FROST & SULLIVAN

Growing Industry Applications of LPWAN Technologies

A Frost & Sullivan White Paper

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Growing Convergence of LPWAN & IoT Technologies

The Internet of Things (IoT) is now changing how societies operate as more and more devices become connected around the world. IoT not only connects devices such as tablets, phones and computers, but also links places, things and people in their physical world to restructure the processes, gain insights and explore new possibilities.

Today, IoT applications are increasingly creating new efficiencies in how companies operate, providing tangible value to customers and generating new revenue streams. Frost & Sullivan forecasts more than 80 billion connected devices and sensors to be installed worldwide by 2020, i.e., about 10 connected devices for every human on the planet. The technology has the potential to help improve the bottom line by reducing operating costs, increasing productivity, supporting new product development or expanding into frontier markets.

Businesses across multiple industries, such as Food and Beverage, Agriculture, Public Services, Manufacturing, Utilities, Logistics and Transportation, realize the need to have advanced and agile back-end infrastructure to handle the rising IoT-based initiatives and solutions, raising four key concerns:

01 **How does this affect power consumption?**

02 **What are the overhead expenses to have these devices connected?**

03 **What is the area of coverage to transmit these devices?**

04 **What is the data capacity in terms of functionality and speed for the connected devices to transmit data?**

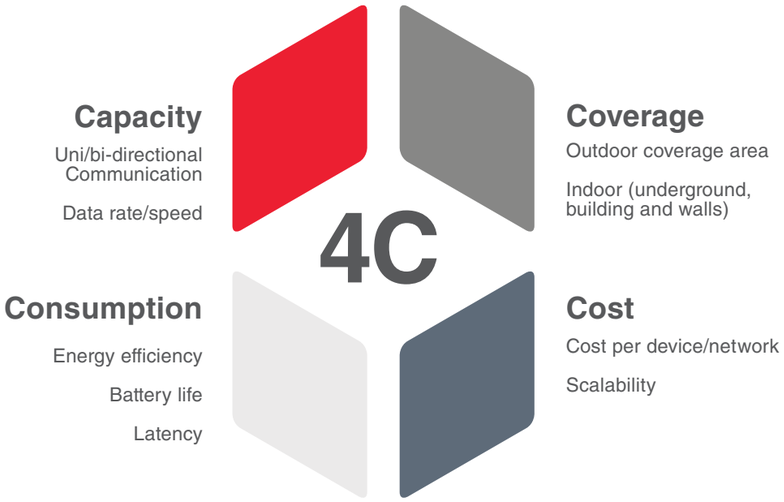
Currently, most IoT devices leverage existing network connections such as cellular, Zigbee, WiFi, and other proprietary technologies. Cellular networks far from provide the ideal functional performance as there remain significant gaps in terms of energy and cost efficiency, data output, and coverage areas. The explosive growth in the number of IoT devices is set to elevate higher demand for low power, cost-efficient, optimized data transmission, and scalable cellular coverage.

As a result, Low Power Wide Area Network (LPWAN) is fast-emerging as a game-changer in IoT development, addressing most limitations of the cellular network (e.g., high power, gaps in coverage). LPWAN possesses unique characteristics that make it particularly attractive for a growing number of deployments across multiple sectors including Utilities, Logistics and Transportation, Agriculture, and Smart Cities.

LPWAN supports IoT and M2M applications that need to transmit small blocks of data over long distances while maintaining long battery life. Its inherent features such as low power consumption operating on small, inexpensive batteries lasting up to 10 years, and suitability for long operating range of more than 2km radius in urban settings are likely to accelerate the number of LPWA connections to 3 billion by 2025, deriving annual revenues exceeding US$20 billion, according to GSMA figures.

In highlighting the key characteristics of LPWAN technology across different verticals, Frost & Sullivan has developed a 4C (Capacity, Consumption, Cost, Coverage) model as a foundation for the LPWAN Application Suitability Index discussed in a later section.

Chart I: The 4C Approach to LPWAN Technology



CAPACITY refers to data rate or throughput in total daily loads of data rate in bytes. High capacity can be assigned to industries and applications in the top 50 percentile while low capacity covers the lowest 20 percentile.

CONSUMPTION represents battery life requirements according to the respective industries. Minimum battery requirement is one to three years while long battery life spans more than 10 years. Consumption also depends on latency, which is inversely correlated with battery life.

COST parameter determines if it is a crucial requirement or pain point for a particular industry/application. Cost for LPWAN can include both module (chip) and network costs.

COVERAGE can be categorized as indoor or outdoor applications, or both. High coverage includes long-range outdoor area and deep indoor coverage such as underground, parking or within buildings with obstacles and interference.

Evolution of IoT Device Market Landscape

Digital transformation is not a destination, but ultimately a journey. It is the evolution of business from analog, people-dependent processes to data-enabled functions.

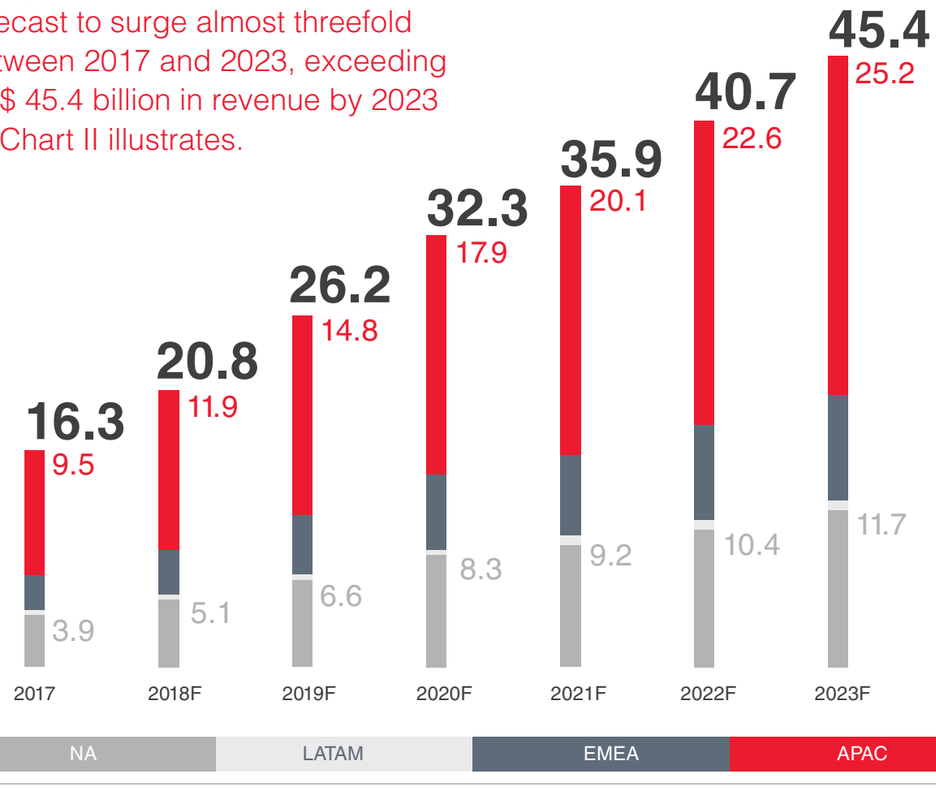
Frost & Sullivan believes that IoT is the catalyst driving this transformation, which begins with collecting telemetric data from sensors, devices, people, infrastructure, and processes, and converting that data into actionable insights using advanced analytics. This data-driven shift signals significant opportunities for LPWAN technology in playing a pivotal role in facilitating the expansion of IoT connections globally.

Growth could occur at the expense of traditional cellular mobile, notably General Packet Radio Service (GPRS), currently the leading carrier of M2M connections worldwide. Proprietary technologies (e.g. LPWAN) that meet the immediate requirements of being low-cost, ultra-power-efficient, and long-range, which cellular mobile connections cannot address cost-effectively, could dominate the IoT market in the future.

Chart II: Global IoT Devices Market, US$ billion, 2017–2023F

Source: Frost & Sullivan (2017)

The global IoT devices market is forecast to surge almost threefold between 2017 and 2023, exceeding US$ 45.4 billion in revenue by 2023 as Chart II illustrates.



Portable asset tracking and connected consumer electronics are mostly driving the growth of IoT devices globally. Robust expansion in building automation systems and security and surveillance are also enabling the increased adoption of IoT. The global IoT devices market is forecast to surge almost threefold between 2017 and 2023, exceeding US$45.4 billion in revenue by 2023 as Chart II illustrates.

Smart devices have come a long way. Manufacturers are now applying the asset tracking concept in inventory tracking, sales recording, and even as a warning to potential instrument failure. Other than asset tracking, companies have begun to explore the possibility of not only tracking commercial vehicles, but also installing vehicle health monitoring systems.

Security and operations are also dedicated areas companies are looking to upgrade. For instance, the opportunity size of the smart buildings IoT-enabled market for North America is projected to reach US$44.8 billion by 2020, at a five-year CAGR of 18.4%.

Although some smart building applications require high bandwidth for video surveillance, certain types of building automation are well suited for LPWAN connectivity. Low power connected sensors can communicate through LPWAN to perform automated tasks such as fire alarm maintenance as well as temperature and utility management.

Meanwhile, smart city applications are stimulating market growth with innovative use cases such as smart parking, smart meters for utilities, and advanced recognition systems. This predisposes low-power wireless technology for continuous applications with low data exchange requirements such as smart lighting, smart meter reading, and home automation. These are only a few of the opportunities LPWAN can offer to unify the numerous IoT applications available today.

Emerging LPWAN Technologies:

Low Power | Low Data | Long Range

The rapid integration of devices with communication systems within the IoT ecosystem across multiple industries is set to lead to widespread adoption of M2M connectivity services.

Approximately 90% of current IoT connections comprise local area networks including Ethernet and Wi-Fi, whereas personal area networks cover RFID, Bluetooth, and Zigbee within short range (refer to Chart III). Long distance coverage in the form of cellular technology may be utilized in IoT devices on a national/cross-country scale despite challenges in implementation and high maintenance cost.

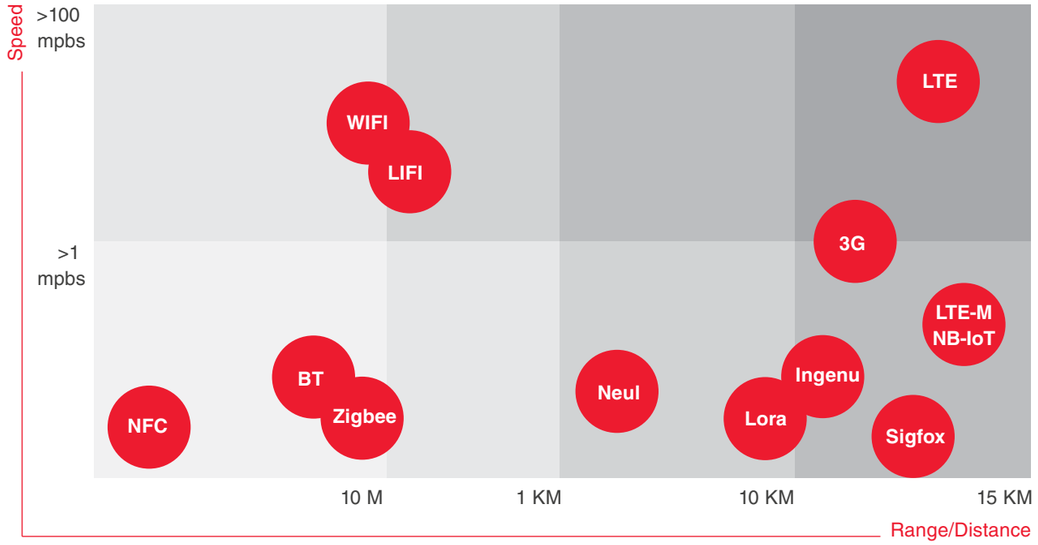
LPWAN is a wireless communication technology specialized for interconnecting devices together, focusing on power efficiency and long range.

Globally, it is becoming the preferred connectivity mode for low-cost, low-power assets, particularly in hard-to-reach locations such as rural areas, underground locations or at the margins of mobile cellular coverage.

Development of LPWAN started in 2011, when SigFox first introduced the technology in 2012 as an alternative to IoT connectivity. Since then, there have been significant developments in LPWAN technology making it more efficient, scalable, and flexible. Core features of LPWA Technologies are outlined in the following page:

Chart III: Wireless Connectivity Solutions—Comparison Matrix, Global

Source: Frost & Sullivan (2016)



Capacity

LOW DATA capacity of 100kbps to 1mpbs in LPWAN technology matches real-data usage in IoT devices, particularly in low throughput transmissions over periodic timeframe. Specific IoT devices, such as wearables, require the most advanced LPWAN technology (licensed LPWA technology) with big data rate and real-time transmission options.

Coverage

WIDE AREA (LONG RANGE) coverage of more than 100m compared to Zigbee, Bluetooth, and Wi-Fi. This facilitates IoT applications in diverse industries covering areas such as urban, rural, underground, parking, and more importantly, those with no cellular coverage or “blank spaces”.

Consumption

LOW POWER consumption with expected battery life of about 10 years involves low-duty cycle and very little energy consumption in idle state. Low power also means low energy consumption, which suggests less need for continuous battery change or upgrades (required in sensors and smart meters for water utilities, smart industries, and remote stations.

Cost

Since LPWAN uses an unlicensed spectrum of less than 1GHz frequency, the absence of hefty spectrum fees allows for LOWER COST benefits compared to cellular technology. Due to lower data volume, LPWAN technology consumes less power, prolonging battery life in IoT devices and leading to reduced operational expenses for companies. Another critical advantage is scalability that results from easy installation, convenient maintenance, and simple functionality.

Chart IV: IoT Requirements vs LPWAN Characteristics

Key Requirements of IoT	Key Characteristics of LPWAN
Long battery life	Low power consumption
Low costs	Low costs (module and connection)
Wide coverage	Long range
Low data rate or packet size	Low data size and throughput
Less human intervention	Reduced complexity and scalability

Benchmarking Emerging LPWAN Technologies

Although many connectivity options and protocols are included in the industry definition of LPWAN, each is implemented differently with significant implications for suitable use cases.

For example, lower frequency options are more suitable for penetrating buildings; a mono-directional (upload) option will have extremely low power consumption, but lack the ability for remote management of the end

	LoRa Alliance	Sigfox	Ingenu	NB-IoT	LTE-M (CAT M1)
LPWAN Technology	CSS (Chirp Spread Spectrum)	UNB (Ultra-narrowband)	RPMA (Random Phase Multiple Access)	OFDMA (Orthogonal Frequency Division Multiplex), 3GPP	OFDMA (Orthogonal Frequency Division Multiplex), 3GPP
Frequency (ISM)	433-434 MHz 470-510 MHz 779-787 MHz 863-870 MHz 902-928 MHz	868–869MHz 902-928MHz	2.4GHz	450MHz-3.5GHz	450MHz-3.5GHz
Coverage / Range	2–5 km Urban 15 km Rural	3–10 km Urban 30–50 km Rural	>15km Outdoor	>15 km Outdoor	>10km Outdoor
Data throughput	70 bps – 50 kbps	100 bps – 1 kbps	100bps-624 kbps	20–250 kbps	200–1000 kbps
Link budget	153–161 dB	149–165 dB	163-172 dB	150-164 dB	146–160 dB
Device/Module cost (US$)	$1-12	$1-10	$4-15	$5–12	$20-40
Connectivity cost per month (US$)	$0.25-2	~$1	$0.8	~$1	$3-5
	Non-Cellular			**Cellular**	

Source: GSMA, Frost & Sullivan (2016)

The table here indicates that SigFox provides the highest coverage, on par with the standard LTE cellular network; while the shortest range for LPWAN is 2km–5km in urban areas provided by LoRa. LTE-M delivers the highest data rate or capacity, up to 1000 kpbs along with 10km range. Link budget as an indicator of data transmission factoring in real-time obstacles is the highest for Ingenu, while the lowest link budget currently is SigFox resulting in high interference and long transmission time.

As stated earlier, LPWAN types have different technical characteristics suited to a range of applications. For instance, SigFox suits small data sensors due to the small size of data as well as long range and power efficiency while LoRa provides a higher throughput or big data size with lower range offering private networks to cover oil refineries or agricultural farms. On the other hand, Ingenu requires 2.4 GHz antenna with higher CapEx for more complex applications. Among other factors, LoRa technology is considered more power-efficient and suitable for critical segments and two-way data transmission.

Recognizing the rapid proliferation of IoT applications and urgent need to fulfil unmet demand, telecom operators are responding to the rise of disruptive proprietary unlicensed LPWAN technology by implementing their own IoT dedicated licensed LPWAN solutions, such as NB-IoT or LTE-M. New LPWAN offerings by cellular companies meet the IoT device requirements in terms of frequency and coverage, providing high speed and data volume with low latency. Most widely used applications for LTE-M (CAT-M1) and NB-IoT are wearables, telematics, payment and tracking devices.

Positive factors for cellular LPWA technologies include high data rate, scalability based on existing infrastructure, and quality of service in terms of security. Since new LPWAN technologies utilize cellular networks, they could face two drawbacks – non-coverage of remotely located areas with no cellular connection and a higher probability of interference with currently used spectrum.

With the diverse range of IoT devices and requirements, there is no one-size-fits-all technology, meaning both licensed and non-licensed LPWA technologies could carve out their own niche without cannibalizing the market share of each other.

LPWAN Connectivity Market: **Key Drivers**, Global, 2016–2023F

	1-2 years	3-4 years	5-7 years
Falling prices of sensors and communication modules increase IoT adoption in multiple use cases	High	High	Low
Support for standardization promotes market confidence, and lowers risk for customers and manufacturers	High	High	Low
Concern about 2G/3G switch off motivates customers to seek alternatives	High	High	Low
Emergence of independent network operators provides customers more buyer power and tailored services	High	Low	Low

Impact Ratings Low Medium High

Source: Frost & Sullivan (2016)

Suppliers are progressively allowing low-cost or royalty-free use of their proprietary technology to increase volume and drive economies of scale. Frost & Sullivan estimates suggest that the wholesale price of IoT chipsets, on average, could drop substantially from US$32 per chipset in 2012 to almost US$8 per chipset in 2018.

Currently, the mobile industry is aligning to ensure both Cellular IoT and LTE-M remains integral to the forthcoming 5G roadmap. On the other hand, proprietary LPWAN vendors are urging standards bodies as 3GPP (3rd Generation Partnership Project) and ETSI (European Telecommunications Standards Institute) to recognize their solutions as de facto standards in their own right. Convergence of LPWAN technologies and LTE would be the logical route to addressing the wide range of IoT use cases.

Availability of LPWAN at competitive pricing could also outweigh concerns about proprietary technologies. This is especially so for customers with use cases requiring only low value and low data rate, such as operations involving fixed assets in remote locations such as metering for water distribution systems.

Finally, IoT customers may currently feel overlooked by commercial telecommunication players. The emergence of telecom companies and private solutions for wireless connectivity targeting the IoT industry could fuel competition which could eventually benefit customers through better packages, improved quality, and low connectivity prices.

LPWAN Connectivity Market: **Key Restraints**, Global, 2016–2023F

	1-2 years	3-4 years	5-7 years
Fragmentation of standards and proprietary network protocols heightens risk for network operators and enterprises	High	Medium	Low
Lack of clarity in business models makes communication service providers (CSPs) reluctant to invest	High	Medium	Low
Potential for congestion in license-free ISM bands limits use of proprietary LPWAN for critical applications	Medium	High	Medium

Impact Ratings Low Medium High

Source: Frost & Sullivan (2016)

Currently, device OEMs (original equipment manufacturers) and vendors are hesitant to invest in proprietary LPWAN technologies that may lose support over time. End customers are also sensitive to this issue with many preferring a technology-agnostic approach with multiple connectivity options or hybrid solutions. The integration of multiple radio modules increases the device's bill of materials and impacts the supplier's margin where hardware is bundled into an "as-a-service" business model.

CSPs see little to no return on low-value connections unless they are part of a broader managed services solution. As a result, partnerships and revenue-sharing business models need to be explored more extensively. Platforms are also required to facilitate more self-service and automation features.

ISM bands are prone to congestion in areas of dense end-points, although LPWAN technologies are designed to avoid interference using modulation and frequency hopping techniques as well as resending of messages. Customers with life- or business-critical applications also require transmission encryption and confirmation that messages have been received, making bi-directionality crucial.

LPWAN Application Suitability Index: Key Verticals

Industry	Application	Coverage	Consumption	Cost	Capacity	LPWA Suitability
Healthcare	Assisted Living /Medical	+	O	+	+	HIGH
Agriculture	Stationary Tracking/ Monitoring	+	+	+	+	HIGH
Agriculture	Livestock Tracking	+	+	O	O	AVERAGE
Consumer	VIP / Pet Tracking	+	+	+	O	HIGH
Consumer	Home Appliances	O	+	+	+	HIGH
Consumer	Wearables	+	O	O	O	AVERAGE
Consumer	Vending Machines	O	–	+	+ / –	AVERAGE/LOW
Transportation & Logistics	Smart Bicycles	+	+	+	–	HIGH
Transportation & Logistics	Asset Tracking	O	O	O	O	AVERAGE
Environmental Management	Environmental Monitoring	+	+	+	+	HIGH
Environmental Management	Environmental Data Collection	O	+	+	+	HIGH
Utilities	Water/Gas Metering	+	+	+	+	HIGH
Utilities	Microgeneration	O	–	+	+	AVERAGE
Utilities	Smart Grid / Power	+	O	O	+	AVERAGE
Smart City	Lighting	+	–	+	+	HIGH
Smart City	Waste Management	–	+	+	+	HIGH
Smart City	Building Automation – e.g. Alarms, Actuators	–	O	+	+	AVERAGE
Smart City	Home Automation	–	O	+	+	AVERAGE
Smart City	Smoke Detectors For Home/ Enterprise	O	O	+	+	AVERAGE
Smart City	Parking	–	+	+	O	AVERAGE
Manufacturing	Industrial – Tank Process/Safety Monitoring	O	+	+	+	HIGH
Manufacturing	Propane Tank Monitoring	+	+	+	+	HIGH
Manufacturing	Industrial – Asset Tracking	O	+	O	O	AVERAGE
Manufacturing	Industrial – Machinery Control	–	+	O	O	LOW

Source: Frost & Sullivan (2017)

+ Represents positive parameters

O Represents neutral parameters

– Represents negative parameters

The LPWAN Application Suitability Index is based on the 4C – Capacity, Consumption, Coverage, and Cost – approach. An industry application with more than two positive parameters is considered as highly applicable for LPWAN while only one match places it at a low applicability level. In case of two high applicability and two medium/low applicability, a qualitative assessment is conducted to evaluate suitability.

In total, eight industries and 24 sub-industries were identified for the Suitability Index. Based on the study, LPWAN technology applications are most suitable for agriculture – stationary tracking and monitoring; environmental monitoring; gas/water metering; and industrial propane tank monitoring. All 4C parameters ranked well for LPWAN technology in these functions. For instance, agriculture, environmental and propane tank monitoring applications operate with 10+-year battery life and outdoor coverage, while water/gas metering has up to 15 years of battery life with deep indoor coverage.

In contrast, LPWAN applications show low to average suitability for some industrial (machinery control) and consumer (vending machine) examples. For instance, industrial (machine control) requires indoor or short-range coverage and high data rate expressed in total 5,000 bytes daily comprising short messages with a high frequency of 100 messages per day. In terms of privacy and data verification, vending machine is not suitable due to high data rate in terms of relatively high throughput of 10,000 bytes per day comprising short messages with high frequency.

Of the eight sectors, LPWAN use cases in five industries – Manufacturing, Agriculture, Smart City, Transportation and Logistics, and Utilities are covered in detail in the following section. Currently, LPWAN technologies are widely adopted in the Utilities and Transportation and Logistics industries (e.g., smart meters and sensors to track and monitor various aspects). Agriculture is an emerging industry for LPWAN usage, indicating high potential for Precision Farming while Manufacturing and Smart City applications are still at nascent stages, mostly using cellular or hybrid technologies such as a combination of Wi-Fi, RFID, and Zigbee.

LPWAN:
Emerging Applications & Case Studies

Manufacturing

General Utilities

Power Utilities

Agriculture

Transportation & Logistics

Smart Cities

Manufacturing

Consumption

The manufacturing industry has been one of the earliest adopters of M2M connectivity to improve supply chain efficiency. Ethernet technology has been adopted on factory floors for supervisory control and data acquisition since the mid-1980s.

Today, M2M wireless sensors are used to monitor devices and components to detect early signs of faults to prevent production downtime. Additionally, performance data can be collected through smart meters to optimize production and reduce inefficient processes.

Challenges in Manufacturing

The manufacturing sector operates on tight margins and is under pressure to achieve savings from operational efficiency

Factory floors need to adhere to multiple standards supplied by different device makers, resulting in poor visibility across the organization

IP network convergence is likely to be a gradual process due to legacy constraints

Replacement of systems could be arduous process over time

Benefits of LPWAN

Requires small and power-efficient sensors so that parts of a machine can be tracked and monitored

Aligns with Industry 4.0 objectives of reducing wastage, optimizing utilization of resources, reducing redundancy, and enabling preventive maintenance

Sufficient to support asset tracking, inventory management, and factory floor visibility

Emerging LPWAN Applications in Manufacturing

- Machine auto-diagnosis, asset control, and reporting
- Tracking and monitoring of temperature of high-value merchandise, assets, and inventory
- Asset indoor location reporting
- Item location tracking
- Storage incompatibility detection
- Smart metering

A Swedish manufacturer leveraging NB-IoT solution for high-precision screwdrivers

Challenge

The Client is a radio product manufacturer with its largest factory site located in Nanjing, China, with over 2,000 employees. Currently, several LPWAN use cases are being implemented in the factory, such as production line monitoring, warehouse monitoring, and package and materials tracking.

There are about 1,000 high-precision screwdrivers in the factory which require routine calibration and lubrication based on the amount of usage. Tracking these tools was mostly a manual process with periodic checks documented on paper.

Solution

The Client saw the benefit in implementing Narrowband-IoT (NB-IoT) in the factory. High-precision screwdrivers were connected with real-time motion sensors attached to NB-IoT modules. Data transmission occurs via a cellular IoT network over the company's private cloud and back-end systems, which makes automatic calculations and intelligent analyses of the collected data.

The smart tool maintenance set-up consists of:

- The Client's RBS6000, a multi-mode base station operated with a pre-commercial software
- The Intel® XMM™ 7115, a modem embedded in Fibocom's module
- Cellular connectivity provided by China Mobile Jiangsu
- China Mobile's Software Development Kit (SDK) together with its OneNet IoT Cloud platform
- Motion sensors from ADI

Impact

1. Reduction in the number of maintenance workers saving on labor and material expenses
2. Prevention and detection of human error during operations and automation of screwdriver usage
3. Prolonging the screwdrivers' service life to decrease operating expenses
4. Maintenance optimization as a result of intelligent analysis of collected data

General Utilities

Capacity

LPWAN technologies are excellent for the General Utilities sector, particularly for metering and monitoring applications related to water, gas and electricity usage as well as leak detection and unauthorized siphoning.

Despite telecom operators pitching their technology solutions, for utility providers, cellular technology is not feasible due to its high cost and high power consumption.

Challenges in Utilities

Increase in cyber security breaches and physical attacks affecting critical infrastructure by accessing sensitive information with lack of interoperability

Shortage of technically skilled workforce and lack of standards

Aging water infrastructure requiring high operating costs and scarce supply of water in remote areas

Benefits of LPWAN

Suitable for meters and sensors that require low volume data transmission

Most applications and devices in utilities require only periodic data transmission resulting low-duty cycles

Low cost enables scalability and massive deployment of large volume of sensors in metering and monitoring

Long battery life increases service cycle from two to three years to 10 to 15 years, improving ROI

Emerging LPWAN Applications in General Utilities

- Water distribution network monitoring
- Gas and water metering
- Smart meter consumption
- Tracking and pipeline monitoring
- Microgeneration: monitoring status of generation equipment (solar, wind, thermal) with sensors

French water utility company employing smart meters using SigFox technology

Challenge

The European Union (EU) aims to replace 80% of electricity meters in its member nations with smart metering systems by 2020. Many utility companies recognized the benefits of smart metering, including real-time leak prevention, and efficient billing.

In July 2014, one of the largest water utility companies in France partnered with SigFox, Connit, and Smarteo to install smart meters in Pays de Gex, a region in eastern France. SigFox was chosen primarily for its high signal penetration allowing the monitoring capability for indoor and underground meters.

Solution

SigFox Technology was implemented based on smart meters manufactured by Arad and Hydroko that can send data twice a day through the VT SigFox network, which is then processed by advanced data management software. To provide metering information for individual units, hardware was installed in each business unit. Besides this hardware, there was no other site-specific infrastructure installation required.

Impact

- Cost efficiency from elimination of onsite metering and remote activation and deactivation of devices
- Improvement of customer satisfaction and promotion of water conservation
- Reduction in water consumption and leakage via sensors notifying about leaks and temperature changes
- Low maintenance with supposed 15+-year battery support

Power Utilities

Capacity

Power Utilities have been early-adopters of LPWAN in the forms of smart meters to read household energy usage as well as to send and retrieve billing information remotely in real-time using smartphones.

Power utilities use connected devices to centralize monitoring of energy consumption and usage behavior. The Utility sector also benefits from enhanced services such as outage management and energy budgeting.

Challenges in Power Utilities

New participants from other industries are entering the Power Utilities sector to compete with traditional participants whose operations are based on legacy business models

Utility providers are under pressure to cope with market reforms. The need to reduce carbon emissions and upgrade aging infrastructure are also raising costs. Policies for providing electricity at lower cost are under serious consideration.

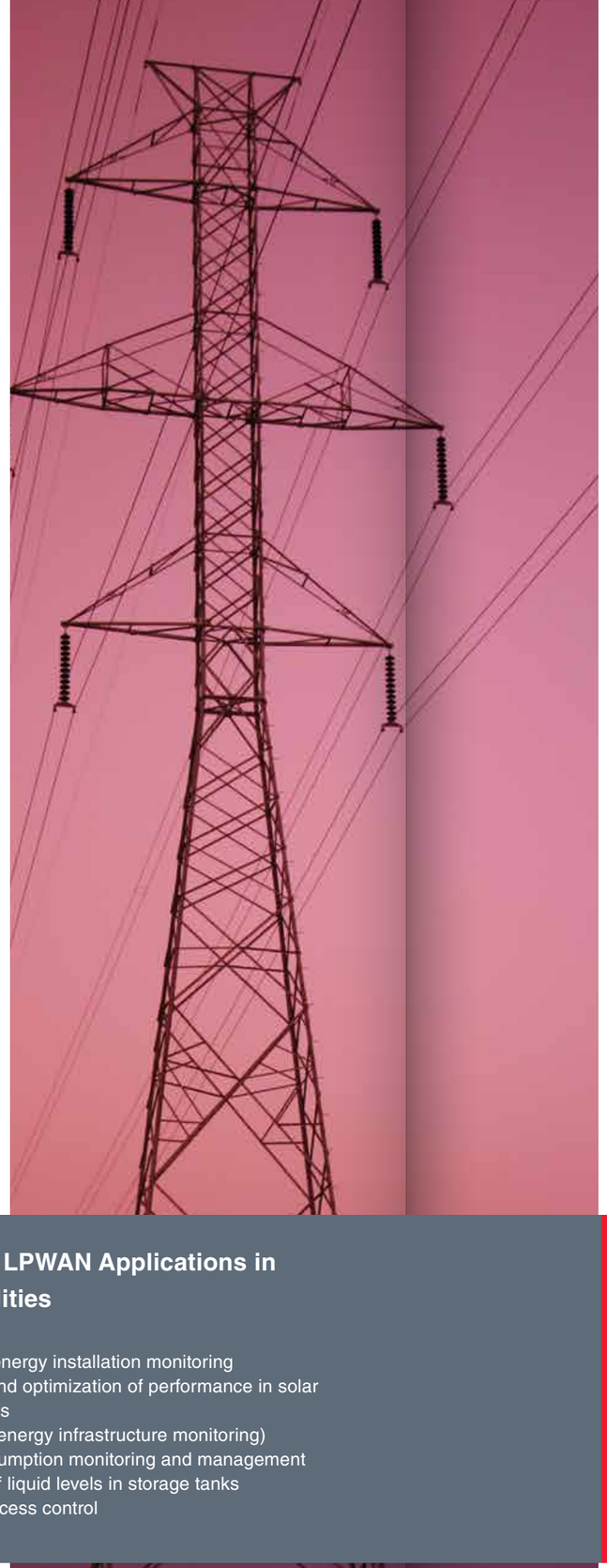
Benefits of LPWAN

Allows frequent communication, low latency, and high data rates

Suitable for densely-populated areas with high obstacles and interference

Aligns with objectives including energy savings for cost optimization, minimizing energy transmission losses, and power outages

Facilitates improvements in energy management and compliance with regulatory bodies



Emerging LPWAN Applications in Power Utilities

- Renewable energy installation monitoring
- Monitoring and optimization of performance in solar energy plants
- Smart Grid (energy infrastructure monitoring)
- Energy consumption monitoring and management
- Monitoring of liquid levels in storage tanks
- Perimeter access control

Ingenu and Caribbean utility company providing advanced metering infrastructure

Challenge

A Caribbean island state was facing frequent problems relating to power supply shortages, blackouts, and low quality of service. The government tasked a state-owned utility company to address this issue by exploring reliable advanced metering infrastructure (AMI) solutions that could withstand the frequent power fluctuations and provide remote monitoring and management of energy infrastructure.

Additionally, the utility company was launching a pre-paid electricity program requiring reliable data transmission and two-way communication capabilities as well as coverage, a challenge due to country's varied topography.

The Client is a privately-owned utility company that generates, transmits, distributes, and commercializes energy in the country.

Solution

Working with GE Digital Energy, Ingenu provided the RPMA network enabling over 24,000 smart meters to provide reliable energy sources for the Client's customers.

The solution offered stable, two-way communication between the Client and customers, providing accurate reporting and monitoring of energy resources and consumption.

The RPMA access points, which served as the communication intermediary between the meters and company's head-end system, were installed in strategic locations to obtain optimized RF performance, allowing a single RPMA access point to serve as many 20,000 GE smart meters.

Due to its limited infrastructure investment, the Client was able to deliver energy services at lower cost, resulting in significant cost savings for its customers.

Impact

1. Operational efficiency in terms of quick detection and response to service issues and interruptions
2. Improvement of customer services due to greater control over energy consumption and costs
3. Cost-effectiveness in energy efficiency for the provider and savings for consumers

Agriculture

Coverage **Consumption**

LPWAN technologies are making it possible for farmers and land managers to track the health and condition of livestock and soil with sensors to alert out-of-norm animal movement, send data on soil conditions, temperature, and humidity for fertilizer, control treatment or irrigation system.

Currently, IoT in Precision Farming (Robotics) is at the early stages of development although it is expected to grow with the deployment of LPWA technologies.

Challenges in Agriculture

Tight margins in farming industry limiting innovation and CapEx levels

High component costs such as plug and sensing devices, temperature and fluid sensors

Fragmented agricultural market dominated by few participants offering solutions across value chain hindering economies of scale

Inaccessibility or necessity to cover long range remote areas with lengthy deployment time

Benefits of LPWAN

Low-cost sensors with long battery life are ideal for agriculture to track moisture, temperature, and alkalinity conditions to improve the yield

Farming requires periodic transmission of data, a few times per hour

Due to remote and rural locations of farms, traditional cellular as well as licensed LPWAN are not viable options

Network stability and scalability is a critical requirement for agriculture

Emerging LPWAN Applications in Agriculture

- Tracking of farm equipment
- Tracking of livestock
- Smart irrigation
- Precision farming
- Crop management: yield, soil monitoring etc

SenSys, Spark NZ, and Actility enabling Smart Agriculture in New Zealand

Challenge

Many farms in New Zealand are remotely located, often surrounded by mountains, making it difficult to provide stable connectivity. Farmers, situated in rural areas, typically lack the capital to invest in new devices with long-lasting, cost-effective batteries that can gather data remotely.

The owners of South Auckland farms are trialing LPWA technology, supported by SenSys (LoRaWAN sensor developer) and Spark New Zealand (a digital service company) to address these challenges, improve business operations, particularly the management of available resources.

Solution

Spark, in partnership with Actility, is rolling out LPWAN for farmers to access their management systems in real-time with one gateway connecting about 100 farms to the network. LoRaWAN sensors allow connectivity through radio frequency up to 15km radius around a base station.

Once the network is operational and the farm is connected, SenSys is ready to install a wide range of LoRa-ready products to address the following areas:

- S3P Soil Probe – measures soil moisture and temperature
- WaterMon – analyzes farm water levels, leaks, and usage
- RainMon – reports rain volume hourly
- Octometer – monitors and reports on milk care and hygiene
- Gate-State – reports on gate or door security

The products are connected to a centralized system indicating day-to-day farm performance while monitoring environmental parameters and other real-time factors critical to farming viewable on an online dashboard with alerts sent via text message.

Impact

1. Efficient management of resources via monitoring soil moisture, air temperature
2. Profit maximization and cost efficiency through accurate usage of fertilizers and nutrients as well as storage leakage prevention
3. Regulation compliance on milk storage and control of milk throughout supply chain

Transportation & Logistics

No Dominant Factor

Availability of low-cost tracking and communication modules with the development of LPWAN technologies have made the Transportation and Logistics sector a key contributor to the IoT market.

Cellular networks can now monitor the location of vehicles, large boats, and other mobile assets while lower-value mobile assets such as parcels, luggage, crates, and packages remain unconnected – providing tremendous opportunity for LPWAN technology with periodic transmission of location data and vehicle condition. Tracking of shipping containers is also possible through LoRa and LTE-M, NB-IoT with limitations in rural areas. Key IoT applications from a sub-sector perspective include automotive, public infrastructure, freight, warehousing and fleet management. Fleet management and cargo tracking were the earliest adopters of IoT and M2M connectivity. On the other hand, waste collection logistics has been an early adopter of LPWA technology.

Challenges in Transportation & Logistics.

Poor cyber security measures in critical infrastructure could increase the risk of confidential data being hacked and asset stolen in smart tracking devices

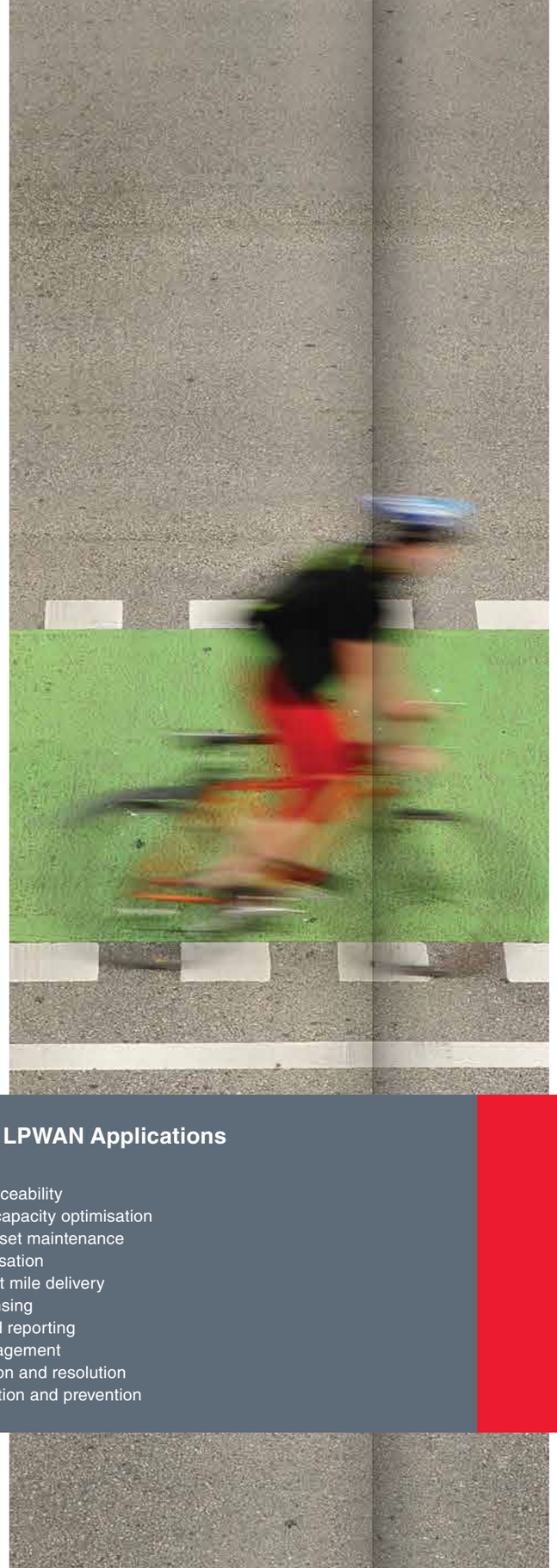
Complex logistics model and connectivity requirements requiring scalability and resilient solutions to cope with vast geographies and urban/underground areas

Benefits of LPWAN

Asset tracking enables optimization of resource capacity and management from shipping containers to grocery delivery

Large volume of logistics assets requires low-cost solutions. LPWAN can bring cost down in bulk US$1 per device

Vehicle diagnostics and performance are low data rate applications that well suited for LPWAN technologies



Emerging LPWAN Applications

- Real-time traceability
- Warehouse capacity optimisation
- Predictive asset maintenance
- Route optimisation
- Improved last mile delivery
- Capacity sensing
- Planning and reporting
- Energy management
- Fault detection and resolution
- Threat detection and prevention

Sigfox supporting bicycle location tracking in Singapore

Challenge

A bike-sharing company in Singapore is rolling out geolocation services for one million bikes on the SigFox Global LPWAN across Singapore and Taiwan.

Bike-sharing companies face problems of misuse, vandalism, illegal parking and lost bikes, casting a shadow over quality and demand for their services. As an early adopter of this technology, the Client is leading the way to tackle an industry-wide problem.

Currently, the operator's bikes are connected to its bike-sharing app using Bluetooth and 3G/4G network. Once a user completes a ride, the user's phone sends a signal on the bicycle's last location to the cloud so that the service provider can pinpoint its location on the map. The challenge is when a bike is moved, and the company is not able to track and trace it.

Solution

By using SigFox's LPWAN technology, the bikes can send their location data at periodic intervals directly to the Client's cloud without relying on Bluetooth or cellular network. SigFox's long-range, low-power technology allows the bike-sharing company to monitor its bicycles more efficiently and effectively.

SigFox's chip embedded in bikes has low bit rate and simple radio modulation enabling a 163.3 db budget link for long-range communications to track the bike user anywhere in Singapore and Taiwan. With information sent to the cloud, the Client is able to use analytics to track operation time and user behavior.

Impact

1. Efficient operation by matching the demand and supply of bicycles
2. Prevention of irresponsible behavior such as illegal parking and bike hogging
3. Reduction in theft and vandalism by real-time tracking
4. Improvement in overall user experience using behavioural analytics

Smart Cities

Cost **Capacity**

The vast number of IoT applications across various industries has not excluded the utilization of this technology as part of day-to-day urban living.

Both trial and ongoing projects worldwide are showing measurable impact ranging from faster car parking to better emergency healthcare. Among the reasons smart cities are built is to reduce resource consumption and enhance the performance and quality of urban services.

Challenges in Smart Cities

The need to address multiple issues concurrently within a limited budget; it can be problematic when policymakers are under pressure to achieve quick results

Different government agencies conducting smart city initiatives independently without collaborating with each other resulting in duplicated efforts

Smart city initiatives purely focused on driving efficiency without considering if they will benefit citizens

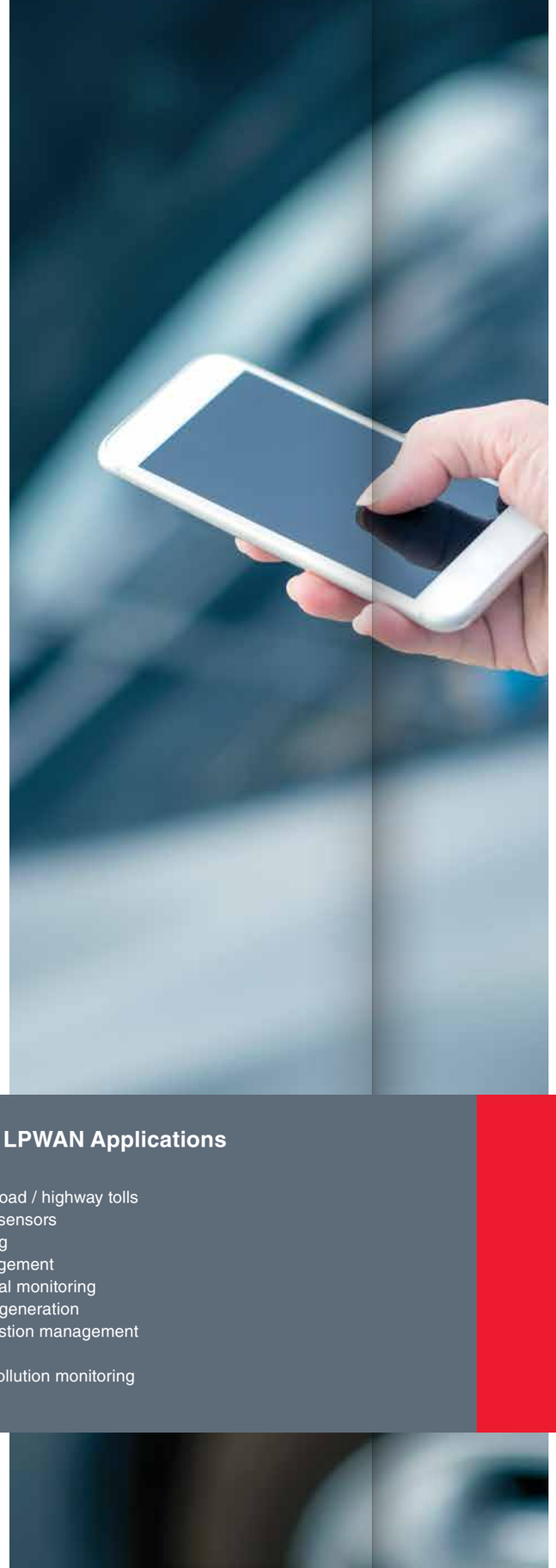
Benefits of LPWAN

LPWAN has the capability to connect between sensors to cloud in urban settings and indoor environments

Use of LPWAN to help drivers locate available car park lots using parking sensors to detect the arrival and departure of cars

With a mobile app, drivers can benchmark the proximity and parking fee before deciding

LPWAN can be used to track everything in a city including urban noise, pollution level, and population density



Emerging LPWAN Applications

- Payment of road / highway tolls
- Parking bay sensors
- Street lighting
- Waste management
- Environmental monitoring
- Solar power generation
- Traffic congestion management
- Urban noise
- Air / Water pollution monitoring

Southern Australian City leveraging LoRa private solution for Smart City connectivity trial project

Challenge

A city in Tasmania, Australia, has implemented the world's first city-wide coverage by IoT network. One main characteristic of the network is the suitability to facilitate long-range connectivity for indoor and urban environments. Consistent connectivity between IoT devices and cloud is compulsory to ensure smart city applications run smoothly with minimal human surveillance.

The main smart functional areas include environmental monitoring and smart vehicle tracking. As the city is located on a small island, water irrigation, water quality, and flow are of high concern as well. Manually checking or replacing batteries for sensors would not only be expensive, but dangerous as well. The solution for these IoT devices needs to have constant energy or long battery life to minimize risk.

Solution

Leveraging technology from its parent company, Semtech, this company is working on solving network coverage and energy challenges. The LoRaWAN technology enables deep coverage penetration through complex indoor settings and performs just as well outdoors, reducing risk. For example, the water quality and flow device require consistent connection to notify water utility companies of water quality or river overflow. The Geolocation feature that comes with this solution can identify locations needing urgent attention.

The LoRaWAN Network is expected to stimulate the growth of local businesses, given the significant improvements to manual processes, safety concerns, transport monitoring, inventory control and healthcare applications

Impact

1. Enhanced control of water quality and flow
2. Prevention of unexpected outflows into rivers
3. Guaranteed coverage of connectivity
4. Pioneering the application of LPWAN technology in Australia

Murata Manufacturing Leading the Way in LPWAN Technologies

Demand for robust and secure connectivity network continues to accelerate with the explosive growth of IoT devices. Businesses around the world keen to leverage the benefits of connectivity and greater insights are increasingly deploying IoT applications. The enterprise-wide application of IoT devices is also raising expectations in terms of cost efficiency, wide coverage connection, long energy sustainability and data transfer capacity. It is therefore critical for business leaders and key influencers to appoint an established technology partner with a proven track record to ease their concerns about securing back-end network connectivity.

Murata Manufacturing is a leading global electronic device manufacturer with a proven track record with wireless communication modules, such as smart-phones and other communication devices. As a key vendor of LPWAN technologies, Murata is committed to fostering innovation to consistently address the 4Cs (Coverage, Capacity, Cost, Consumption) of LPWAN application suitability for its wide-reaching end-users.

To respond to customers' diverse needs, Murata has formed strategic partnerships with market leaders to accelerate the development of products using LPWA technology. Murata recently partnered with Semtech and STMicroelectronics, for developing a Module solution which could leverage the strengths of all three partners for this technology.

While the main focus for Murata's development of this Module solution was to support the LoRaWAN market, the hardware would also support other protocols based on FSK technology and to switch between the two – if required. The Open MCU Module could also support use with Sigfox and the development of a dedicated Firmware release for the Murata Module, which is in the final stages of development – expected to be released in 2018.

Furthermore, Murata's high quality RF design, RF performance and RF components have earned itself several pre-certified radio regulatory approvals. Both software and hardware modules are available on Murata's LoRa Platform, producing the industry's smallest module size (also known as the compact LPWAN wireless module) with an option that covers the frequency band for North America, Europe, and ASEAN countries.

These capabilities clearly position Murata among the industry leaders, providing the most efficient LPWAN technology that nurtures an ever-expanding ecosystem of low-power IoT applications, enhancing the connectivity and convenience for users around the world.

We Accelerate Growth

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ABOUT MURATA

Murata Manufacturing Co., Ltd. is a worldwide leader in the design, manufacture and sale of ceramic-based passive electronic components & solutions, communication modules and power supply modules. Murata is committed to the development of advanced electronic materials and leading edge, multi-functional, high-density modules. The company has employees and manufacturing facilities throughout the world.

For more information, visit Murata's website at www.murata.com