Low and Slow: LPWAN May Be the Right Tool for the IoT Job

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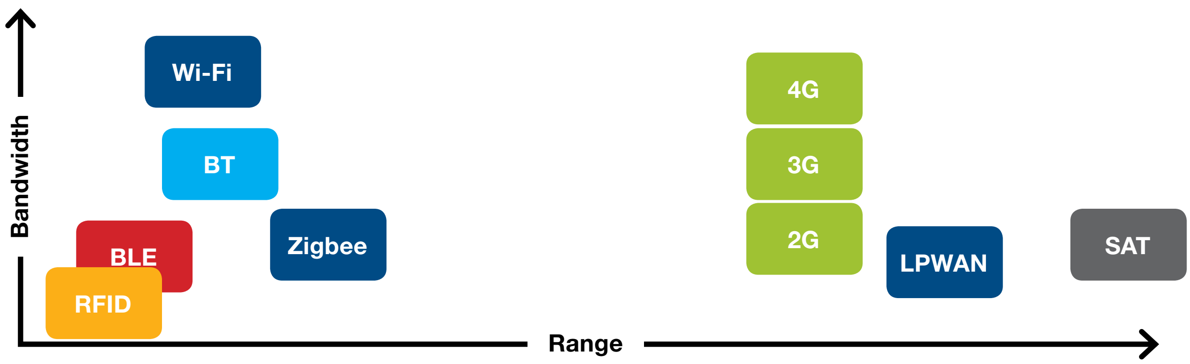
At the heart of Internet of Things (IoT) solutions is the communications between and from remote sensors that enables businesses to both measure and act remotely.

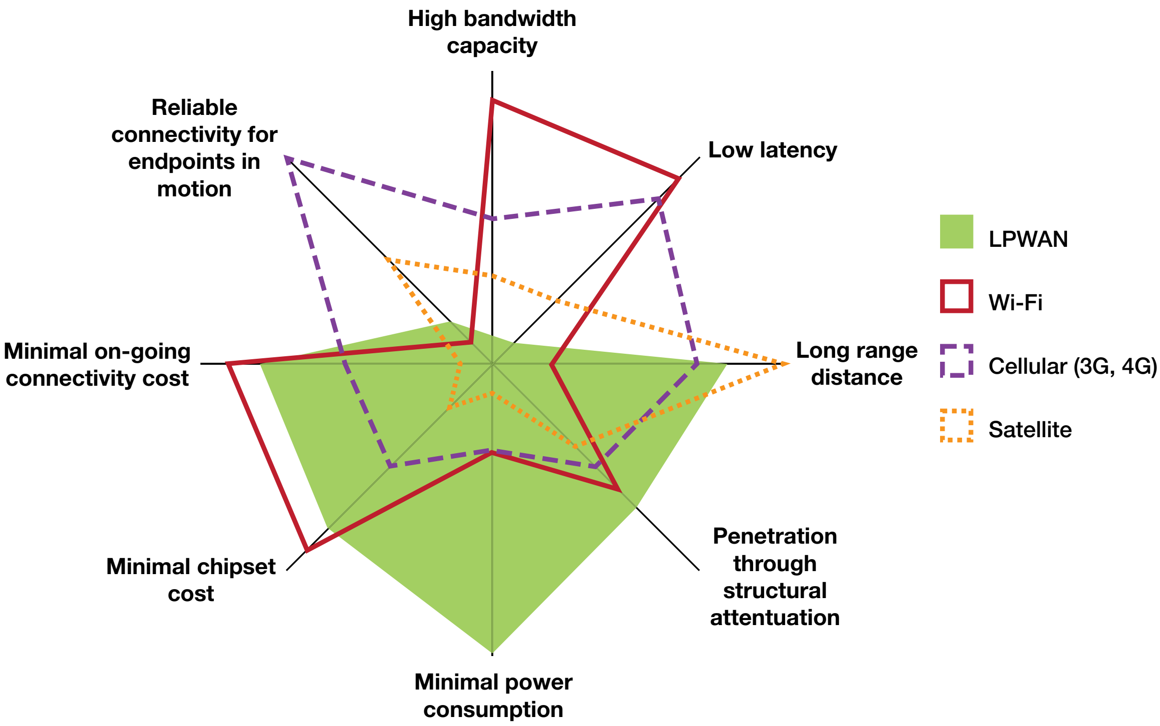
Focusing on connectivity might seem trivial in today's age of seemingly ubiquitous mobile coverage, but not all connections are equal. Just as project managers face the Iron Triangle (triangulating scope, schedule, and cost), so IoT decision makers need to satisfice in order to choose the optimal connectivity standards for their solution. Opting for higher bandwidth might compromise range or cost, as the figure below indicates.



As always, the real world becomes even more complicated. Organizations need to evaluate the following criteria to select the best fit for their specific needs:

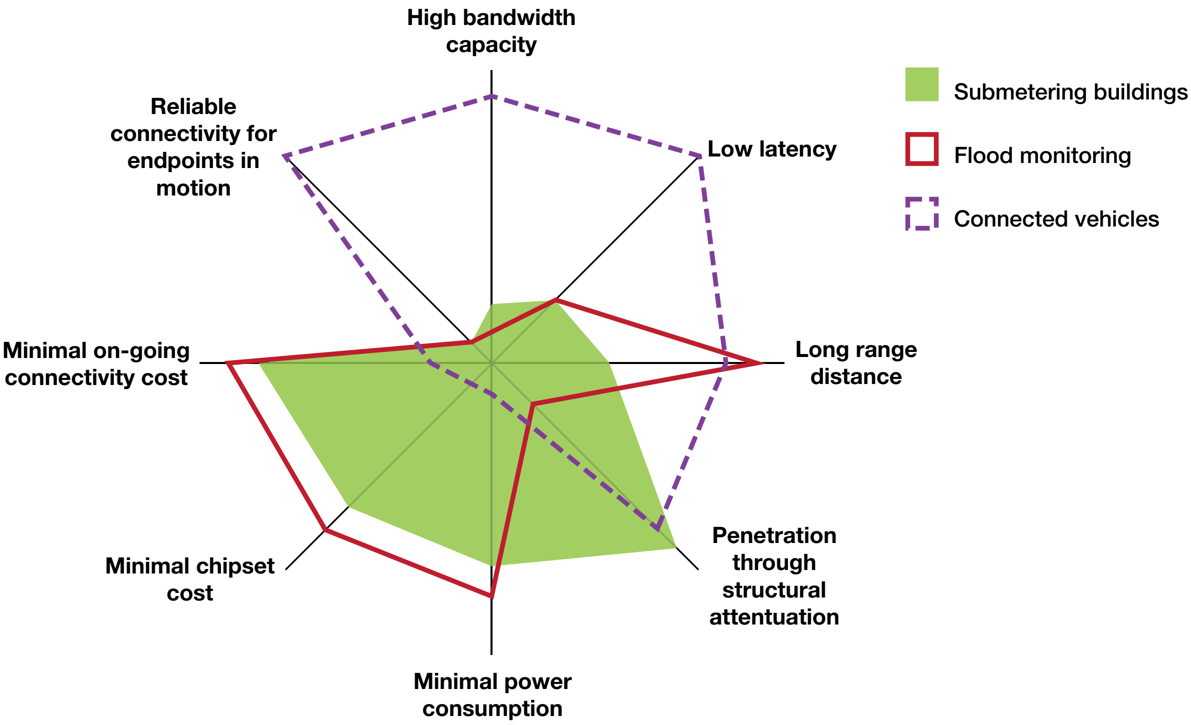
Attribute	Reasoning
Range	Connectivity ranges from close as metres to as far >50km
Latency	Lower latency means less delay in data transmission
Battery life	Power consumption requirements
Bandwidth capacity	Maximum data throughput
Bandwidth costs	Rate of data transmission from endpoints to collection points
Scalability	Ability to handle thousands to millions of endpoints
RF environment	Consider impact of interference across adjacent technologies
Robustness	Not all environments are equal: some are wetter or colder, some have vibrations, etc.
Cost	Implication of connectivity cost in unit economics
Mobility	Is the connected "thing" static or in motion?
Open versus proprietary	Risks of proprietary technologies versus standards-based technology
Future proofing	Which LPWAN technology is future proof and, if so, for how long?
5G readiness	What are the potential dynamics with a 5G network?

We've presented a simplified example of how decision makers should think through these trade-offs below.



Let's make this more real. How would the connectivity requirements of a sample IoT use case fare in this relative analysis? We will use the performance compromises from the previous figure to evaluate metering, flood monitoring, and connected vehicles.

Connected vehicles have complex connectivity requirements. They need real-time latency if they're engaging in vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communications, because they're potentially sending large data volumes (from LIDAR to infotainment), the range required to communicate to V2I may be quite long, and the vehicle is (obviously) in motion while sending communications. On the other hand, the engine control unit (ECU) and gateways have access to copious power, the cost of the RF modem is trivial in comparison to the MSRP of a new vehicle, and the ongoing communications costs have been effectively budgeted by buyers of services such as OnStar, SiriusXM, and other tools.



In contrast? Flood monitoring stations don't need "near-real-time" latency and they send minimal volumes of data (e.g., location and river level) from a fixed location. However, those stations potentially need to send that data a long way from a remote area with minimal power sources that may be expensive to return to (meaning battery life is important), with relatively cash-strapped organizations paying for the deployment and ongoing operations — and it has to be robust because the only time it's really needed is when it's most likely to fail (e.g., in the flood).

As we can see, selecting the "best fit" communications standard for these two use cases would lead the buyer down two very different paths. Connected vehicles need high capacity and real-time latency while environmental monitoring's requirements for long life and low maintenance make for a good fit for LPWAN solutions.

What Is LPWAN?

LPWAN connectivity is unapologetically low (power) and slow (throughput and latency). Low-power wide area networks is an umbrella term covering a class of low-power, long-range, low-to-medium rate wireless area networking technologies. The term literally splits into the two key distinctions: low power and wide area.

LOW POWER: There are many situations when there is no fixed power source when deploying an IoT device. As a result, the solution relies on battery power. But, as you know from your own smartphone, battery life declines in direct correlation to use. Battery life depends on factors including device on-time, transmit power, the sensor itself, outside temperature, how clear the wireless channel is, how much data is being sent, and so on. LPWAN solutions have an expected battery life of about 10 years through low-duty cycle and very little energy consumption in idle state. Low power also means low energy consumption, which means less need for battery change, replacement, and upgrades.

LTE-M is a 4G cellular technology standardized in the 3GPP Release 13 to suit devise with simpler, cheaper wireless modules and long battery life.

NB-IoT is also defined 3GPP Release 13 as a standards-based feature that reduces UE power consumption without compromising coverage.

LoRaWAN is a public specification for LPWAN connectivity developed by the LoRa Alliance. “LoRa” describes the underlying physical radio layer which can also be used for peer-to-peer communications, while “LoRaWAN” indicates the link layer protocol.

Sigfox is a proprietary narrow-band solution that either acts as its own network operator or licenses the exclusive regional operating rights.

WIDE AREA: LPWAN solutions boast of their comparative range and radio-frequency penetration in comparison to Zigbee, Bluetooth, and WiFi. LPWAN solutions have a typical reach of multiple kilometres, and with unobstructed line of sight and minimal signal congestion, users can expect over 15 kilometres. This facilitates IoT usage in areas such as urban, rural, underground, parking, and building interiors.

LPWAN technologies can be divided between licensed and unlicensed spectrum:

- **Licensed LPWAN solutions** include NB-IoT and LTE Cat M1. Both NB-IoT and LTE-M1 work in carrier licensed spectrum, enabling network operators to **guarantee quality of service (QoS) levels.** The former has very low bandwidth throughput (e.g., 250kbps) with high latency (>1 second), strong range (~15km) and correspondingly minimal power consumption. The latter has higher throughput (~1Mbps), lower latency (15ms), good range (10–15km), and quite low power consumption. Most North American carriers have deployed or are in the process of deploying LTE-M networks.
- **Unlicensed LPWAN solutions** include LoRa, Sigfox, Weightless (W, N, P), and Ingenu. They include mesh networking protocols like Zigbee and star topologies like LoRa and Sigfox. Unlicensed does not mean unregulated; there are minimum standards for transmission power and interference with other users. Assuring QoS is difficult as the bands are shared with other devices.

What Are The Benefits of LPWAN?

Long-range applications, with low bandwidth and latency requirements, that need to minimize power consumption and manual maintenance are ideal for LPWAN deployments. This brings down the upfront cost of components and equipment and the running costs post-deployment by matching capability with actual requirements of the application.

Some readers may be concerned about the low data capacity (e.g., 100kbps to 1mbps) of LPWAN. For the best-fit use cases, this should match the actual ongoing-data usage in IoT devices, particularly in low throughput transmissions over a periodic timeframe. It also works to inhibit over-ambitious schemes, enabling IoT projects to focus on just working.

Where And When To Consider LPWAN

Environmental monitoring
- Flooding
- Pollution (e.g., air, water, noise)
- Avalanche/seismic

Metering
- Commercial: water, gas, etc.
- Submetering in multi-unit residences

Monitoring
- Tank level monitoring
- Asset tracking

Process manufacturing
- Conveyors, pipelines, pumps, valves, vats
- Motors, drives, fabrication
- Assembly, packaging, vessels, tanks

Discrete manufacturing
- Conveyors, pipelines, pumps, valves, vats
- Motors, drives, fabrication
- Assembly, packaging, vessels, tanks
- Inventory tracking

Energy
- Batteries, UPS, generators, fuel cells
- Drills and industrial manufacturing equipment

Transportation and logistics
- Geo-locating item, parcel, case or pallet
- Fleet management
- Cold chain monitoring

Agriculture
- Animal tagging and tracking
- Soil moisture
- Greenhouse monitoring
- Machinery maintenance monitoring

Smart cities
- Smart street lighting
- Garbage monitoring
- Non-revenue water and leakage
- Parking metres

Smart buildings
- Submetering
- Building automation
- Fire alarm maintenance, temperature monitoring, HVAC
- Commercial
- Vending machine levels
- Cold chain, etc.
- Rental car geo-location

Healthcare
- Asset tracking
- Maintenance
- Patient tracking

Smart Cities

Local governments have widely distributed fixed and mobile assets, including street furniture, garbage, vehicle fleets, buildings, traffic management and information, transit operations, water, public safety, and emergency services. Citizen expectations increase every year, but the budgets can't rise in equivalent fashion. Accordingly, municipalities are investing in connected solutions.

LPWAN has a role in a number of these critical use cases:

- **Smart street lighting.** Municipalities around the world have embraced LED street lights for the energy efficiency, but smarter cities have connected their new lighting standards as well. LPWAN works to improve monitoring and preventative maintenance, and it's the right connectivity solution for a widely dispersed, latency-free system.
- **Non-revenue water monitoring.** Over a third of all treated water in Canada is lost to leaks and wastage. Reducing the incidence and damage caused by leaks saves cities money.
- **Environmental monitoring.** This includes noise, air pollution, water quality, water reservoir levels, etc.
- **Asset tracking.** Municipalities have more mobile assets than they realize, from tools to construction equipment, from street sweepers to skid steer loaders, from garbage trucks to lawn mowers. Establishing where those capital assets are (both during the week day and off-hours) and what their maintenance status is could save considerable amounts, while using minimal amounts of data across a very wide area — a natural fit for LPWAN.
- **Public works.** Bridges, tunnels, and roadways in Canada are in dire need of reinvestment. In other nations, these major infrastructure projects are being IP connected to enable remote monitoring of their status and safety (e.g., yaw, vibration, or load). By definition, these are geographically dispersed assets and the data requirements are not real time.
- **Civic asset solutions like smart parking apps, bike-sharing/escooter geolocation, and smart trash collection.** All of these share common characteristics — widely dispersed, difficult to sustain ongoing power, no latency requirements — making them suitable for LPWAN connectivity.

Smart Farming

It is unusual for agriculture to get attention from the technology sector, but farmers have focused on better data for decades. The rise of precision farming is driven by the opportunity for more efficient farming practices.

Soil metres can sense moisture, temperature, Ph balances, and even potential pests. Given the scale of Canadian farms today (778 acres or double Toronto's High Park, on average), transferring the data to the farmer (whether at the office or in the combine) in real time makes for better decisions made at the right time, potentially saving a crop or a herd.

LPWAN is a natural fit for farmers. Farms have specific requirements: their properties are large, making fixed wireline solutions hard to power and too costly; they're rural, so often have patchy cellular coverage; the running cost of satellite can be excessive. Using battery-powered LPWAN technologies resolves those technical hurdles.

Precision irrigation. Farmers increasingly use sensors to focus on as-needed irrigation, limiting waste water and energy expenditures.

Cold weather solutions for vineyards and other high-value soft-fruit crops. Frost can destroy a farmer's profit margins — but they have options when the temperature is near zero, from deploying covers to watering. This can be extremely localized, so having ground readings may help the timely deployment.

Tank flow monitoring. This technology doesn't apply to just dairy farmers. Given the distances involved, knowing the balance in the diesel and propane tanks can save unnecessary stress.

Animal tagging and monitoring. Keeping tabs on the temperature and activity levels of large animals like cattle or sheep serves multiple purposes. First, it enables advance warning of illnesses, and second, potentially allows for more accurate response to both oestrus and birthing.

Greenhouse. Monitoring energy usage, temperature, humidity, access controls, etc.

Farm Equipment. Tracking farm equipment for maintenance and repairs.

Industrial

The industrial Internet of Things (IoT) may not seem like an ideal fit for LPWAN, given the low latency demands for applications like motion control, close loop control, and even monitoring and supervision like vibration or temperature sensing. From IDC's point of view, though, this does not exclude LPWAN from manufacturing entirely — it just means that buyers need to focus on the RIGHT use cases. Manufacturers have substantial assets that would benefit from tracking and monitoring, they have large factories and warehouses, and they often operate across multiple locations with third parties such as logistics firms. Common LPWAN use cases might include:

- **Monitoring and maintenance:**
  - Tank level monitoring, asset tracking, production monitoring, inventory tracking
- **Machine predictive reporting, asset control, calibration and preventative maintenance:**
  - Conveyors, pipelines, pumps, valves, vats, motors, drives, fabrication, assembly, packaging, vessels and tanks
- **Pallet, case, or item location reporting; indoor location reporting**
- **Storage incompatibility detection within containers, warehouses, and factories**

Retail and Supermarkets

As the retail world is confronted with the ever-growing ecommerce threat, firms are embracing IoT in order to compete with better data and analytics. LPWAN has a role in this evolution for a number of specific tasks:

- **Energy efficiency.** Freezers and fridges consume large amounts of energy already, but when left open or if the temperature is errant, then the costs grow as spoilage comes into play. LPWAN enables firms to move from employee clipboards to digital monitoring without requiring the additional power sources that a wireline solution would need.
- **Cold chain monitoring.** Tracking spoilable foods (e.g., meat, seafood, fruits, eggs, dairy) through the farm-to-table process.
- **Inventory management.** Gaining visibility into shelf-level data reduces out-of-stocks and minimizes inventory carrying costs.
- **Sanitation.** Employee handwashing notifications (already in use in the healthcare sector).
- **Asset tracking.** Inexpensive way to track shopping carts for path analysis but also for recovery when abandoned/stolen.
- **Connected vending machines.** Remotely manage inventory levels, maintenance, and even possibly variable pricing.

Construction

The ability to use onsite real-time sensor networks complemented by drone-collected data that monitor and act on critical field parameters is having tremendous financial, operational, and safety benefits for the construction industry. If construction monitoring and post-construction data collection are done well, accidents and mishaps will be minimized, preventing the loss of millions of dollars in damages and delays. Early use cases across commercial and residential high-rise buildings are in progress while major infrastructure works, such as highways, tunnels and bridges, mining, gas, and other verticals, have already seen investments.

- **Ground water monitoring is a meaningful problem for civic works.** The City of Ottawa's notorious Rideau Street sinkhole ate the road in the midst of the city's Light Rail Transit construction, costing millions in over-runs. Adding wirelessly connected sensors would help monitor both ground water patterns and the local geology impacts.
- **Asset monitoring and tracking.** Construction sites have hundreds of thousands of dollars in capital tied up in highly mobile tools, equipment, and vehicles. Theft is a real issue in the sector, as is maintenance. LPWAN fits with both site control and preventative maintenance.
- **Site monitoring and tracking.** Integrating sitewide sensor data into a near real-time understanding, including 2D and 3D mapping.
- **Ensuring compliant curing and minimizing cracking in the case of real-time concrete monitoring.** ASTM C1074

standards for concrete curing estimates the in-place strength of concrete to allow activities like:

  - Removal of formwork and reshoring
  - Post-tensioning of tendons
  - Termination of cold weather protection
  - Opening of the roadways to traffic

- **Building monitoring and tracking.** Specialized sensors for construction site monitoring takes place at each stage of the construction, from excavation to foundation formation and piling to floor to the steel frames and floor-by-floor cement. The key field data that needs to be monitored and/or inspected is for:

  - Tilt
  - Strain
  - Soil water pressure
  - Noise
  - Smoke
  - Dust
  - Temperature for drying and curing of concrete (maturity) in real time

Early use cases across commercial and residential high-rise buildings are in progress while major infrastructure works, such as highways, tunnels and bridges, mining, gas, and other verticals, have already seen investments.

Logistics

Smart sensors enable logistics companies to track the location of containers as well as their condition by monitoring vibration, opening/closing of container doors, and temperature or humidity. This helps logistics companies better manage inventory levels, optimize land use, and improve efficiency.

- **Logistics traceability.** A large volume of logistics assets requires low-cost solutions. LPWAN can bring cost down toward $1 per device. As the cost per sensor drops, it enables a shift to tracking smaller, less expensive items (from container to pallet to case).
- **Capacity optimization.** Asset tracking enables optimization of resource capacity and management from shipping containers to distribution centres to grocery delivery.
- **Predictive maintenance.** Vehicle diagnostics, performance, fuel consumption, etc. are low-data-rate applications well suited for LPWAN technologies.
- **Security.** Security and access monitoring is well-suited for LPWAN in logistics.

Recommendations

Practice 1: Identify Network Capacity and Performance Requirements

Challenge: Selecting the most suitable wireless access technology depends on a realistic dimensioning of the network traffic and performance across at least the following metrics:

- **Total monthly uploaded and downloaded data**
- **Frequency of data uploads and downloads (i.e., number of uploads per day)**
- **Scheduling requirements such as sleep periods and wake-up cycles**
- **Total acceptable end-to-end latencies**
- **Coverage requirements**

Practice 2: Evaluate Business Case Including Capex and Opex

Challenge: The total cost of ownership (TCO) is important to understand and involves both capex and opex components. The key things to take into consideration include:

- **Provisioning costs.** In addition to initial set-up costs for SIM provisioning, there is also the issue of establishing and maintaining reliable power sources. This potential ongoing soft cost is often ignored, but is a major factor in favour of LPWAN's long-term field durability.
- **Ongoing connectivity costs.** This has been an issue for cellular and satellite-based IoT, and it comes down to a trade-off between coverage and scale. Accepting LPWAN's low-bandwidth, high-latency nature comes with operational cost savings. Connectivity costs are often measured relative to the value of the "thing" connected, which is why firms may opt to use more expensive standards — relative to the overall project cost, the ongoing bandwidth issues might not be that meaningful.
- **Bandwidth growth planning.** Organizations need to be realistic about accounting for additional bandwidth growth or the introduction of high-bandwidth endpoints in a mix of low-bandwidth and high-bandwidth devices.
- **Modem costs and future trends**. It's important to understand the cost of the RF modem in the context of the use case. In many industrial applications, the underlying equipment such as an industrial robot or tooling may be so expensive as to make the RF module insignificant in comparison. In other use cases, with high volumes of distributed sensors and modems, the lower cost of the LPWAN solutions over cellular may be a critical tipping point.
- **Ecosystem for modules, sensors, and base stations.** The lifespan of industrial equipment might be over a decade. During that time, the size and scale of the different connectivity standards ecosystem will influence the cost and availability of replacement and new components.
- **Ease of deployment and maintenance.** The difference in underlying business models between LPWAN standards has meaningful implications for buyers in terms of deployment and maintenance. Organizations with the skill and desire to create their own private network may want to consider the more open standards, while others may prefer the benefits of having a telecommunications provider manage the network.

IDC's research shows that Canadian businesses are embracing IoT solutions to improve efficiencies, optimize decision making, and find new revenue growth. Decision makers must choose the right technology solutions to find the right balance of bandwidth, range, and latency versus cost. LPWAN will have a role for many organizations as the perfect compromise of lifespan, connectivity capabilities, and cost.

For more information, visit telus.com/**lpwa**