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IoT and Network Sunsets: A 4G/5G Planning Framework

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INTRODUCTION

The concept of machine-to-machine (M2M) communications has been around for decades and predates the internet. Initially, these M2M networks used two-way radio networks, but in the early 1990s, the arrival of GSM and other digital cellular technologies provided the opportunity to create wide-area complex M2M systems, ranging from asset tracking to security services.

M2M is a foundational technology for the Internet of Things (IoT) that uses internet connectivity and cloud technology to link and unite different M2M systems, together with other fleets of connected devices and things. The goal is to deliver data over interactive and integrated networks across multiple environments.

Smarter connected devices, cameras, and sensors continue to be developed and rapid developments are occurring in real-time analytics, machine learning (ML), and artificial intelligence (AI) at the edge and in multiple clouds. Together with the global rollout of faster 4G LTE and 5G networks, these trends mean that the IoT has become a strategic imperative for everything from smart grids to smart cities—and every major industry.

Against this background of diverse deployments of legacy M2M solutions and emerging IoT projects, many of which are part of digital transformation initiatives, it is essential to have a clear understanding of the current state of connectivity options and likely future developments. This will ensure that a project's lifetime is not compromised by the unexpected elimination of the underlying connectivity service.

This paper examines the current cellular connectivity options available and identifies planned network closures, as well as the issues associated with regional decisions to either expedite or extend network closures. Additionally, it explores the challenges that need to be considered and provides a framework to assess IoT projects to make the optimum choice for connectivity options.

IOT CONNECTIVITY GLOBAL OVERVIEW

According to Omdia's data, in 2019, global cellular networks connected more than 9 billion subscribers, with 4G LTE connecting approximately 57% of these. Since its introduction, LTE has been the fastest developing mobile system ever, with more than 769 operators running networks in 225 countries. However, these LTE networks were primarily designed and optimized for smartphones, mobile internet, and (increasingly) video, which require high speed and large bandwidth.

Omdia estimates that, of these 9 billion subscriptions, nearly 1.1 billion are M2M and approximately 200 million are low power wide-area (LPWA) cellular technology. Many M2M and IoT applications do not require high speed and large bandwidth. Most use cases are quite well suited to the data rates and bandwidth of 2G networks. So, it was a rude awakening for many M2M application owners when some mobile operators decided to switch off 2G networks and use the spectrum for new 4G LTE services.

The resultant fallout of angry customers and the emergence of alternative non-cellular LPWA alternatives were not anticipated. The mobile industry woke up and recognized that it was not paying attention to loyal M2M clients' needs. This resulted in a flurry of development and standardization work. In less than two years, the industry managed to deliver three new technologies to enhance M2M solutions:

- Narrowband-IoT (NB-IoT, sometimes referred to as LTE Cat-NB, LTE Cat-NB1, or Cat-N1)
- LTE-M (also referred to as enhanced machine-type communication [eMTC])
- LTE Cat-M1 and extended coverage GSM for IoT (EC-GSM-IoT)

2G: A trusted workhorse – cost-effective, but long in the tooth

GSM was one of the first 2G technologies to be used extensively around the world and was designed to allow travelers to use voice and text while roaming between different countries. This circuit-switched technology was deployed initially in 900 and 1800MHz, then later in 850 and 1900MHz. The introduction of packet switch network capability encouraged the development of M2M solutions. Today, most M2M applications still use General Packet Radio Service (GPRS) or Enhanced Data Rates for GSM Evolution (EDGE) for connectivity. The simple technology and global frequency plan mean that most devices were tri-band or quad-band, relatively low cost, and facilitated global roaming.

In 1Q16, 3GPP Release 13 specified a new standard called EC-GSM-IoT, which includes improvements to GSM to address enhanced M2M and massive IoT requirements. Specifically, the technical enhancement improved coverage by up to 20dB compared to GPRS. There were also developments that enhanced the data handling and power efficiency of devices to improve battery life.

Although Orange and Ericsson did network testing of the EC-GSM-IoT technology, to date, there do not appear to be any chipsets available or networks enhanced with this capability.

3G: A network designed for data

3GPP specified the Universal Mobile Telecommunications System (UMTS) and the first network was launched in 2001. Initially, networks were deployed in the 1885–2025MHz and 2110–2200MHz frequency bands. Today, global networks operate in different combinations of 28 frequency bands between 700 and 3500MHz.

The networks were further enhanced in 2008 with the evolved high speed packet access (HSPA/HSPA+), providing data speeds of up to 168Mbps on the downlink and 22Mbps on the uplink.

As part of the UMTS 3G program, the IP Multimedia Subsystem (IMS) architectural framework was developed to deliver Internet Protocol (IP)-based multimedia to mobile users. This included the provision of voice calls over IP versus circuit-switched voice and is the basis for voice over LTE (VoLTE), which is a key component of 4G networks.

In 2019, there were just over 2.1 billion 3G connections. These are anticipated to decline to 1.7 billion by 2024, mainly due to the evolution to newer, faster, and overall more efficient 4G technologies.

4G-LTE: The fastest growing network

The demand for always-on connection and the growth of video traffic required a significant enhancement to the network to increase both bandwidth and speed, as well as to reduce the cost of delivering data.

4G-LTE uses orthogonal frequency-division multiple access (OFDMA) as a radio access technology and supports flexible bandwidths between 1.4 and 20MHz. This means that LTE radios are incompatible with 2G and 3G and therefore require separate radio frequencies. The architecture of the LTE network was significantly redesigned with the radio access network simplified so that the base station and controller could be combined, making the sharing of radio resources more efficient. LTE also introduced the concept of multiple input, multiple output (MIMO) antennas at the transceiver to increase throughput. Additionally, the network was designed as an all IP system, no longer supporting circuit-switched voice.

Because LTE was first commercially deployed in 2009, it has experienced faster growth than any mobile technology ever developed. The development of LTE has continued with the introduction of LTE-Advanced (LTE-A), which uses channel aggregation to combine channels to achieve bandwidths of 100MHz. This, in turn, puts even more pressure on spectrum allocations to ensure the availability of sufficient spectrum.

As previously noted, LTE IoT capability was developed and introduced very rapidly in 3GPP Release 13, with commercial deployments of NB-IoT (sometimes referred to as LTE Cat-NB, LTE Cat-NB1, or Cat-N1) and LTE-M (also referred to as eMTC) or LTE Cat-M1 ramping up in 2018. Collectively, these technologies are referred to as mobile IoT by the GSMA, a term that refers to the technology necessary to address the LPWA requirements of the IoT market. The LPWA use cases have common characteristics, including low power consumption, low device unit cost, secure connectivity, strong authentication, optimized data transfer for small and intermittent data, and coverage improvements over existing technologies for both outdoor and indoor use.

Each of the technologies has unique advantages, making them complementary and able to fulfill a diverse set of IoT applications and services. NB-IoT can be deployed in several different ways, including within an LTE frequency band or in the guard band of the LTE carrier. It can also be deployed in non-LTE spectrum in a standalone mode with a system bandwidth as narrow as 180kHz. The peak data rate for NB-IoT is less than 100kbps, and it does not support voice or mobility. LTE-M is deployed only in LTE frequencies and can support up to 1Mbps peak data rates, mobility, and VoLTE.

The development of these two IoT technologies has continued, with 3GPP Release 14 introducing higher data rates and multicast and improved positioning support for LTE-M, as well as NB-IoT. This release also supported new categories of devices known as Cat-NB2 and Cat-M2, which carry greater bandwidth with higher peak upstream and downstream speeds. In Release 15, frozen in March 2019, the developments continued with NB-IoT, including support for time-division duplexing (TDD), small cells, and enhancements, to reduce the power consumption still further.

In March 2020, the Global Mobile Suppliers Association (GSA) released a snapshot report on the state of the LTE and 5G market. It identified that there were 159 operators investing in NB-IoT with 107 deployed or launched networks. There are 69 operators investing in LTE-M with 45 deployed or launched networks. In terms of LTE IoT equipment, the GSA identified a total of 303 devices supporting either single technology or multiple technologies, based on the availability of 29 different chipsets. However, none of the chipsets yet support 3GPP Release 14 LTE Cat-M2.

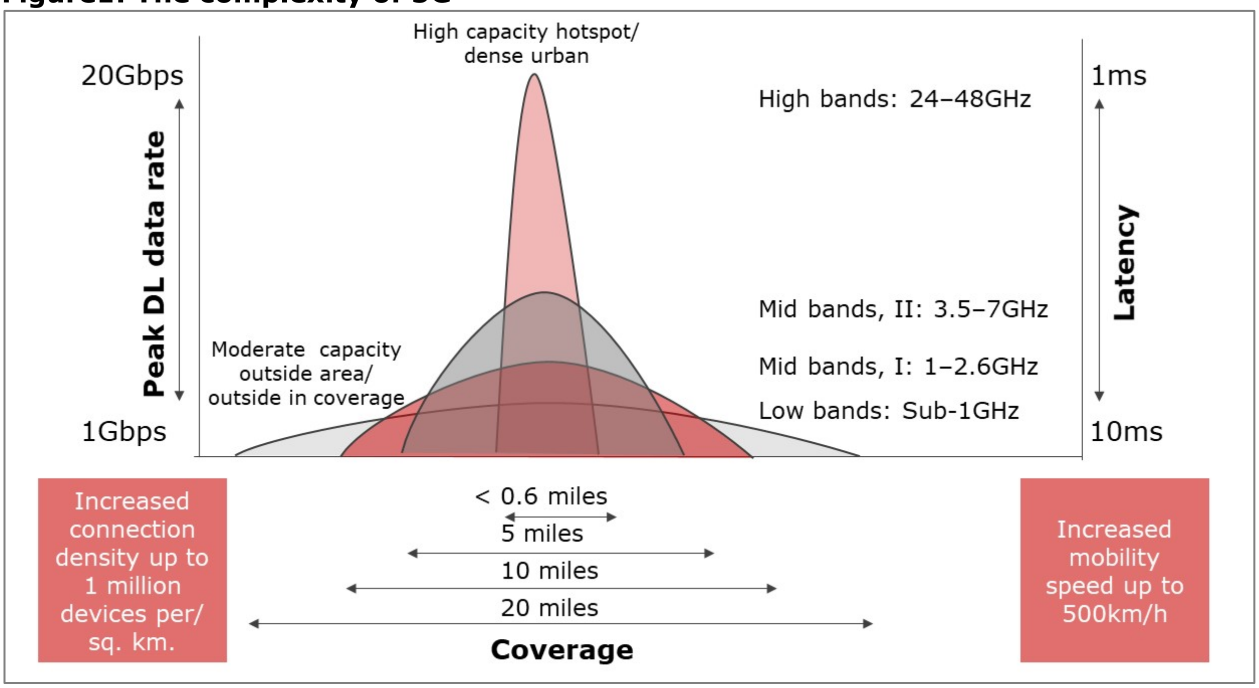
4G/5G: Coexistence and evolution

This continuous pace of developing IoT technologies and the overall ecosystem is important because it demonstrates a commitment to the statement made by the 3GPP: NB-IoT and LTE-M technologies will continue evolving as part of the 5G specifications.

The development of 5G technologies is premised on heterogeneous multiple access satellite, Wi-Fi, fixed line, and cellular technologies all interworking. It was within this context that NB-IoT and LTE-M became part of the 5G family.

In 2019, the development and initial deployment of 5G technologies happened at the same time as the continued advances in 4G LTE were occurring. The intent is that 5G will not replace LTE, but the two technologies will be tightly integrated and coexist over the next 10–15 years.

Figure1: The complexity of 5G



Source: Heavy Reading

5G brings significant hardware and software developments. These include virtualization methods that will facilitate very dense deployments of devices and slicing the network to deliver discrete IoT applications and services, such as robotics, autonomous vehicles, and augmented reality. At the same time, 5G will harness spectrum previously never used to deliver extremely wide radio channels capable of supporting ultra-reliable and low latency applications. All this capability will be delivered at a lower cost. It is anticipated that a cell site with full 4G and 5G capacity will deliver mobile data 10x more cost efficiently than a 4G site does today.

As shown in **Figure 1**, these new frequencies in the 24–48GHz band will allow extreme data rates and low latency, but the footprint of coverage is significantly reduced. One other thing to note from this figure is that the complexity of spectrum that will be used to deliver the services is significantly increased. In the future, customers will need to consider multiple factors, in terms of the connectivity and service delivery, that they will require, which will increasingly be part of service-level agreements with communications service providers.

3GPP Release 15 introduced new radio technology, known as 5G New Radio (NR), that works alongside 4G LTE and allows in-band LTE IoT. This is achieved by having two deployment models: non-standalone (NSA) that uses the existing 4G/Evolved Packet Core (EPC); and standalone (SA) that uses a new 5G core and natively supports LTE IoT. Release 16, due to be finalized in 2020, will enhance the IoT by delivering phase two 5G specifications, including ultra-reliable low latency communication (URLLC), which is important for factory 4.0 robotic and automation processes, as well as massive machine-type communications (mMTC) improvements. The latter improvements include NR/LTE-MTC coexistence and the ability for LTE-MTC devices to connect to the 5G core network.

In this combined 4G and 5G scenario, the IoT will coexist and continue to evolve, leveraging the capabilities of both networks across the diversity of needs of multiple industries and delivering many new solutions and services.

GLOBAL STATUS OF NETWORK SUNSETS

The previous section showed that, from a technology perspective, the mobile wireless industry does not stand still, and its requirements for improved utilization of spectrum to deliver services cost efficiently are fundamental to its business model and long-term sustainability. The mobile industry and regulators have coined the term "refarming" as the mechanism used to repurpose a frequency band that has historically been allocated to a prior generation of technology for the use of 4G and 5G technologies. In this task, the challenge is to balance technology enhancements against service continuity for customers, as well as investment certainty for the license holders.

When a mobile network operator switches off a specific generation of cellular technology, it means that all devices and services cease to operate, and this is known as "network sunsetting." In North America and Asia Pacific, some 2G and 3G networks have already been switched off. To date, most 4G-LTE global deployments are already operating in the 850, 900, 1800, 1900, and 2100MHz frequency bands.

In Europe, the process to evaluate the refarming of spectrum and the switching of 2G or 3G services is in the early stages, with governments, regulators, and mobile operators exploring the implications of these decisions.

A list of the known and planned global 2G sunsets and global 3G sunsets has been assembled from public announcements and reports and is included in the ***Appendix***.

In Europe, multiple factors are complicating the decision about closing 2G or 3G technology and refarming the spectrum. A specific issue is the EU eCall regulation that requires all cars and light vans built after March 31, 2018 to be fitted with eCall modems. In the event of a crash, an eCall-equipped vehicle initiates an emergency call that sends information, such as the location of the accident, to emergency services.

The regulation is technology-neutral and includes the options of 2G, 3G, and 4G technology. However, the current EU standards for eCall devices are limited to 2G and 3G technologies that use circuit switch connections. As has already been stated, LTE does not support circuit-switched voice, and not all operators currently support VoLTE; instead, voice calls are transferred onto either 2G or 3G networks.

The growth and continued deployment of smart meters that use 2G GSM technology is also a major consideration. These devices are intended to have an extended life and be the foundation of nascent smart grids.

Given these complications, the European Commission department in charge of telecom regulation and policy (DG CNECT) is conducting a study on the prospective use of 2G and 3G networks, including the provision of the eCall service. This study is expected to provide insights on the continued demand for and lifespan of existing 2G and 3G networks and their spectrum requirements. The primary objective of the study is to explore arguments for continuing the priority status of GSM in the 900MHz band and determine if GSM should be treated on an equal basis as other technologies. It is anticipated that the study will also cover aspects related to the need to upgrade vehicles and public safety answering point (PSAP) infrastructure with 4G interoperable functionality. A report from the study is expected to be published in April 2020.

Table 1: Global sunset summary

Region	2G	3G
Europe	Complicated by eCall and smart metering	Cost inefficiencies of 3G make it prime candidate for closure
Asia Pacific	Extensive closures already	Extensive closures, many more planned; timing will be dependent on VoLTE
North America	Likely completely closed by 2021	VoLTE and population coverage will govern closure
Latin America	Ecuador and Mexico, but no other known plans; 850MHz is the only common frequency across all countries	No known plans
Middle East & Africa	2G dominates and will remain as circuit switch voice backup to LTE if no VoLTE	3G less deployed and many countries leapfrogging to 4G

Source: Heavy Reading

In summary, as shown in **Table 1**, the global refarming and sunset picture is very different by region and technology. Clearly, Europe is in a state of flux and the situation will likely be clearer after the EU review; the strong probability is that GSM will prevail. In general, in Asia Pacific and North America, GSM is on its way out; Latin America has yet to grapple with the situation. In the Middle East & Africa, GSM will continue to dominate. Most likely, LTE will leapfrog UMTS deployment, alleviating the refarming question.

CONNECTIVITY CHALLENGES

Any enterprise that has considered or is considering IoT connectivity must factor in the following challenges as it strategically plans deployments and integration into existing business operation and processes.

Geographic coverage and network availability

Every business has a different geographic footprint that it needs to consider. The type of coverage will be dictated by the product, process, service, or application that is being deployed and will determine the type of cellular network technology to use. A large manufacturer that is connecting its global cold chain will be looking for uniformity of coverage and data capability, as well as lowest cost roaming, so it will probably use 4G LTE. On the other hand, a small- or medium-sized enterprise with a local manufacturing or logistics operation may consider a private 4G LTE network or even a 5G one for performance that can be linked to public networks to join an extended supply chain seamlessly.

Application needs and longevity

From an implementation perspective, the advice that is most often given for initial IoT projects is to start small and with discrete projects. However, it is also important to have a game plan for how the IoT project fits in with the overall digital transformation plan that is addressing current business processes. This will ensure that the initial and follow-on IoT projects can be seamlessly integrated and scaled to grow with the new business and that any connected products and solutions can be continuously upgraded to remain operational throughout their lifespan.

Data strategy

A key aspect of the connectivity plan for IoT that is often overlooked is to consider what data is going to be generated and then what is going to be done with it and where. This will determine how much data is going to be transmitted over the wireless network and at what speed to fulfill monitoring and control function requirements. Additionally, the current and future data analytics requirements need to be considered to determine where the processing will take place: either at the edge for latency requirements or in the cloud for more compute-intensive applications. On this basis, the data flows can be assessed from a data value and storage perspective. These requirements will help determine the overall architecture of the required network and help with choices on fixed versus wireless solutions, as well as on private versus local and global public wireless networks.

Security

Any design for an IoT system must start with security, especially where the system interacts with complex business processes and enterprise data flows and systems. The approach must be to create an end-to-end secure solution. The same security principles used in IT systems need to be combined with proven concepts from cellular networks and best practices for secure device design.

Future-proofing

The most distinguishing characteristic of enterprise, industrial, utility, and city IoT systems is that they are planned to be operational for extended periods. In some cases, this can be as long as 20 years. This means that the IoT network needs to have the ability to deliver over-the-air (OTA) updates to firmware and software components securely and with an updated mechanism for validating the update and successful new operating status. This will have to be done at scale and repeatedly over many years. Making sure that there is a mechanism to track and audit the changes and ensuring system interoperability will be vital.

A 4G/5G PLANNING FRAMEWORK

The complexity of current and future communications options is best tackled by means of an analysis and planning framework that captures the specifics of a company's business and project needs from a connectivity perspective. This can be done standalone or in partnership with a consultancy, systems integrator, or communications service provider. The framework captures a set of standardized connectivity challenges that need to be considered and addressed.

Once the current status has been determined, the future project and business design considerations need to be assessed against the same list. This consistent evaluation of current and future needs can be used to create a set of connectivity options.

The development of options can be with the initial partners, or it can be put out to tender. Whichever approach is selected, it is essential that the partners or vendors understand the current state of play of the various communications options and have a good view of future 4G/5G developments so that they can advise on the most future-proof options.

The final option selection will be optimized to the unique aspects of the project and business, and it will need to balance the total lifetime cost of ownership and operation with lifetime performance needs.

More information on the process steps is outlined below.

Primary and secondary challenges

In the 4G/5G planning framework, the primary challenges capture and expand upon the broad objectives of connectivity for the IoT solution. The secondary challenges focus on the specifics of the IoT solution and performance. For example, are there elements that are stationary, some that are nomadic but within a set location and some that are mobile? How do these different elements interact with each other? How will coverage plans need to be overlapped for optimum performance? Are humans involved? Is there a requirement for voice and data communications? The framework below brings up many more questions.

Evaluation of the current status

The evaluation process should look at the current business strategy, operations, and systems together with existing M2M and IoT projects. There are likely communications and connectivity systems already in operation to support IT systems, business processes, and remote facilities, and these need to be captured, as they can potentially provide a base on which to build. It is also essential to understand them so as not to create a solution that conflicts with these systems in the future.

Defining design considerations

For the new IoT solution, working through the challenges and reviewing the objectives of the solution against each one will create the communications requirements for all elements of the solution. The requirements can then be reviewed against the current status to identify any conflicts that might arise if the new IoT communications system is implemented. This approach provides the option to modify the new IoT solution requirements or to consider what would be required to update the current status to ensure compatibility with the new solution. As an example, if there is a requirement for future-proofing the new IoT solution via OTA capability and the current IT processes do not support this, then the option is to abandon the requirement or include the requirement for the IT system to be upgraded. Either way, there will not be a surprise later in the project.

Design options: The need for technically qualified partners

The next step in the process is to subject the generated list of requirements to a design review with partners that have the technical expertise and knowledge of diverse industry and technology roadmaps to suggest multiple options to make the IoT solution a success. As previously noted, numerous technologies are available that can be deployed standalone or combined to form a hybrid and tailored technology solution. The key is to come up with performance, longevity, and operating options that can be defined and financially evaluated.

Selection of optimal solution for each challenge: The blended solution

Due to the diversity of the unique challenges of each industry's IoT solution, there can be no universal approach. However, by consistently assessing an IoT solution against the connectivity challenges and existing systems to determine a core set of requirements and then working with technically able partners, an optimal selection from myriad options can be determined.

The final strategy will likely blend 4G and 5G technologies and be optimized to balance the total lifetime cost of ownership and operation with lifetime performance needs. This could include the determination of a service-level agreement to ensure the optimized solution is delivered by all vendors or via a managed operation using a service provider or systems integrator.

Table 2: 4G/5G planning framework

Primary challenge	Secondary challenge	Review process			
		Current status	Design consider-ations	Options	Optimal solutions
Geographical availability: Countries/regions/ continents/world					
Ubiquitous coverage and worldwide roaming					
Linkage to IT systems and business processes					
Standard vs. proprietary technology					
Private network or public or hybrid					
Global industry ecosystem support					
Longevity of the IoT solution					
Maintenance and evolution of the IoT solution					
Upgrade in the field (OTA)					
Key performance indicators of IoT solution					
	Mobility vs. stationary and nomadic				
	Coverage requirements				
	Voice/data-only				
	One-way, bi-directional, or ad hoc communication				
	Data traffic amount, frequency, and throughput				

Primary challenge	Secondary challenge	Review process			
		Current status	Design consider-ations	Options	Optimal solutions
	Mission/business-critical vs. best effort (i.e., reliability, quality of service)				
	Latency sensitive (real-time) vs. tolerant				
	Always-on vs. standby most of the time				
	Power consumption				
	Secure, encrypted devices and connection				

Source: Heavy Reading

SUMMARY

Technology convergence and the rapid pace of change of communications are making the choice of connectivity a critical decision for IoT solutions. Using the 4G/5G planning framework and partnering with a specialist can help identify potential options, ease the process, and ensure speedy time to market, as well as longevity of the resulting IoT solution. Once the initial base case framework has been created, all future requirements can be assessed against it and the framework updated with new assessments and new options.

The uncertainty around 2G/3G network longevity means that investment in 4G connectivity for current requirements is the logical decision. Because 4G NB-IoT and LTE-M technology will coexist and interoperate in a 5G world, 4G connectivity is a solid investment, especially when it can be enhanced—in some cases updated and in other cases migrated to 5G networks.

APPENDIX

The following tables were created by Heavy Reading based on publicly published materials. Please keep in mind that this is a snapshot in time. Heavy Reading has tried to verify the data, but *cannot* be absolutely certain about the correctness of the information. If any readers have access to official links and statements that can add to the accuracy of **Table 3** or **Table 4**, please contact the author at stephen.bell@informa.com.

Table 3: 2G GSM known sunsets

			Planned closures					
Region	Country	Already closed	2020	2021	2022	2023	2024	2025
Americas	US	AT&T						
	US			T-Mobile				
	Canada	Bell Mobility	Rogers Wireless					
	Mexico		AT&T Mexico					
	Mexico		Telefónica					
	Ecuador	CNT EP						
	Trinidad & Tobago	Bmobile						
Europe								Vodafone
	Switzerland	Sunrise 2100	Salt	Sunrise 900				
	Switzerland		Swisscom					
	Germany							Vodafone
	Italy							Vodafone
	Liechtenstein			Swisscom				
	Netherlands							Telenor
	Netherlands		T-Mobile					
	Sweden							
	UK							
Asia Pacific	Australia	Telstra						
	Australia	Optus						
	Australia	Vodafone						
	Bangladesh							Grameen-phone
	China		China Unicom					
	India	Bharti Airtel						
	India	Reliance						

			Planned closures					
Region	Country	Already closed	2020	2021	2022	2023	2024	2025
	Japan	NTT Docomo						
	Japan	KDDI						
	Japan	SoftBank						
	Macau	SmarTone						
	Macau	Hutchison						
	Malaysia			Digi – after 2020				
	Myanmar				Telenor			
	New Zealand	2degrees						
	New Zealand	Spark						
	S. Korea	KT						
	S. Korea	SK Telecom						
	S. Korea	LG U+						
	Singapore	M1						
	Singapore	Starhub						
	Singapore	Singtel						
	Taiwan	Chunghwa						
	Taiwan	FarEasTone						
	Taiwan	Taiwan Mobile						
	Taiwan	Taiwan Star						
	Thailand	TrueMoveH						
	Thailand	AIS						
	Thailand	DTAC						

Source: Heavy Reading

Table 4: 3G known sunsets

			Planned closures					
Region	Country	Already closed	2020	2021	2022	2023	2024	2025
Americas	Canada				Rogers Wireless			TELUS
	Canada							Bell
	US		T-Mobile		AT&T			
	US		Verizon					
	US				Sprint			
Europe	Austria		Three					
	Switzerland						Sunrise	
	Germany		Vodafone					
	Germany		T-Mobile					
	Denmark		Three					
	Ireland		Three					
	Liechtenstein			Telecom Liechten-stein				
	Norway		Telenor	TELIA Norge				
	Netherland		Vodafone		KPN			
	Sweden		Three					Telia
	Sweden		Telenor Sverige					Tele2
	UK		Three	BT	EE			
					Vodafone			
Asia Pacific	Australia	Telstra 2100						Telstra
	Australia	Optus						
	Australia	Vodafone						
	China		China Mobile					
	India	Reliance	Airtel					
	Japan							NTT Docomo – 2026
	Japan						SoftBank	
	Malaysia			Digi – after 2020				

			Planned closures					
Region	Country	Already closed	2020	2021	2022	2023	2024	2025
	Myanmar							Telenor, 2025–2026
	New Zealand	2degrees						
	Pakistan					Telenor		
	S. Korea	KT						
	Singapore	M1						
	Singapore	Starhub						
	Singapore	Singtel						
	Taiwan	All carriers						
	Taiwan	Chunghwa						
	Taiwan	FarEasTone						
	Taiwan	Taiwan Mobile						
	Taiwan	Taiwan Star						
	Taiwan	Asia Pacific Telecom						

Source: Heavy Reading