for recycling of hardware and terminals. These actions helped to smooth the process of upgrading the utility, both meeting the regulatory requirements, and providing a future-proof, flexible, reliable and secure technology foundation for the future.

Costs, but also benefits, of switching to another technology

The impact on any given organisation of 2G and 3G switch-off will vary substantially depending on that organisation's specific circumstances. For some enterprises it will necessitate some substantial changes, whereas for others it will be largely irrelevant.

It is clear that a major stimulus to upgrading from 2G/3G to 4G/5G comes from necessity. If MNOs are upgrading their networks and refarming 2G and 3G spectrum to support later technology generations, those networks will be unavailable to use, necessitating a change by the MNO. There are some obvious drawbacks to this.

The first, most obvious, is the cost of replacing the hardware. Any scenario where the enterprise needs to switch out existing devices or connectivity modules before their natural end-of-life inevitably has an associated cost. For those enterprises that are simply adapting their product roadmap, the good news is that module cost for NB-IoT, LTE-M and even LTE devices is comparable with, or lower than, that of 2G devices, and substantially cheaper than 3G. In instances where the connectivity module is embedded in the device, the requirement is likely to be for a whole new replacement device, with greater cost implications.

Alongside the hardware costs, there is also the logistics costs of handling the upgrade of devices. This might simply involve the mailing out of new 'attended' devices. Or it may involve truck roll for a specialist engineer to switch out part of an embedded system in a remote asset. In tandem with the logistics cost, there is also a management overhead in handling the migration. Like it or not, the simple act of having to navigate through the process of technology upgrade has an associated cost in terms of occupying management resources and time.

Finally, it is impossible to ignore the sustainability consideration. While replacing devices before the end of their natural life certainly creates some e-waste, upgrading is likely overall to be beneficial in terms of sustainability, both through using more efficient technologies and not having to run old inefficient networks. →

→ According to the Transforma Insights 2022 Enterprise IoT Connectivity Survey, there were mixed experiences of the challenges associated with upgrades (see Figure 4). Only 6% of respondents who had been through such a process said there were no challenges associated with it. But the responses other than that were fairly evenly spread. 41% said that the logistics of migrating the devices was a significant issue. The next highest rated challenges were that of buying additional replacement devices, and understanding how to make the transition.

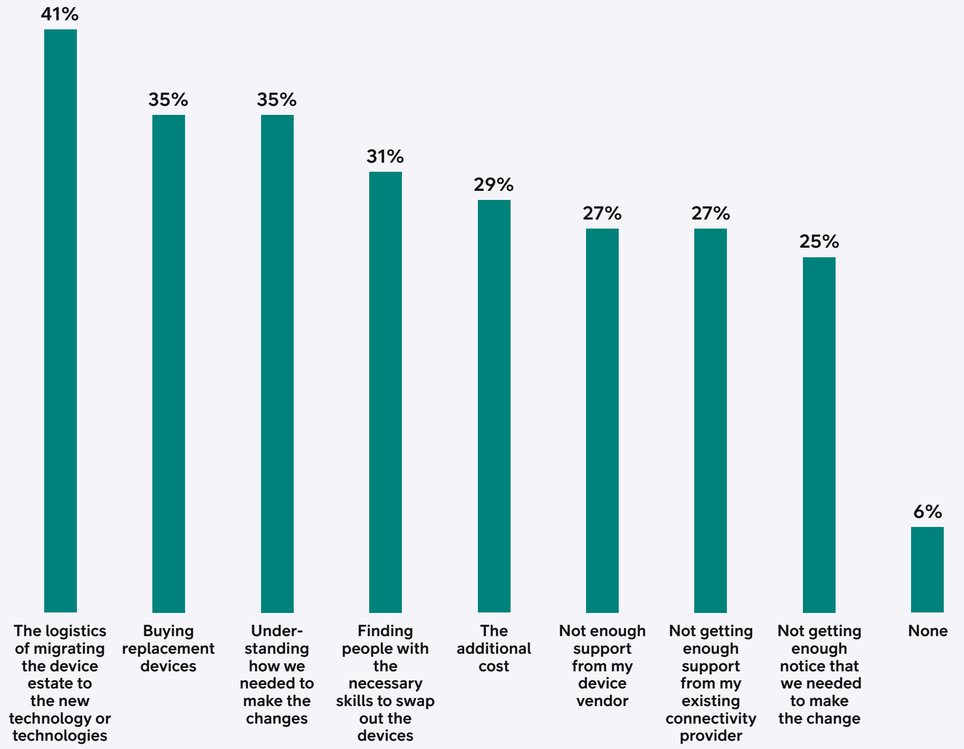
It should be noted that these challenges are in the context of 60% of respondents finding that the process overall was fine to navigate, as illustrated in Figure 3, above. Enterprises have successfully found ways to mitigate the challenges, by doing their homework on technology trends and capabilities, by requesting help from their vendors, and through effective planning.

Alongside these drawbacks, there are significant benefits to undertaking connectivity upgrades. These are relevant whether the upgrade is required as a result of the technology generation being switched off, or where it is undertaken voluntarily. According to the aforementioned Enterprise IoT Connectivity Survey, of those enterprises that have gone through a migration from 2G/3G to 4G/5G, 58% found that it brought significant benefits, for example in better capabilities, lower cost, or better management of devices, 37% found it brought some benefits, and only 5% described it as bringing little to no benefit other than maintaining the connectivity to the devices.

The opportunities and benefits associated with the upgrades include:

- **The capabilities of the upgraded technologies are far superior to those of 2G and 3G.** In the next section we explore the relative technology capabilities of all the different generations. In summary, NB-IoT and LTE-M offer slightly superior data throughput but with substantial improvements in power consumption and coverage, making them a much better choice for battery powered devices. In the case of LTE (Cat 1, Cat 4 or even Cat 0) the technologies provide much higher data rates.
- **Opportunity to implement more future-proof technologies.** Enterprises can select technologies which can be expected to be around for decades to come. LTE has had a lifespan so far of around 13 years and if it is anything like 2G it can be expected to remain a fixture for the next 20 years. LTE has much better compatibility with future generations than 2G or 3G had, meaning that we expect LTE devices to be more future-proofed than 2G and 3G and a safe choice for IoT deployments. Furthermore, the NB-IoT and LTE-M technologies are both now part of the 5G standard meaning they will continue to be supported for as long as 5G is available.
- **Introduce mitigating features in the event of future switch-off.** Similar to the previous point here, but specifically here we consider the addition of features which might reduce the impact should the chosen connectivity technology be switched off in future. Specifically, here we consider the remote SIM provisioning (RSP) capability associated with embedded SIMs (eSIM), whereby a device can be remotely moved to a different network in the event of that network being switched off, although it won't be able to help in the event of all such networks in a market being switched off.
- **Upgrade devices to include other new functionality.** The aforementioned RSP/eSIM is one example of a new technology with valuable capabilities which could be added to the existing installed base of devices while also upgrading the network connectivity. Upgrading the generation is an opportunity to also upgrade other features →

Figure 4: Challenges of 2G/3G upgrades
[Source: Transforma Insights Enterprise IoT Connectivity Survey, 2022]



Question: What aspects of the 2G/3G migration did you find challenging?
[Select any that apply] n = 1,018

Light Systems

Sweden-based Light Systems is a provider of wireless control systems for automotive, energy and -particularly - street lighting. Some of its initial IoT deployments, dating back up to 20 years, involved the use of 2G. It elected to upgrade to a combination of NB-IoT and LTE-M, the new Low Power Wide Area (LPWA) technologies available from many MNOs.

The process for upgrading saw Light Systems assess its requirements and evaluate a variety of different connectivity solutions, including a non-cellular option with Light Systems managing its own network. However, as Leif Edh, CEO, shares: ”Managing your own infrastructure is not profitable. For us it was far better to collaborate with Telia so we can provide a complete solution, fully managed by professionals in every part.”

The technology upgrade also delivered additional value for the company, in terms of adding extra functionality beyond simply switching on and off street lights, such as energy monitoring and coordination of lighting across large geographical areas to counter potential energy shortages and to improve sustainability. According to Edh: ”LPWA allows us to create low-cost measuring and control units that can be built into equipment, allowing us to offer customer adapted solutions that are flexible and easy to use. These will help improve energy efficiency and are a crucial step towards a sustainable society.”

→ of the device. Another example is making greater use of edge computing. Some applications can be substantially improved by placing more processing and storage onto the device itself, allowing more localised processing.

- **Opportunity to reconsider your whole protocol stack.** Many IoT deployments do not make optimal use of the diverse range of technologies available today, and certainly do not ensure that all the various elements (e.g. device, connectivity, protocols, operating systems, cloud) work optimally with each other. Making the change of connectivity technology also presents an opportunity to rethink how the overall application is built. This might be particularly complex in scenarios where there are devices using both cellular and other technologies.
- **Improve your connectivity.** Many cellular connectivity IoT devices were deployed in a somewhat unmanaged way, for instance simply taking SIM cards from an operator and plugging them into an IoT module. IoT connectivity offerings are now much more ’managed’ with sophisticated features in connectivity management platforms (CMPs) and device management that ensure that the enterprise has much greater transparency over device status and greater control over its operation.
- **Make your connectivity cheaper.** The price of cellular-based IoT connectivity has come down quite considerably in recent years. Many enterprises shifting away from legacy 2G and 3G networks have found that connectivity charges are at least 50% lower than when they were selecting their 2G/3G tariff.
- **Be more sustainable.** Enterprises are increasingly focusing attention of being more sustainable. Making use of more efficient technologies (4G and 5G are more efficient than 2G and 3G) is ultimately more sustainable, even allowing for the e-waste that might be associated with disposing of redundant old devices. This is particularly important with energy costs sky-rocketing.

Generations explained

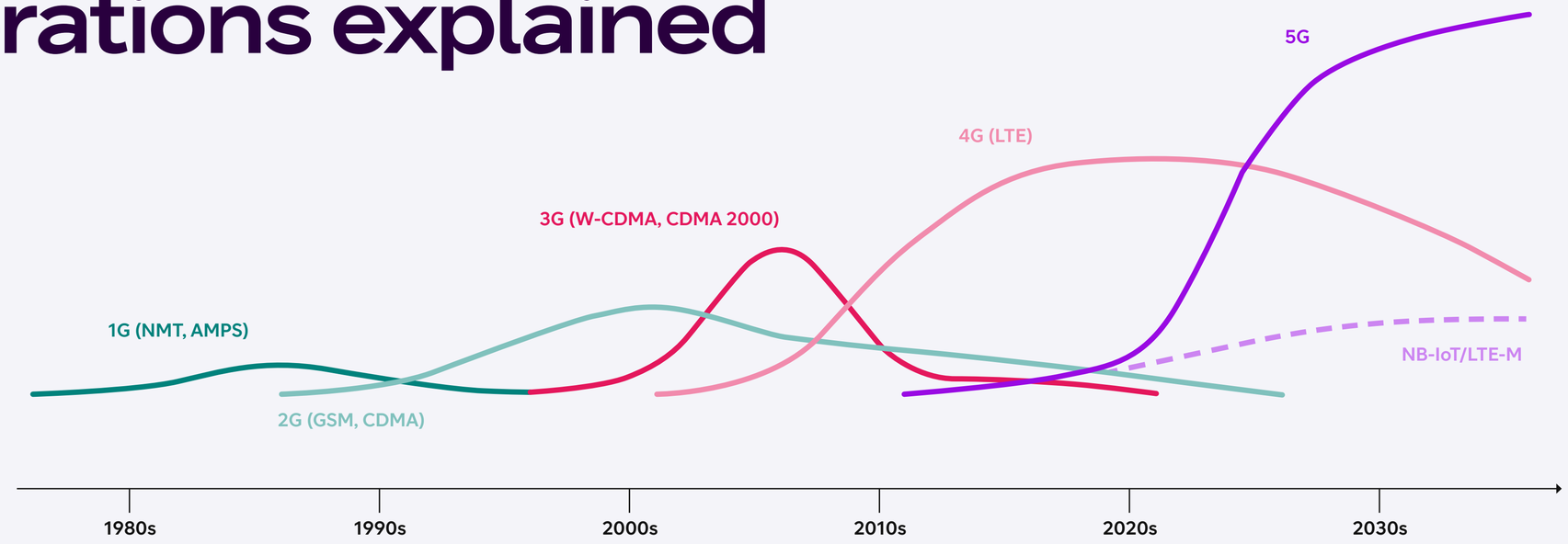


Figure 5: Cellular network generations
[Source: Transforma Insights, 2022]

The first mobile networks, using analogue technologies, were rolled out in the 1980s. These were swiftly superseded by the much more sophisticated (at the time) 2nd generation GSM and CDMA networks in the 1990s, which made much more efficient use of spectrum, were more secure and could deliver data services. In this context, what is happening with 2G and 3G networks now is simply replicating what happened with the first generation of mobile networks.

After 2G, the Third Generation Partnership Project (3GPP), a grouping of standards development agencies, took charge of developing new cellular standards, firstly several variants of 3G and then a single converged 4G technology in the form of LTE, which was first launched in 2009.

At that point a couple of interesting IoT-oriented technologies crop up. In response to the growing importance of IoT, the 3GPP embarked on a process of developing technologies more optimised for IoT's requirements, e.g. low data rates and low power consumption. The result was actually two technologies: NB-IoT (also known as LTE Cat NB1/2) and LTE-M (also known as LTE Cat M1). The aim with these two technologies, which are both considered to be part of the 'Low Power Wide Area' (LPWA) category of technologies, was to have deliberately degraded capabilities in order to provide cheaper low power devices that could operate on batteries.

As well as LTE-M and NB-IoT, there were also continuing evolutions of LTE to give varying sets of capability some of which are more relevant to IoT, such as Cat 0 and Cat 1 bis.

At the same time that these developments were ongoing, the 5G standard was also being developed, and networks were first launched in 2019. In 2022 a new variant of 5G was also added in the form of 5G Reduced Capability (RedCap) which seeks to provide a toned-down version of 5G to provide a lower price point and longer battery life.

There are, of course, other technologies available for connecting IoT devices, but in terms of being deployed in a consistent manner with a natural evolution path, it is within the 3GPP family that the evolution tends to occur.

I’ve decided to upgrade From 2G/3G, what are my options?

Once you have decided to upgrade your IoT devices from 2G/3G to another technology, you have a few options. To explain them, it’s worth considering the evolution path of cellular technologies over the last few years, as well as considering issues of capability, coverage, longevity, and cost.

Capabilities

The various different cellular connectivity technologies have different capabilities, which an enterprise will want to consider when making decisions on how they might want to upgrade.

There are effectively two types of technologies that enterprises need to consider. With the arrival of the LPWA technologies, LTE-M and NB-IoT, effectively the technology space forked, with some technologies focused on providing bandwidth (i.e. 4G and 5G) and others on providing cheap devices with long battery life (i.e. LTE-M and NB-IoT, and to a lesser extent Cat 1 bis and 5G RedCap).

Consequently, and as illustrated in Figure 6, the top performing technologies in terms of downlink speeds are 5G NR (200 Mbit/s), LTE Cat 4 (150Mbit/s) and 5G RedCap (85Mbit/s). They are typically, however, not the best for supporting long battery life, which are NB-IoT and LTE-M. NB-IoT, for instance, can be expected to support devices on battery power for several years.

It is generally the LPWA technologies, LTE-M and NB-IoT, which address those applications that historically might have been addressed by 2G, and in a much more power-efficient manner. Applications requiring high bandwidth (or low latency) will need to focus on 5G NR, and to a lesser extent 4G.

We should also note a couple of further limitations of NB-IoT and LTE-M. Firstly that they don’t support voice services, should that be relevant for the application. While LTE-M networks can be enabled to do so, MNOs generally have not done so, simply because there is no demand because there are no handsets using LTE-M. NB-IoT also does not support SMS, which may necessitate some enterprises re-architecting their applications. Finally, NB-IoT devices do not hand over between cells, meaning they are not appropriate for tracking of mobile devices.

Coverage

Alongside the above considerations of capabilities, an enterprise also needs to be aware of which technologies might be available in the required →

Figure 6: Capabilities of cellular technologies for supporting IoT
Source: Transforma Insights, 2022

	Maximum downlink speed	Battery life	Longevity	Global coverage	Affordability
2G - GPRS/EDGE	*	**	**	****	*****
3G - HSPA	***	*	*	***	****
4G - LTE Cat 1	***	**	****	*****	****
4G - LTE Cat 1 bis	***	***	****	***	****
4G - LTE Cat 4	****	**	****	*****	***
LTE-M	***	****	*****	****	*****
NB-IoT	*	*****	*****	***	*****
5G NR	*****	*	*****	***	*
5G RedCap	****	***	*****	***	***

→ geographies. Not all of the different technologies are yet available in each market, and where they are they may have widely varying coverage.

Today, most markets in the developed world have 4G networks with >95% population coverage. These LTE networks support the various categories, including Cat 1 and Cat 4. They can also support LTE-M, although not every network operator has undertaken the necessary upgrade to support low power functionality. Similarly Cat 1 bis is not approved everywhere.

According to the GSM Suppliers Association, there were 57 LTE-M networks at mid-year 2022. NB-IoT also requires a network upgrade. There have been 124 commercial launches of NB-IoT networks so far. The presence of an NB-IoT or LTE-M network in a market is not necessarily an indicator of national coverage.

Today 2G, where available, generally also has 95% population coverage, although in some major markets, networks have already been migrated. 3G generally has inferior coverage to both 2G and 4G. 5G networks have been launched in around 70 countries as of mid-year 2022.

Longevity

The focus of this report is on upgrading from 2G and 3G networks as they are switched off. Therefore, we should also give some consideration to the likely longevity of these new technologies. Clearly 2G and 3G networks are on the way out, although they may be appropriate choices depending on which geographies and timescales might be required. The most future-proof technology is likely to be the most recent, and this is certainly the case for mobile networks. 5G networks will be around for the foreseeable future, certainly well into the 2040s. However, given their higher costs, we don't generally think that there is any need to wait for 5G, there are plenty of other sufficiently future-proof technologies for most deployments.

No MNOs anywhere in the world have yet given any indication of, let alone set a timetable for, switching off LTE networks. We expect them to be around for the next 20 years. However, if that kind of timescale is even too uncertain, NB-IoT and LTE-M, will be around for even longer, because they are supported as part of the 5G standard.

Cost

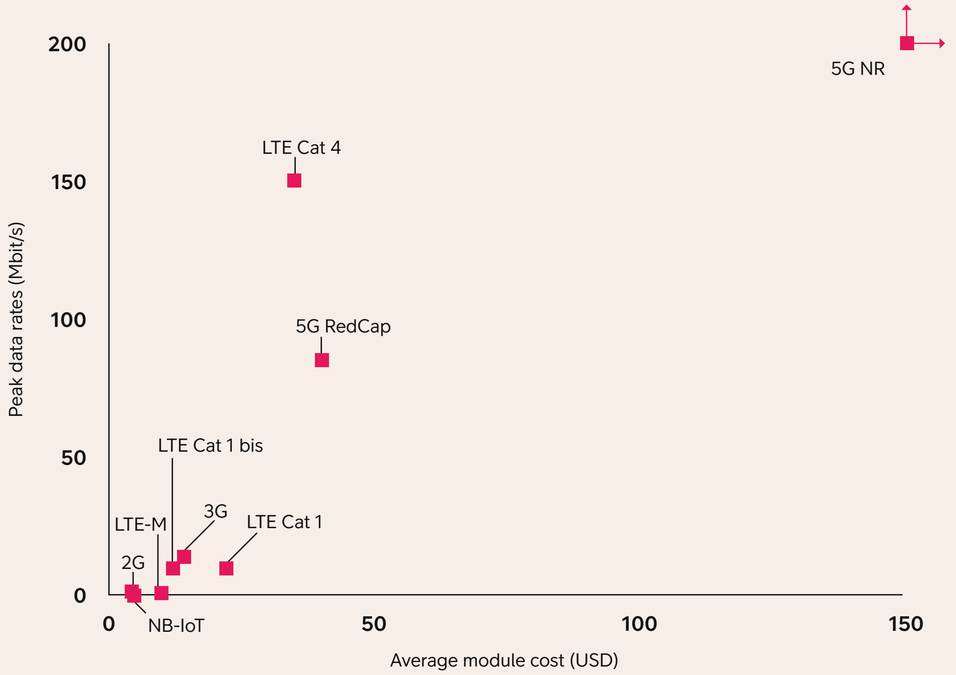
The main factor to counter-balance the capabilities listed above, and the considerations of coverage and longevity, is the cost. The preference of any organisation to opt for 5G New Radio (NR) will be mitigated by the high unit costs today, typically over USD100 per module. Clearly there will be some use cases where the ultra-high bandwidth and ultra-low latency will be incredibly valuable, but that probably won't be the majority. Similar can also be said of 5G RedCap, which in its current iteration is likely too expensive for most users, although we expect future technology releases to refine it quite considerably.

As a replacement for 2G, the most obvious options are NB-IoT and LTE-M, both of which have module prices somewhere in the vicinity of USD5 per unit, with NB-IoT the slightly cheaper of the two. That's comparable with the old 2G price points.

The other alternative is LTE, which has the advantage of coverage today, as noted above. Here costs can be as low as USD10 for Cat 1 bis, USD20 for Cat 1 and USD30 for Cat 4.

The relative price points of the different technologies, along with the peak data rate, is presented in Figure 7.

Figure 7: Cellular technology module cost and peak data rates
[Source: Transforma Insights, 2022]



It also needs to be considered how these prices might change over time. We expect both 5G NR and 5G RedCap to become considerably cheaper over the next 5 years. With greater volumes of device sales we also expect LTE-M and NB-IoT to become cheaper too.

Recommendations

Transforma Insights makes the following recommendations to any enterprise that is considering its 2G/3G upgrade strategy:

- **Check when your 2G/3G networks are being phased out.** Your mobile network operator or service provider should be able to give you plenty of notice of the timing. Also, bear in mind that these upgrades are not immediate, with often a gradual degradation of the 2G/3G network coverage or capacity ahead of the final switch-off date.
- **Set a plan early.** Managing this type of upgrade can be a headache and there are quite long lead times on ordering hardware (particularly with current semiconductor shortages), and building competence and resources to handle the truck roll. Starting early also allows you to start swapping in future-proof technology whenever you replace devices.
- **Undertake an audit of connected devices.** You need to understand what connected devices you have deployed, what technologies they use, which of them need to be replaced and by what date, and how that fits in with your existing device lifecycle.
- **Understand the technologies.** What are the alternatives most appropriate to your application? Which networks are available in the markets in which you are present? How do you ensure that the chosen technology works well with the rest of your IoT stack?Enterprises should understand the technologies they are using and ideally have a technology strategy, rather than simply adopting a patchwork of different technologies.
- **Understand what approach you need to take.** In the sections above we outline a number of different approaches to managing connectivity upgrades, e.g. from changing product roadmap through to swapping out an existing deployed base. All of this will depend on the type of product, its expected lifetime and how imminent is the 2G and 3G switch-off.
- **Budget for the cost of any upgrades that you might need to undertake.** Depending on the impact on your business, as discussed in the 'How will this affect my organisation?' section, there may be additional hardware, distribution and installation costs.
- **Do your due diligence on the provider that you're working with.** Too many companies are underinformed on the technologies that will support a critical part of their business. Choose your partner carefully. Look for experience in your particular circumstances. Look for examples where vendors have worked in the relevant field. Also look for an organisation that you expect to be around for the long-term.
- **Find a managed connectivity solution.** Simply plugging connectivity from any provider into a device and hoping it will work fine is not a good strategy. You will want a managed IoT solution giving you better transparency over what is happening to your devices and control over them. An upgrade is an opportunity to get a more robust, transparent and future-proofed connectivity deployed. Take that opportunity.
- **Find fall-back options.** There are several technologies which might be appropriate for mitigating risks related to future switch-off. The first is to choose a technology that we expect to have a long life span. LTE-M, for instance. The second is to use tools such as eSIM for instance, or having multimode devices, to allow yourself some redundancy in the event of losing access to a network in future.
- **Future-proof yourself by putting longevity of technology into your future RFPs.** Make it a requirement of your suppliers that they guarantee that they will continue to support your devices for the required lifespan. MNOs today have a much better idea of the expected lifespan and longevity of their networks, so should be better placed to provide guarantees.

This report is produced by Transforma Insights in collaboration with sponsors Telia Company and Ericsson.

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Transforma Insights is a leading research firm focused on the world of IoT, AI and Digital Transformation (DX). Led by seasoned technology industry analysts we provide advice, recommendations and decision support tools for organisations seeking to understand how new technologies will change the markets in which they operate.

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