Combining Bluetooth and Low Power Cellular for IoT:

Practical Design Considerations and Innovative Use Cases

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Introduction

This white paper is the third in a series of guides that provide product engineers with practical advice on how to take advantage of the capabilities of the low power cellular protocols LTE-M and NB-IoT. My colleague Paul Elvikis and I co-wrote the first white paper in this series, titled **Choosing the Right Route to Low-Power Cellular IoT: A User Guide to Simplifying LTE-M/NB-IoT Design Projects**. In addition to providing a primer on the technologies, that white paper provided a number of best practices and caveats for engineers navigating through their first few cellular IoT design projects. The second white paper in this series, titled **Cellular IoT Modem vs. Module: Navigating a Crucial Decision for IoT Design Projects**, does a deep dive into one of the most critical decisions an engineering team makes in the early stages of a cellular IoT project.

This third cellular IoT white paper examines another topic that many engineering teams should think about early on in their planning processes: how to expand the use cases of LTE-M and NB-IoT by combining those two cellular technologies with Bluetooth. This white paper explores that topic in depth and also presents three innovative use cases that become possible when combining cellular IoT and Bluetooth.

Before I go any further, I should give a preface. This white paper is written for product engineers who are tasked with designing wirelessly-enabled devices and network deployments, but who are not RF experts who live and breathe advanced wireless engineering. If you are not the kind of specialized RF engineer who is excited to read hundreds of pages of technical documentation about LTE-M, NB-IoT, and Bluetooth 5, this white paper is for you. Our goal is to help you successfully prepare for and execute your first cellular IoT design projects without needing to have the same level of expertise as a deeply specialized RF engineer – allowing you to complete the projects in your pipeline with practical information and advice that product engineers can immediately put to use.

Why Cellular IoT + Bluetooth?

The LTE-M and NB-IoT protocols were designed to give IoT platforms a way to take advantage of nearly-ubiquitous cellular infrastructure in a way that is practical for the battery life of an IoT device while also having costs that are practical for IoT deployments. In the previously mentioned white paper, Kaye and Elvikis discuss why the kind of "always on" cellular protocol used by smartphones is ideal for the way those devices are used but would be ill-suited to all but a very few IoT use cases, both technically and in terms of costs. LTE-M and NB-IoT were designed specifically for IoT, with architecture that continues to take advantage of nearly-ubiquitous cellular networks but with battery life up to 10 years as well as hard costs and operating costs that are well-suited to IoT.

The choice between LTE-M and NB-IoT gives engineers a way to select a technology that aligns with the needs of each device:

- LTE-M gives engineers the ability to design with a wider bandwidth, offers a higher transfer data rate than NB-IoT, and achieves battery life up to 10 years. Engineers typically use LTE-M when higher-throughput is a top priority for a given project's performance and when coverage penetration is a lower priority.[1]

- NB-IoT gives engineers better coverage penetration and a longer projected battery life than LTE-M. Engineers typically use NB-IoT when a device's use case and deployment environment make coverage penetration a higher priority than maximizing throughput.

I should note here that engineering teams do not face an either/or decision when it comes to LTE-M and NB-IoT. Unlike some other wireless protocols that make you choose among more than one "flavor" early on in the design process, cellular IoT allows you to embed both technologies in a device so that your team has the option of using one or the other as best suits the implementation and how that device will be used later on. The provisioner is able to later optimize the device's and IoT network's performance by leveraging whichever of these makes the most sense on a device-by-device basis.

These capabilities of LTE-M and NB-IoT are compelling on their own.

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Ten years of battery life is a game changer for IoT. And so is the ability to leverage cell towers in a cost-effective way that makes IoT possible anywhere a phone has at least a single bar on the screen. But LTE-M and NB-IoT are even more compelling when you add the short-range, smartphone-ready, mesh-capable capabilities of Bluetooth.

For this discussion, I refer to Bluetooth 5, which has a number of enhancements that optimize it for IoT deployments. My colleague Mahendra Tailor, formerly the Technology Leader at Laird Connectivity, wrote a number of practical guides for designing with Bluetooth. One such guide is **this recent one about Bluetooth range** which has a detailed discussion of new features in Bluetooth 5. Bluetooth complements LTE-M and NB-IoT's features by making it possible for engineers to add additional short-range capabilities to devices, take advantage of Bluetooth mesh networking, and achieve signal performance in complex RF environments that are challenging for cellular signals. It also has capabilities that simplify the process of incorporating smartphone-enabled capabilities, which play a valuable role in a number of use cases.

Three Cellular IoT + Bluetooth Use Cases

Together, cellular IoT and Bluetooth can support use cases that would not be ideal – or even possible – separately or with other combinations of technologies. This makes it possible for organizations to explore use cases for IoT that were not previously possible.

The following are three innovative projects that our team has supported throughout their development. These use cases may provide inspiration and blueprints for projects your team will work on in the near future.

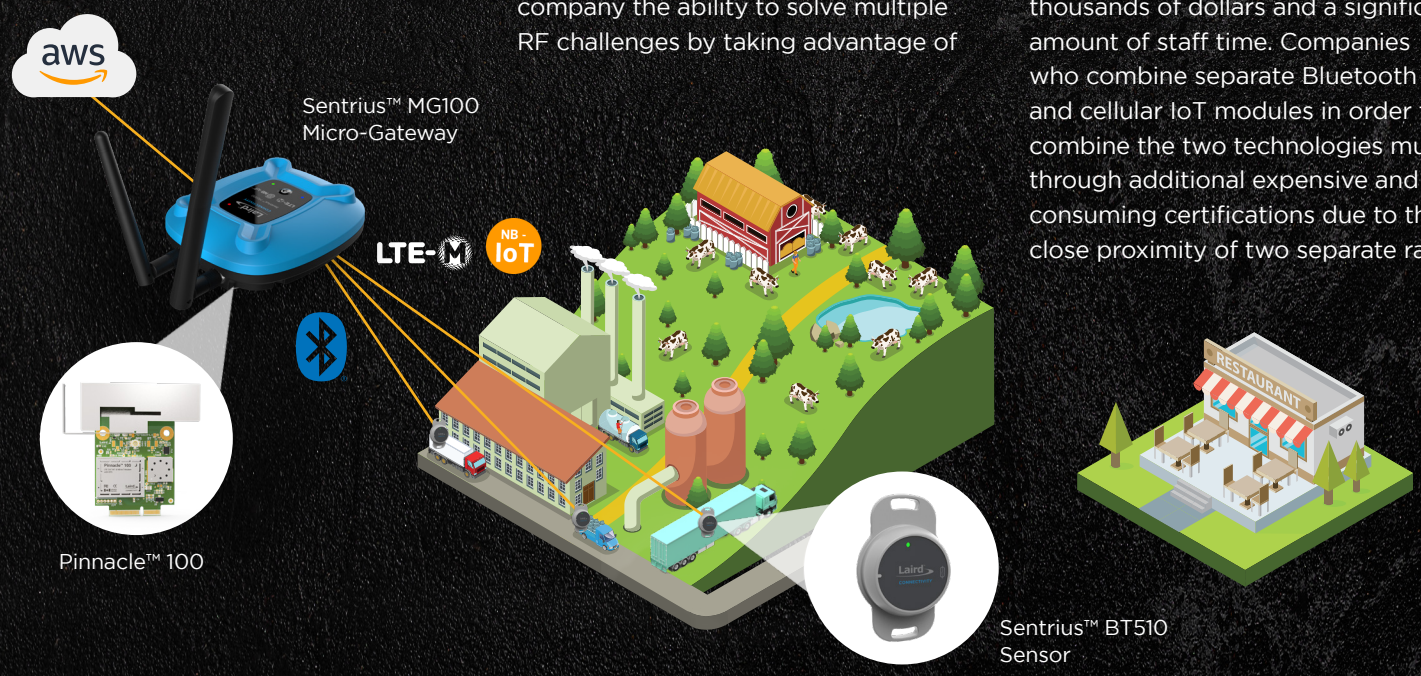
[1]There are a number of online tools for calculating and comparing data throughput rates of LTE-M vs. NB-IoT. A number of factors influence throughput, so no single example is definitive. **As an example, this analysis by industry group GSMA** based on field tests with both technologies showed that LTE-M had downlink speeds roughly 4-5 times greater than NB-IoT and uplink speeds roughly double.

Use Case 1: Cold Chain Monitoring

Laird Connectivity has worked with customers in the cold chain market for quite some time. These partnerships have led to collaborations on how to combine the capabilities of cellular IoT and Bluetooth to address the complex challenge of food safety.

For example, a food safety compliance company that works with food transportation clients, food warehousing companies, and food service organizations want to take advantage of the ready availability of cellular networks to ensure that foods are kept at the proper temperature at each stage of the supply chain process, from truck to warehouse to truck and finally to food service location. This use case utilizes Bluetooth sensors communicating with one another in small spaces with complex RF environments, such as refrigerated trucks and temperature-controlled warehouses. Using the robust signal qualities of Bluetooth, these sensors measure temperature and humidity of foods in transit through each stage of the supply chain across a variety of environments. They then use cellular IoT gateways to send that data to the cloud via cellular connectivity, which is readily available throughout the entire supply chain. Using this combination of Bluetooth devices with a cellular IoT gateway gives this food safety company the ability to solve multiple RF challenges by taking advantage of the combined strengths of Bluetooth, LTE-M, and NB-IoT – including Bluetooth's ability to enhance wireless penetration indoors, even in difficult RF environments like those involving food service and food storage.

This use case utilized Laird Connectivity's Pinnacle™ 100 cellular + BLE modem. This modem comes with a pre-integrated antenna and cloud connectivity functionality that dramatically accelerates design, deployment, cloud integration, and smartphone interface development. One important thing to note about the advantage of using Pinnacle is that it is pre-certified for cellular IoT and Bluetooth as co-located wireless technologies, which saves a company thousands of dollars and a significant amount of staff time. Companies who combine separate Bluetooth and cellular IoT modules in order to combine the two technologies must go through additional expensive and time-consuming certifications due to the close proximity of two separate radios.



Use Case 2: Industrial Equipment Monitoring

Wireless sensors are not new to industrial applications, but this project uses the combination of cellular IoT and Bluetooth to enable an innovative predictive maintenance initiative that a Laird Connectivity customer recently implemented.

Industrial environments are notoriously difficult for wireless technologies and a cellular-only approach is not practical for the kind of factory-wide monitoring of industrial pumps that feed data into an AI-driven predictive maintenance program designed to increase uptime and minimize expenditures on maintenance by identifying issues early. Utilizing low-power cellular has significant advantages for this deployment because of the availability of cell infrastructure and the robust data reporting that the company wanted in order to perform intensive data analysis. But a cellular-only approach was not practical because of the RF challenges related to the location of sensors, surrounding materials in walls and machinery and other aspects of the factory's design. Bluetooth, because it performs very well in that environment, became the basis for device communications at the equipment level.

Another advantage of combining Bluetooth with cellular IoT in this use case is the ability to minimize the need for multiple data plans. By having Bluetooth sensors report to a cellular gateway in an indoor setting, you avoid a situation where each cellular node requires a data plan. Using Bluetooth sensors eliminates those operational costs. This type of Bluetooth + cellular IoT also allows more edge computing to truly happen at the edge. For example, instead of having every packet of data to be sent back to the cloud, Bluetooth sensors deliver data to the gateway where it is analyzed at the edge. Only data requiring additional analysis and action is sent to the cloud by the gateway, thereby reducing the burden on cloud computing as IoT devices continue to rapidly proliferate.

One additional benefit of using Bluetooth in this use case is the flexibility it gives the company to perform firmware updates to sensors as frequently as necessary, via Bluetooth Firmware Over the Air (FOTA). Together, Bluetooth and the cellular IoT protocols allowed us to achieve a successful implementation in an environment and with cloud connectivity objectives with which other technologies would potentially struggle.

Use Case 3: Electric Charging

The first two use cases are in the B2B realm. But this third one is fascinating because it leverages the combined capabilities of cellular IoT and Bluetooth to support a consumer application where smartphone connectivity is critical.

The manufacturer of electric car charging stations wanted sensors on each charging station to deliver real-time information to drivers' smartphones, regardless of whether the drivers stay at their vehicles or leave to shop, work, etc. These real-time updates would include charging status and alerts as well as other diagnostic information about their electric vehicle. These same sensors would also provide hourly updates to the manufacturer about the performance of the charging station and any necessary maintenance or other alerts.

Bluetooth sensors gave the manufacturer the ability to deliver updates to customers either locally via a Bluetooth signal (if the consumer is within range) or via the cell network (if the consumer is out of Bluetooth range). Laird Connectivity's Pinnacle™ 100 gave the company the flexibility to support customers in either of those ways via a smartphone interface

Because they provide the infrastructure for delivering data to the cloud, cellular networks were vital for this project. Because of this, the cellular IoT technologies were a centerpiece of this implementation. And Bluetooth sensors gave the manufacturer the ability to deliver updates to customers either locally via a Bluetooth signal (if the consumer is within range) or via the cell network (if the consumer is out of Bluetooth range). Laird Connectivity's Pinnacle™ 100 gave the company the flexibility to support customers in either of those ways via a smartphone interface, as well as gather critical operational data that ensured uptime of the charging stations.

There are many other innovative case studies that are possible when cellular IoT and BLE are combined, including remote equipment sensing at sites like wind farms, remote health monitoring of medical devices for in-home patient care, and a variety of agricultural applications. As Laird Connectivity continues to work with clients around the world on cellular IoT projects, we plan to share more of these on our **Cellular IoT page** as well as on the **Resources page** of our website. And as always, our sales engineering team has extensive experience working with companies to collaborate on innovative design projects that utilize the latest wireless technologies including cellular IoT + Bluetooth devices.

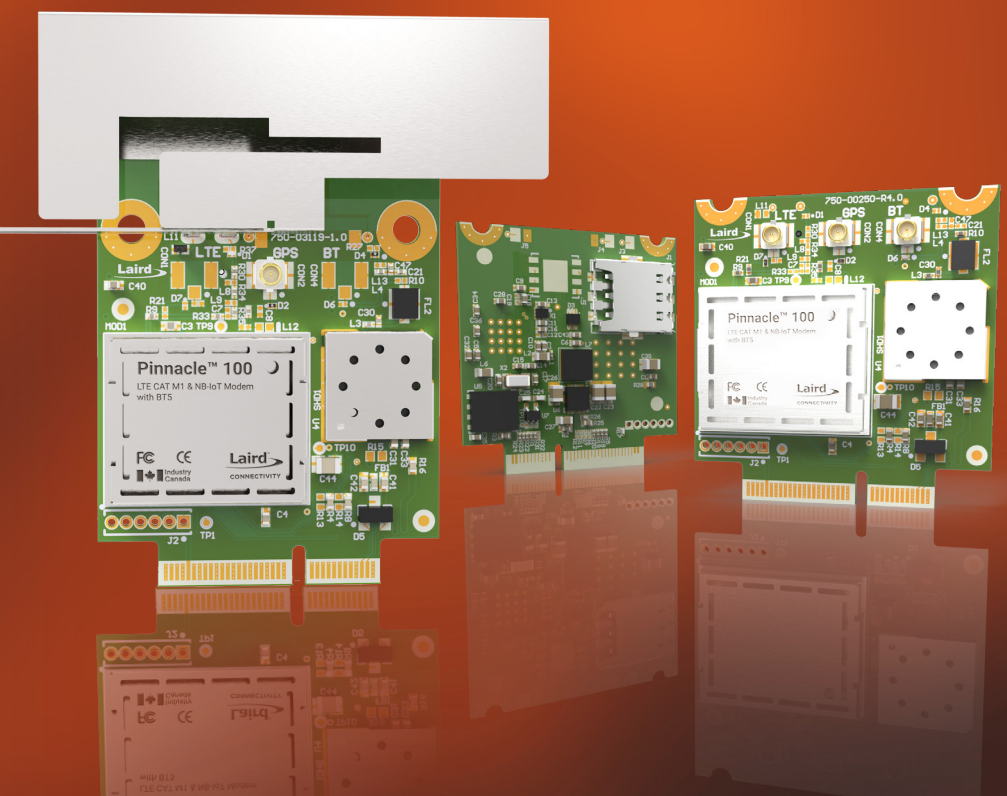
About Laird Connectivity's Cellular IoT Solutions:

Laird Connectivity's **Pinnacle™ 100 Series** seamlessly combines low-power cellular LTE and Bluetooth 5 technology into one fully-integrated solution. This unique combination enables new use cases using low-cost, long-range Bluetooth sensors all connected to the next generation LTE network in a much simpler and lower cost solution architecture.

The Pinnacle 100 incorporates a powerful Cortex M4F controller running a hostless Zephyr RTOS-based software implementation, complete Bluetooth 5 functionality, and LTE-M/NB-IoT capabilities – all fully-certified from a radio regulatory, cellular, and network carrier perspective. This intelligent modem additionally provides complete antenna flexibility, including pre-integrated embedded and external options such as Laird's Revie Flex LTE and NB-IoT antenna.

This unique combination of capabilities simplifies common use cases like using a smartphone to configure and create an LTE connection in a product. It also enables new use cases combining multiple long-range meshed Bluetooth sensors connected to the Cloud over the evolving global low-power LTE network. Bridging Bluetooth sensors to a single intelligent LTE device allows customers to optimize sensor coverage and manage cellular data with a simple, low-cost architecture, not to mention decrease time-to-market and deliver real-time insights.

For more information, visit our **Cellular Solutions** page.



About the Author:

Jonathan Kaye is the Senior Director of Product Management at Laird Connectivity. In this role at the company, Kaye is a lead developer of Laird Connectivity's embedded wireless connectivity solutions. He has more than 20 years of experience in the embedded wireless and product design field, including positions at EZURiO and Lever Technology before joining Laird Connectivity a decade ago.

About Laird Connectivity:

Laird Connectivity simplifies the enablement of wireless technologies with market-leading wireless modules and antennas, integrated sensor and gateway platforms, and customer-specific wireless solutions. Our best-in-class support and comprehensive engineering services help reduce risk and improve time-to-market. When you need unmatched wireless performance to connect electronics with security and confidence, Laird Connectivity delivers — no matter what.

Learn more at lairdconnect.com

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