

Delivering IoT connectivity in an evolving network landscape

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Foreword

This report was developed with the collective insight of IoT industry leaders at Gemalto and respected members of the IoT community in Europe and the US.

Our thanks to them for their time and contributions. Manfred Kube is Head of IoT Products & Enterprise IoT Marketing Communications, based in Germany. Neil Bosworth is the UK and Ireland Manager at Gemalto M2M and has been working on the IoT since 2006.

Sourav Rout is a senior management professional, having worked in the telecoms sector for almost a decade, with additional exposure to the cyber security and data science industries. He is a member of the IoT Council.

Dan Shey is Managing Director and Vice President at ABI Research, focusing on M2M/IoT, digital security and blockchain in the telecom, industrial, IT and OT ecosystems. His work involves strategic analysis of the entire IoT value chain extending from devices through value-added services.

Jamie Moss, Research Director for Enabling Platforms, covers M2M, IoT and loE technologies. He conducts competitive analysis, data modelling and develops front-end analytical tools for products and services in the machine-type connectivity market. Adarsh Krishnan, Principal Analyst at ABI Research, orchestrates research regarding the Internet of Everything, Enterprise, and M2M. He focuses on research and analysis of the loE value chain and provides content relating to smart buildings, smart grids, and LPWA network connectivity technologies.

Introduction

Connectivity in the IoT is not as straightforward as it should be.

In yesteryear, M2M connectivity choices were fairly straightforward. 2G networks evolved to provide a reliable internet-based backbone adopted across the world using only four frequency bands. Some major Mobile Network Operators (MNOs) considered 2G outdated and announced its 'sundown' causing device manufacturers to have to make decisions with regards to the geographical deployment of their equipment. With some devices there was a certain level of 'futureproofing' that could be done by incorporating 3G. This meant the ability to make a global product was still straightforward as it maintained the similar robust underlying technology. Unfortunately, 3G is also now being shut down, in some places before 2G.

The evolution of the IoT has complicated the issue of connectivity for wide geographical deployments.

MNOs today are making announcements regarding deployment of the new technologies with wide coverage claims. However, it remains unclear whether that coverage is by geography or population, or indeed when commercial rollout will begin. In addition, MNOs in various countries

are announcing roll-outs of different technologies, supporting different features across the world. This would not be so problematic if they were using the four major bands, but in today's IoT there are approximately 30+ bands and multiple combinations in use thanks to 4G LTE.

“Regardless of the applications and the data requirements, it all boils down to having networks available to connect to. If you want to guarantee connectivity to a network across the world right now, there are no options other than LTE-CAT1 with 2G for fallback. LTE-CAT1 is a hidden champion!”

— Jamie Moss

A number of conditions need to be in place for LTE-based IoT networks to be adopted more widely. They must support a high number of devices, have a long-range, wide spectrum, and offer excellent coverage that works as well in cities and buildings as it does in open environments. They also need to ensure connected devices can maintain a long tenure and not unnecessarily burden device battery life. Of course, operators and vendors must work to keep the total cost of ownership as low as possible.

For those building devices to work on these networks, the complexity comes from several sources:

What are the connectivity requirements, in terms of speed, power use, latency?

What networks are prevalent in the markets the devices will operate in?

Will the devices travel and in which geographies?

What is the physical form factor of the devices in service?

Many of our customers operate their devices globally, for example to track assets. But despite the excitement around next gen Low Power Wide Area (LPWA) networks such as LTE-M and Cat NB-IoT, they aren't widespread or stable enough for this to be a viable option today if devices travel internationally.

Cellular IoT deployments have historically been based on technology which has been thoroughly tested by the mobile phone market, originally with 2G 'modem' style and SMS functionality followed by the packet-based Internet Protocols carried on 2G, 3G and LTE. The smart phone industry relies on these networks to be robust. IoT device makers have benefitted from the exhaustive testing and predictable behavior of these networks thereby taking for granted this functionality enabled by the connectivity modules in their devices.

The IoT on new LPWA networks has taken a different route to market. NB-IoT and LTE-M are the first cellular networks to be exclusively used by machines. We don't have the luxury of mobile phone manufacturers' budgets for testing these networks. For this reason, it is essential to expect further evolutions and updates to the behavior of new LPWA networks. This leads to design complexity, a need to implement a strategy for delivering 'firmware over the air' (FOTA)—which has now become mandatory for some MNO approvals—and consideration for traffic management with legacy cloud platforms. All this takes time and R&D budget.

We commissioned this report, working with influential voices in the industry, to better understand the real challenges and options for connectivity. It aims to help our customers understand global LTE-CAT1 connectivity, the road to LTE-M and other network standards, and also consider the implications of this on their own IoT supply chain processes.

Next gen LPWA network roll-out

Forecasts for the roll-out of next gen LPWA networks are very hard to decipher.

Whilst there has been strong momentum in some network rollouts, we are far from having global coverage across the board. Some markets are hamstrung by the “chicken and egg” situation – the cost of a rollout is high, but the short-term return is low as IoT engineers prefer—for the moment—to favor established, understood, global network connectivity options.

This is true across the board for NB-IoT, CAT-M, and beyond.

Our panel took their best guesses as to when the next generation of LPWAN connectivity options would be widespread and resulted in the following:

Best guess predictions	Gemalto	Sourav Rout	ABI Research (Dan Shey, Jamie Moss and Adarsh Krishnan)
LTE-CAT1	Available now	Available now	Available now
LTE-M	Widespread by 2021. Today's initial network is based on 3GPP Rel.13 with Rel.14 due for release in 2019.	Deployment ongoing in tandem with the rise of NB-IoT. Widespread by 2021.	17 commercial launches. 34 originally expected by year-end 2018, but many in Europe may stall. Strongest in Asia-Pac and the Americas. Preferred for mobile use cases.
NB-IoT	Increasing momentum in 2019, globally widespread in 2020, and stable by 2021.	To be the dominant IoT technology of choice after 2021.	63 commercial launches. 88 expected by end of year 2018, Strongest in Europe and Asia-Pac. Preferred for stationary IoT use cases. Coverage to be widespread by 2020.

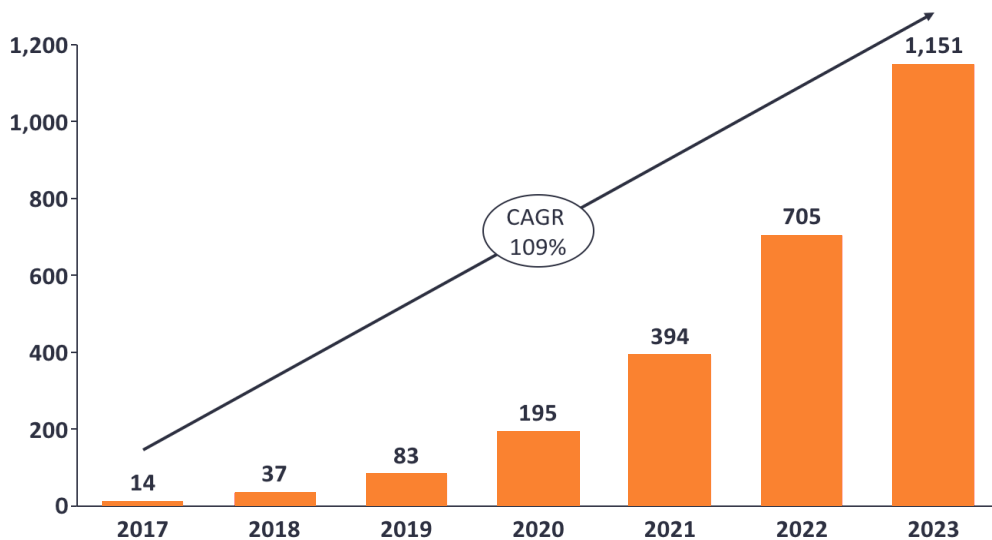
Beecham Research¹ anticipates that – by 2020 – only 26% of IoT deployments will use next gen connectivity. We expect this will be lower for global use-cases, or where devices need to travel, given that many markets will not have comprehensive next-gen connectivity rollouts complete. This will limit the potential usefulness of next-gen LPWAN in the short term.

“OEMs continue to delay their plans for using LPWA networks due not only to existing software issues but also revisions to technology standard specifications. OEMs need assurance that networks are available and working properly before they start implementing new technologies in their products.”

— Dan Shey

Given the lifecycle of long-term IoT deployments, many of the projects being planned today will most likely roll out using current network technology. This is important as these devices may have an eight to ten-year lifecycle, may travel, and will operate across different regional environments with different frequency bands in use and different networks in play. And for shorter lifespan low-power asset tracking devices, global reliability cannot be assured with existing next-gen infrastructure.

This observation is reinforced by the forecasts from IoT Analytics: whilst there will be significant growth in the value of the LPWAN market, it is not until past 2021 that we will see the value of the market reach real scale—when new technologies become preferable to what is available on the market today.



Source: IoT Analytics – August 2018

Figure 1:

Source: <https://iot-analytics.com/lpwan-market-report-2018-2023-new-report/>

¹ <http://www.beechamresearch.com/files/BR%20LPWAN%20EXEC%20Summary.pdf>

THE GEMALTO CINTERION PLS62-W

The ONLY wireless module for complete global IoT connectivity.

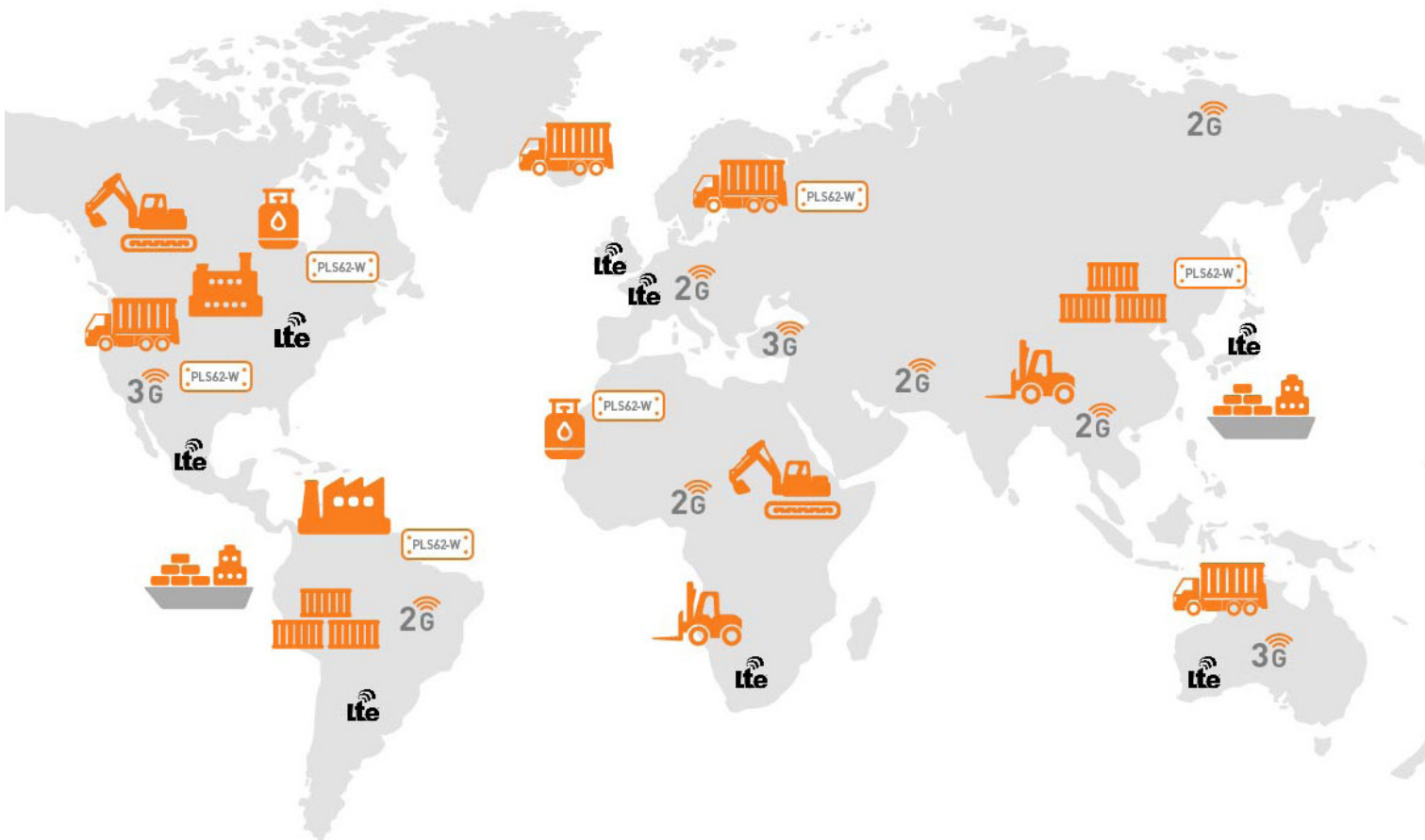
The Internet of Things is revolutionizing industries and connecting societies like never before.

New data driven insights are changing business models and reshaping global competition.

But getting thousands of devices to talk to each other across the world has not been simple, **until now...**

HOW IT WORKS

The PLS62-W combines LTE CAT1 with existing 3G and 2G support to deliver global coverage today. It connects assets on existing global networks **today and into the future.**



Monitor your global assets with the PLS62-W

Key Specs and Features

The Gemalto Cinterion PLS62-W wireless module can be configured for any IoT device to allow it to connect to mobile networks around the world.

PLS62-W

 12 Band LTE Cat 1	 JAVA embedded
 Seven Band 3G HSPA Quad Band 2G GSM Design	 RLS Monitoring (Jamming Detection)
 USB 2.0 High Speed compatible	 Multi Design Capability (LGA)
 Embedded TCP/IP Stack	 Cell ID for On-Demand Positioning
 Incremental FOTA	



33mm
29mm

Companies around the world are taking advantage of global connectivity to supercharge their activities.

Shipping firms are tracking ships and containers effortlessly



Global agricultural firms are optimizing crop development



Manufacturers are tracking devices anywhere in the world



Sensors can be deployed worldwide reducing the need for multiple SKUs



Global logistics is now simplified



New possibilities in the IoT like connected cars are opening up



The supply chain of IoT projects

“The enterprises building IoT products and their end-users shouldn’t have to become experts in telecommunications in order to be able to benefit from its potential. So, a single SKU product that they know will just work is optimally the best option.”

— Adarsh Krishnan

IoT projects do not have trivial supply chains, and this complicates connectivity choices. There are several key areas consideration:

Regional vs. global use: a fairly commonplace and very sensible choice for connectivity involves using a locally available network in the market/region in which you are operating. In Europe, a regionally limited LTE-CAT1 connectivity option, for example, is acceptable if the device will either never leave or operate outside Europe.

If you need to have a device that operates in different markets, then you may find yourself dealing with **the challenge of multiple SKUs**. Devices will have to be built with variants to span the different LTE frequencies in use around the world. This will cause complications in manufacturing (building devices in China for use in the US, for example), questions of inventory (how to forecast demands for US, Asian and European devices) and added complexity in testing. Then there is the cost of prototyping, testing, development and production as you will have to duplicate work—including costly Global Certification Forum and MNO approvals—across the different SKUs. This will extend time-to-market accordingly.

The **lab vs. real-world testing challenge** is not something that should be discounted. In an ideal situation, you want to test connectivity in a real-world scenario. But if you are manufacturing or developing devices for use outside your territory’s network coverage, you will be restricted in what you can do. For example, if you are building a device using LTE-M connectivity in a market where rollouts have not taken place yet, you will have to do lab testing to ensure it works. Furthermore, the lab testing will simulate an ideal network. It will not account for ‘end to end’ connectivity, coverage gaps, areas of low signal strength or cell edge behavior. And there is no guarantee that test equipment accurately represents incompatibilities on the network side.

If your devices travel or you have a global footprint, the complexity of managing multiple connectivity options outweighs the cost of investing in a single global connectivity module.

“Global companies trying to build international mobility into their IoT deployments have found it a real challenge. If you take something as simple as asset tracking across borders, they quickly discover different network standards. And because they aren’t experts, they look to solution providers offering “IoT orchestration” to manage that problem. But often what they need is an all-purpose connectivity solution that plugs into their hardware and gives them the connectivity they need.”

— Sourav Rout

The connectivity decision matrix

There is no universal truth for connectivity that makes sense in all contexts. It is more a matter of selecting the right connectivity for the right use-case given the deployment timeframes, global nature and technical aspects of a given project. Each project is different, especially in this new age of the IoT. Requirements must be evaluated on bandwidth requirements, the location of devices, the power-limitations of devices and sensors, the frequency of connectivity, latency concerns and numerous other factors.

The following matrix was developed to account for most key decisions needed to determine the right connectivity choice in the near term.

	LTE-CAT1	LTE-CATM	LTE NB-IoT
Network Availability	Derivative of commonly used mobile standards for cell phones. Most of the world covered.	No Global rollout. Most of US and Australia covered. Western Europe fragmented with a few operators.	No Global rollout. China main adopter. Western Europe fragmented with a few operators. Some coverage in Eastern Europe.
Fallback	2G and 3G fallback Supported in 3GPP specification	Not specified in 3GPP so if solution supports fallback it needs to be handled manually by host application	Not specified in 3GPP so if solution supports fallback it needs to be handled manually by host application
Mobility	Seamless cell site handover for mobile applications.	Limited – Needs to be handled and monitored by host application. Enhancements expected in Rel14 (market maturity 2020)	Specification designed for Stationary applications.
Power	Effective Lower power for large transactions (~100kB)	Designed for low power with features such as PSM and eDRX.	Designed for low power with features such as PSM and eDRX

Data Rate	10Mbps	Theoretical 300Kbps (DL), 375Kbps (UL)	Not designed for continuous operation
Duty Cycle	Paging Cycles in idle up to 2.56s in idle.	Paging Cycles in idle up to 2.56s in idle. Up to 44 min in eDRX. Up to 413 days in PSM.	Paging Cycles in idle up to 2.56s in idle. Up to 175 min in eDRX. Up to 413 days in PSM.
Upgradability	Full image transfer possible if necessary	Requires delta firmware upgrades due to technology bandwidth	Requires delta firmware upgrades due to technology bandwidth
Latency	Tens of ms	Hundreds of ms	Several seconds
Duplex	Full Duplex FDD (2 antennas for 3dB increase)	Half Duplex	Half Duplex
Price per module	Double digit \$	High single digit \$	Low single digit \$

The primary consideration needs to be the availability and stability of the chosen technology in the target geography, bringing into scrutiny the choice of network operators, **roaming partners** and the ramifications of a potentially invisible asset. The roaming behavior of LTE-M and NB-IoT, is envisaged significantly different to that of the seamless nature of the mature LTE-CAT1, 3G and 2G networks meaning it will be difficult to implement a truly globally mobile device with LTE-M and NB-IoT technologies.

Secondly, the ability to deploy OTA updates is essential when using new networks. It is expected, during the ramp up of CAT-M and NB-IoT networks, that the device should expect at least two updates per year for early deployments which adds costs to deployments. Careful consideration should be given to the size of the image payload

and overhead, power consumption and the impact on data consumption with respect to tariff plans. Essentially, the back-end and field-deployed devices need to be carefully designed from the outset in order to handle and manage mass deployments of firmware files securely.

Price is also a consideration. Companies looking to deploy global IoT projects can be assured that the higher investment requirements for a connectivity module with universal connectivity through LTE-CAT1 are offset by the simplicity of the solution. OEMs can now treat connectivity as a fixed cost, and save time on bespoke R&D, the cost of testing in target geographies or researching alternatives.

This approach also removes the chance that devices are not be able to connect somewhere in the world, which sometimes happens despite prior testing and assurances from network partners. Devices that go off the grid cause costs to rise, as does having to resort to developing multiple SKUs for different regions.

For companies considering embarking on a new IoT project, it is advisable to observe the following:

- **When is the product planned for mass market release?**
Consider R&D time for an emerging technology. It is fair to expect chipset and module manufacturers along with mobile networks to be at an evolutionary stage.
- **Is my product an evolution of an existing 2G, 3G or LTE design?**
Application software needs to be adapted to handle different behavior on the networks. Handover and fallback being two examples.
- **Which MNO(s) will I partner with and what is their presence in the target geography?**
Partnership is key in order to be informed of network behavior and potential changes in approvals requirements. Pay particular attention to roaming and roaming partner network behavior as the implementation of the standards may lead to a firmware change/swap requirement when switching operators. Devices implementing LTE-CAT1, 3G and 2G do not suffer from this evolutionary effect.
- **Is my product mobile or stationary?**
LTE-M and NB-IoT are primarily designed for stationary applications although LTE-M has limited ability for mobility. Improvements are expected.
- **Is my product dependent on low power?**
For the absolute lowest power (10-year battery life), new features such as Power Saving Modes and (e)DRX are specifically designed for LTE-M and NB-IoT. These features will represent a step change in the suitability of cellular devices for remote applications. Companies with products dependent on low power will relish these features and invest significant R&D resources to ensure optimization.
- **How will I deliver firmware updates?**
Reliable and secure image transfer can be very difficult to deploy, especially with a large image size across a low speed network.

The **PLS62-W products** from Gemalto offer **the only solution** that implements standards adapted for machine communication whilst retaining the features taken for granted in previous generations of cellular M2M and IoT standards. The Gemalto PLS62-W also supports device management tools catering for secure delta firmware updates. In the absence of mature, widely deployed LPWA networks, the ability to rely on LTE-CAT1 should not be underestimated.

Form Factors

“Many companies are trying to “smartify” their legacy systems. And that means thinking about where their existing tech is located, its size, weight, power consumption and what it needs to connect to. And then they face the question of opting for a plug-and-play solution or building something bespoke.”

— Sourav Rout

In order to connect the wide varieties of IoT devices everywhere in the world the Gemalto PLS62-W products are supported in a number of form factors.

Module

Modem designed for integration on host PCB, the module is the common choice for higher volume projects. It is necessary for the designer to have board level RF and embedded design skills. The final applications require type approvals.



Modem Card

Applications which require a ‘swappable’ RF module concept commonly use the industry standard PCIe interface. Many industrial motherboards and routers adapt this standard.



Terminal

The easiest method of integration. Pre-Approved and ready to use IoT system with industrial interfaces such as USB or Ethernet. The terminal is a popular choice for adding connectivity to existing hardware.



Choosing the right path forward

There is much deserved excitement about the next generation of LPWAN technologies. The potential these low-power technologies will bring for expanding the potential reach and applications for the IoT is limitless.

But engineers working on IoT projects are pragmatists. They need to plan for long project lifecycles. They need to anticipate devices being in a wide variety of locations. They need to avoid complexity in their supply chain or implementation processes. And crucially they need to think about the return on investment for their connectivity solutions.

As such, finding the right option for the right use case is a critical consideration in the planning of IoT projects. Choosing the wrong connectivity option will add to the cost and timeline for your project, build in complexity you need to tackle in development, manufacturing, testing and distribution, and limit the usefulness of your connected devices.

If you have feedback on any of the materials herein or want to learn more about Gemalto's IoT connectivity technologies, please get in touch at gemal.to/iot-network-evolution.



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