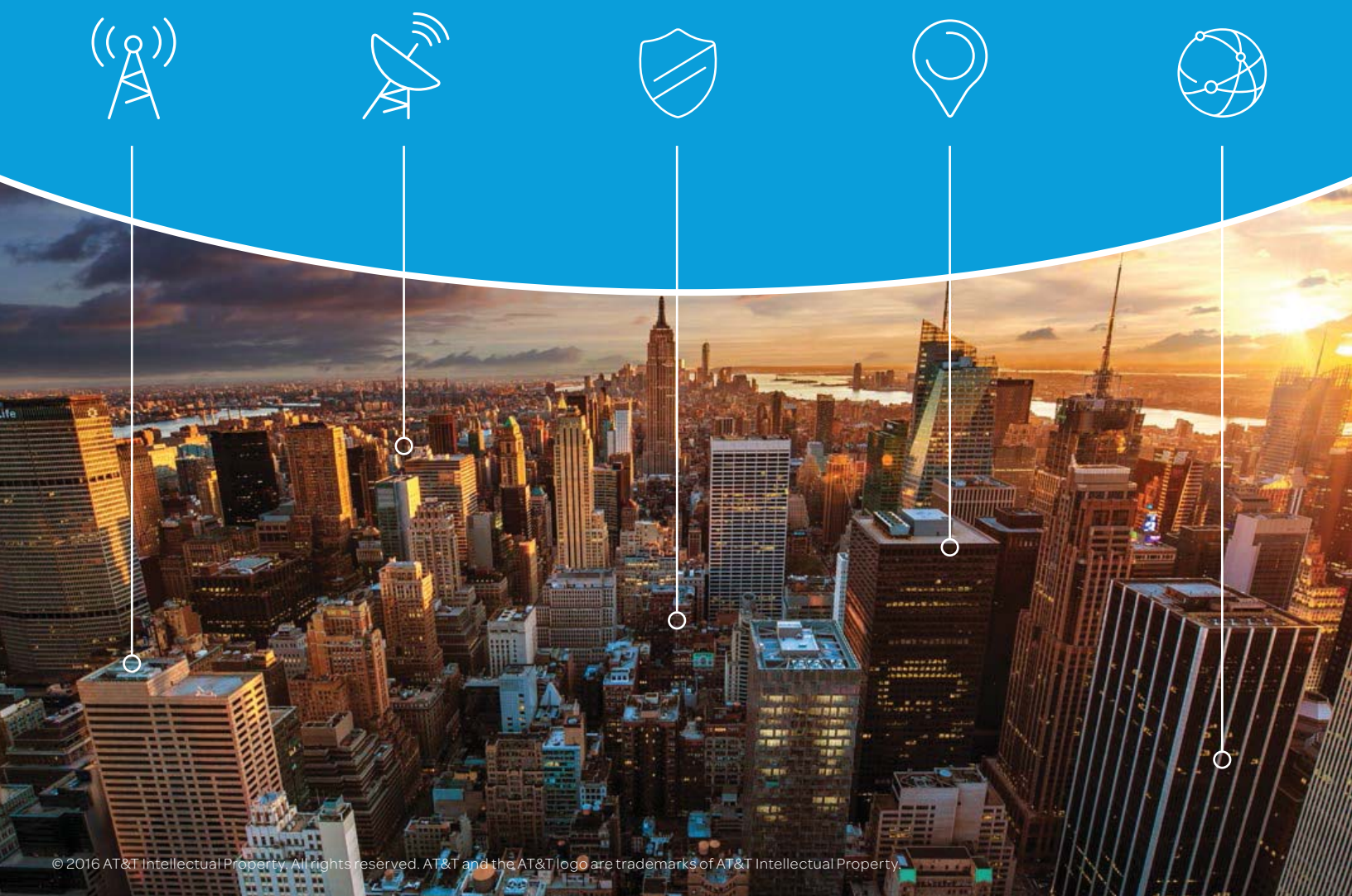
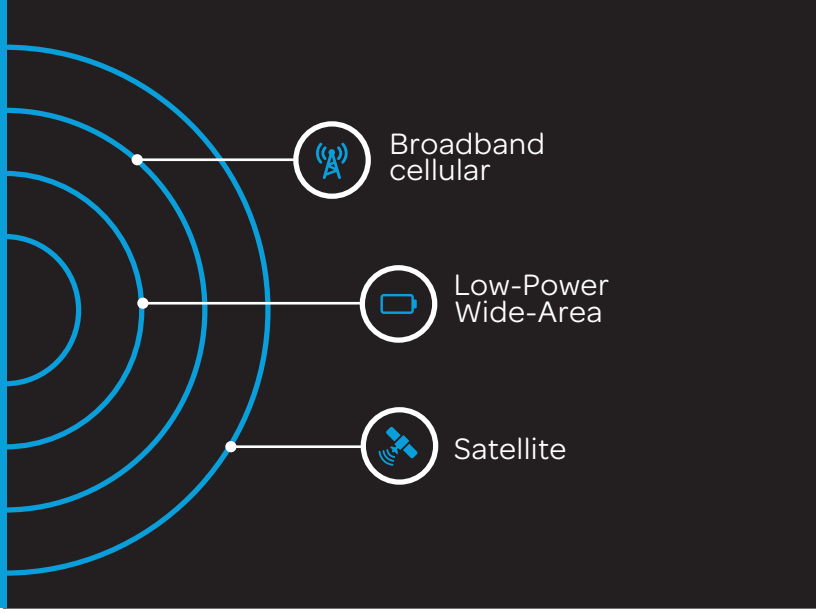
MOBILIZING YOUR WORLD

What you need to know about IoT wide area networks

How to choose the right WAN technology for the Internet of Things



IoT networks are evolving



Choosing the best wireless technology for your Internet of Things (IoT) takes careful consideration. In this whitepaper, we examine IoT wide area networks (WANs) including cellular, Low-Power Wide-Area (LPWA), and satellite services to help you choose the right network technology for your specific needs.

IoT wireless networks are evolving to help meet the needs of a wide variety of connected devices—from wearables, cars, and homes to streetlights, parking meters, and industrial automation devices—so they can work seamlessly together. With such a broad diversity of potential applications, it can be difficult, if not impossible, to bring a one-size-fits-all approach to every situation.

To choose the right network requires consideration of many factors: from coverage needs and device location to power consumption and the cost of deployment. Each of these factors can contribute to a different network decision.

Broadband cellular connectivity has dominated the IoT landscape for more than a decade. Key advantages include global reach, scalability, diversity, and high bandwidth capabilities.

When cellular is not an option, satellite services can help provide connectivity to virtually anywhere on earth. Yet, in IoT, not all connected devices require such robust capabilities.

New Low-Power Wide-Area (LPWA) networks are entering the IoT space as alternative wide area network technologies to short-range networks like Wi-Fi. LPWA technologies provide strong benefits including opportunities to help lower the total cost of ownership plus providing extended coverage and longer battery life.

As a leading integrated and global IoT service provider, AT&T understands that your IoT solutions can span across different network technologies. We offer a multi-network approach so that we can provide the flexibility and agility you need to help optimize your IoT solution.

Broadband Cellular

3G and 4G LTE

Today, several generations of cellular technology support IoT services. 3G and 4G stand for third and fourth generation technologies. LTE (Long Term Evolution) is a standard which has focused so far on broadband, high-speed wireless communications.

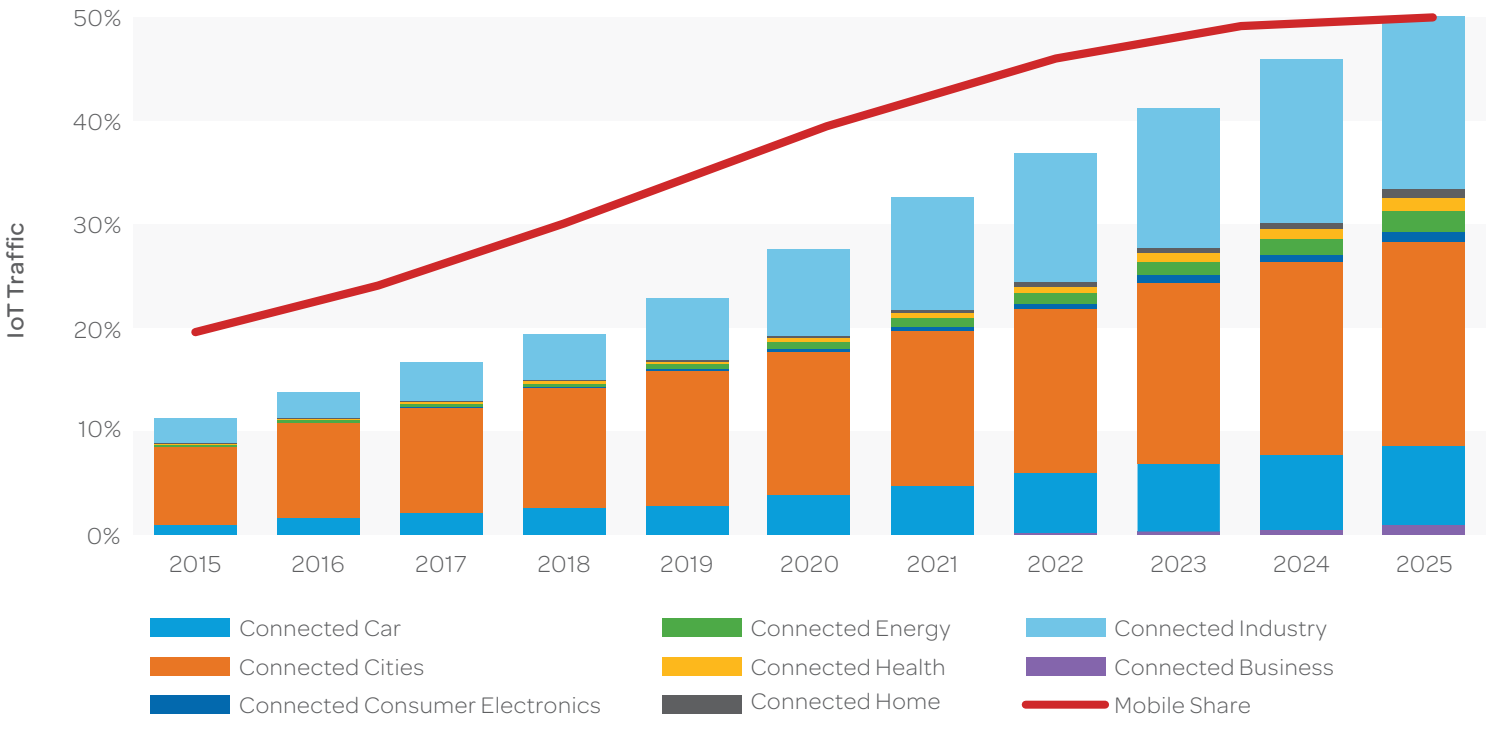
Broadband cellular connectivity has played a pivotal role in the explosion of IoT connected devices, and supports a full range of IoT applications from low bandwidth exception-based reporting to applications that have high bandwidth needs. By 2025, Machina Research expects that mobile networks will carry 50% of IoT data traffic[1].

Over the last decade, AT&T has connected more than 29 million IoT devices to its network[2].

[1] Source: IoT Global Forecast & Analysis 2015-2025, Machina Research, August 2016. Excludes consumer audio-visual applications

[2] As of Q2 2016

IoT Traffic by Sector 2015-2025[3]



[3] Source: IoT Global Forecast & Analysis 2015-2025, Machina Research, August 2016. Excludes consumer audio-visual applications

Global coverage

Cellular connectivity has long been the choice for large-scale device deployments in part due to its global coverage by Mobile Network Operators (MNOs), based on widely adopted standards. AT&T provides global coverage across more than 200 countries and territories and over 500 wireless networks with Global SIM technology. LTE coverage is currently available in 85 countries and growing.

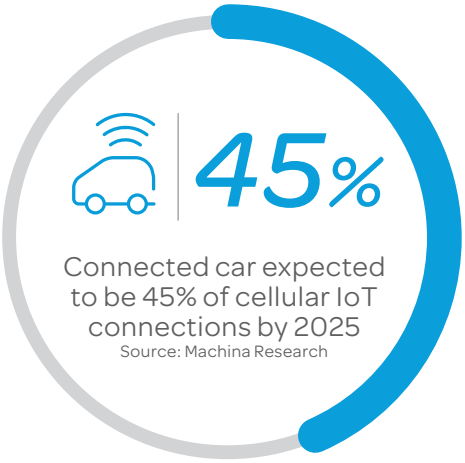
AT&T provides cellular IoT coverage in more than 200 countries and territories with Global SIM

Scalability and Performance

The scalability of the cellular network makes it well-suited for a large number of devices in a single deployment for virtually any type of asset or machine. LTE, specifically, has been designed to greatly enhance capacity and operates with a more flexible architecture allowing it to process a significant amount of data traffic.

For many low and moderate bandwidth applications that have infrequent data usage, 3G has been effective. If your IoT application uses high bandwidth, such as streaming video, 4G delivers improved performance that for many consumer and some enterprise applications, is becoming the expectation. In a recent report by Machina Research, the connected car will account for 45% of cellular connections in 2025 because it needs comprehensive coverage, high-speed mobility, and high bandwidth[4].

[4]Source: Machina Research, IoT Global Forecast & Analysis 2015-2025, August 2016



Cost-effectiveness

Cost plays a role in virtually any venture, and for IoT, device and module prices are key contributors. When new network technologies enter the space, typically the components for these new networks are more costly than their predecessors. We have seen this when comparing 3G with 4G, until recently. This trend is now changing in light of newer, lower-cost 4G LTE technologies for many IoT applications. Broadband cellular modules such as those from Winstron NeWeb (WNC) announced by AT&T in Q1 2016, are priced in the range of 3G modules today and should continue to decrease in price with large scale adoption.

High Security

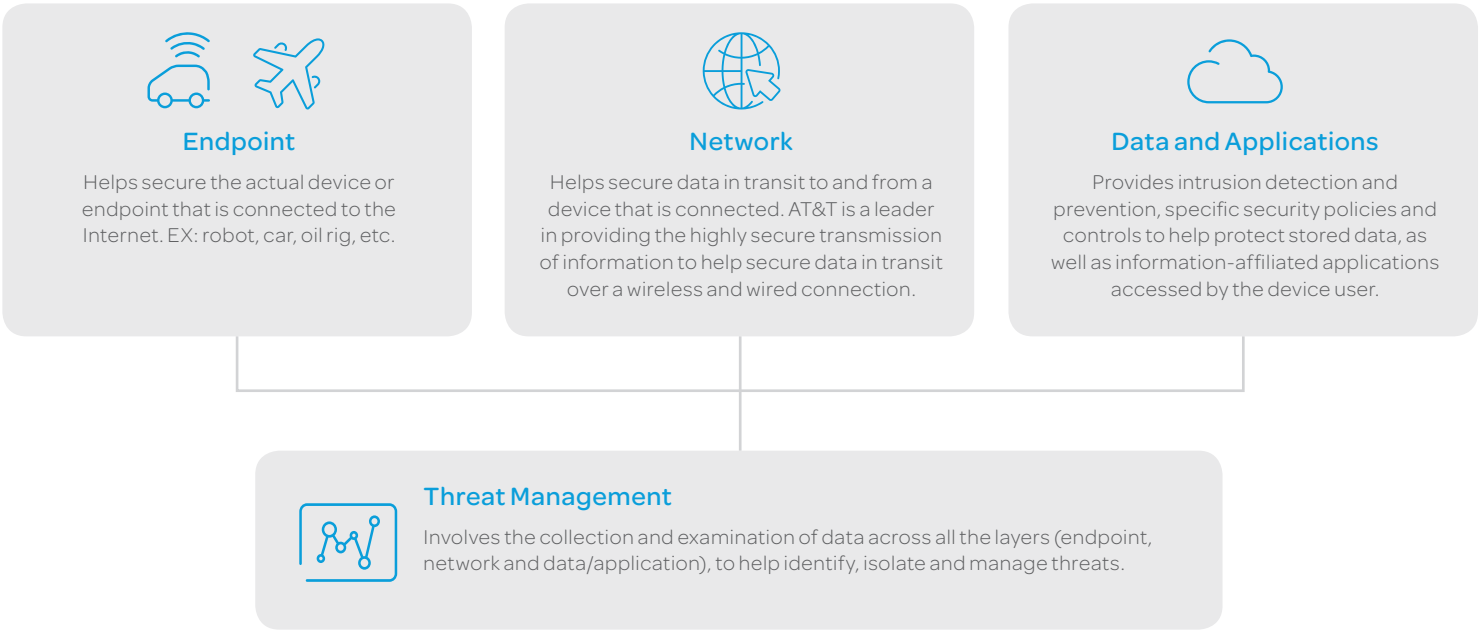
IoT solutions have many system layers and require a correspondingly layered approach to security. In addition to high security at the network layer, carrier-grade security with AT&T helps protect the device, network, and systems that make up the end-to-end solution. AT&T offers insight into IoT security in the *CEO's Guide to Securing the Internet of Things*.

5G

5G is the next generation of cellular technology and will bring about even faster data speeds and lower latency than its predecessors. Speeds could be measured in gigabits per second, rather than megabits per second. Speeds like this will likely spur further IoT innovation as well as enable improvements to solutions on the market today. That said, 5G standards may not be available before 2018, and even later for 5G-enabled IoT devices.

"Speeds could be measured in gigabits per second, rather than megabits per second"

Layers of IoT Security



Low-Power Wide-Area (LPWA)

LPWA networks are intended for IoT solutions that need low power consumption, extended battery life, and good penetration in buildings and underground. Several different technologies are being developed and deployed to support such IoT requirements. An important category of LPWA is a mobile operator-managed IoT network based on 3GPP standards for IoT networks. The two most commonly identified technologies as defined within the 3GPP standards for these purposes are LTE-M (also referred to as LTE Cat-M1) and NB-IoT (Narrow-Band IoT).

Due to its key characteristics, LPWA is likely to have a significant impact on the growth rate of future IoT innovation and spur even higher volume device deployments than are present today.

Key characteristics

Low Power

Two features defined within 3GPP standards for IoT are power saving mode (PSM) and extended discontinuous reception (eDRX). PSM and eDRX are features that enable very long battery life, with 10 years or more expected for low data usage cases. They are capable of delivering multiple years of device operation on a single, small form factor battery (assuming hourly application readings and factoring in the effects of battery self-discharge and degradation.)

Coverage Extension

LPWA is capable of today's expectations of broad cellular-level coverage, delivering nationwide and/or international coverage with specific support for urban, in-building, and subterranean environments[5]. With its coverage extension (CE) feature, LTE-M and NB-IoT devices will be able to achieve coverage in today's most challenging radio frequency (RF) environments.

LPWA can offer extended battery life of 10 years or more

[5] Source: LPWA: disruptive new networks for IoT, Machina Research, November 2015

Benefits

LTE-M and NB-IoT deliver multiple benefits that can lower the costs, and extend the range of your IoT solution. Cost and battery life have long been considered when making decisions on IoT system architectures. LTE-M and NB-IoT are uniquely suited to address both of these factors and more. A summary of benefits includes:

Longer battery life
Extended battery life of 10 years or more for enabled IoT devices.

Lower cost hardware
Chipset and module costs are expected to be in the $5 to $10 range.

Lower cost of service
Thanks to wide area coverage and the expected high endpoint capacity per cell, connectivity costs are expected to be lower than broadband cellular service.

Extended coverage
The CE feature can provide coverage up to 7X better than traditional cellular networks[6]. This includes improved connectivity within subterranean locations like basements and parking structures which makes LPWA ideal for water meters, electric meters, alarm panels, and similar installations.

7X

LPWA coverage up to 7X greater than cellular and great for basements and parking garages

[6]Coverage will vary by application and does not indicate an expanded radio frequency footprint

LPWA Technologies

There are two primary categories of LPWA technologies: licensed and unlicensed.

Licensed Spectrum LPWA

Licensed LPWA uses MNOs' current wireless spectrum holdings. MNOs have long held licenses to operate within dedicated spectrum specifically for the use of wireless communication. It is how they provide the highly reliable, scalable, and highly secure environments that large enterprises have come to expect. As described above, there are two key types of licensed LPWA technologies commonly referenced as defined within the 3GPP standards: LTE-M (Cat-M1) and Narrow-Band IoT (NB-IoT).

Unlicensed Spectrum LPWA

Unlicensed LPWA technologies use publicly available, open spectrum. Wi-Fi routers, cordless telephones, and other communication devices also access unlicensed spectrum, which can cause interference, thereby degrading performance. There are several competing LPWA solutions within unlicensed spectrum. It is unclear which of these will survive in the long run.

Licensed compared to Unlicensed LPWA

	Licensed LPWA (LTE-M, NB-IoT)	Unlicensed LPWA Technologies
3GPP standards-based	✓	✗
Dedicated licensed spectrum (Reduced Interference)	✓	✗
Carrier-grade security	✓	✗
Coverage benefits from existing cellular networks	✓	✗
Long battery life	✓	✓
Low-cost modules	✓	✓

LPWA Expectations and Predictions

LPWA networks are expected to play an important role in serving the IoT market because of lower-cost module hardware, reduced service costs, smaller form factors, improved battery life, and coverage enhancements. The question is which of the network technologies will prevail in the long run?

Dependability

LTE-M and NB-IoT operate over dedicated, licensed, and managed spectrum whereas unlicensed proprietary technologies do not. This means that there's no risk of the data traffic having to compete with non-managed devices operating within the same frequency range, as is the case in an unlicensed band. Less interference means an improved quality of service that's more dependable.

Scalability

By deploying a 3GPP standards-based technology for IoT, not only can MNOs like AT&T use their existing spectrum and avoid the potential for frequency conflict in an unlicensed range, they can also scale quickly.

LTE-M for example, can be deployed by MNOs as a software upgrade to their existing LTE network. This means it can launch quickly as a nationwide service, then scale globally over time. Standardization also leads to increased growth and adoption rates in additional ways:

- Improved economies of scale via global deployments and interoperability
- More robust solutions, since multiple companies work towards improving the end product
- Lower pricing, thanks to increased volume and scale

Security

When it comes to IoT, securing and protecting data is imperative. Because LTE-M and NB-IoT are SIM-based technologies, they deliver carrier-grade, best-in-class security measures. AT&T takes a multi-layered approach to IoT security that will also extend to LPWA. For more on the approach, read our report, *The CEO's Guide to Securing the Internet of Things*.

Technology costs

Bill of Materials (BOM) costs of LTE-M and NB-IoT modules are expected to be comparable during the first few years on the market.

Example use cases for Broadband Cellular and LPWA technologies[7]

Bandwidth	Technology	Devices
1 Gbps 100 Mbps	Cat-4	Routers • Network bridges • Gateways • High resolution video Endpoint concentrators
10 Mbps 1 Mbps	Cat-1	Video surveillance • Connected healthcare • In-car hotspot • Retail signage Digital signage • In-car infotainment • Enterprise PDA
100 Kbps	LTE-M	Asset trackers • Telematics • Smart watches • Alarm panels • Pet trackers Fitness bands • Point of Sale terminals • Gas/water meters • Patient monitors
10 Kbps 1 Kbps	NB-IoT	Smoke detectors • Parking control • Smart agriculture • Smart cities • HVAC Lighting • Electric meters • Industrial monitors

This table includes a summary of potential application use cases for cellular and LPWA IoT communication. Not all are listed and many use cases may work well across multiple network technologies.

[7]Source: CAT-M vs. NB-IoT: Energy Consumption vs. Payload, Sequans Communications, January 2016