

WHITEPAPER

The Internet of Blueberries, Oxygen Tanks, Engine Parts, and the Next 100 Billion 'Things'

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Contents

Overview.....	2
The Need	3
The Challenge: Ensuring Visibility for the Next 100 Billion Things	4
Bluetooth for Visibility?	5
Luna: Simple, Seamless, Secure	7
Easy Provisioning	9
Enhanced Security for Location Tracking	9
Secure bidirectional communications.....	10
Use Case: Condition Monitoring of Perishable Goods	11
Use Case: Home Healthcare and Patient Monitoring	12
Use Case: Real-Time Visibility for Shippers, Logistic Providers, and End Customers	13
Promising Future Directions	14
Unlock Real-Time Next-Level Visibility	14

Overview

At first glance, blueberries, oxygen tanks, and engine parts have little in common. However, they are each assets that someone cares about and needs to monitor in order to ensure safety, usability, and profits.

Remember when COVID vaccines were first shipped? In a time of relatively new and widespread real-time awareness, the world watched as the temperature-sensitive medicine was transported under strict monitoring and tracking conditions (Figure 1).



FIGURE 1. COVID vaccines required careful monitoring to ensure that their temperatures didn't fluctuate and that they made it to their intended destinations.

The public could immediately see the value of visibility, and this begged the question, “Why can't we monitor other perishables and valuable assets?” We still lose [\\$162B in food each year](#) in the US alone, mostly due to spoilage. American hospitals lose \$8B in equipment annually. Manufacturing and supply chains struggle to endure the chaos in obtaining materials. What's needed is efficient, accurate, real-time, low-cost asset monitoring.

In this whitepaper we will examine a groundbreaking communications protocol that addresses the limitations of visibility provided by traditional Internet-of-Things (IoT) solutions. This new, award-winning protocol has real-world practicality as shown by several use cases.

The Luna protocol, designed and implemented by Luna XIO, Inc., now steps up to provide unprecedented visibility for perishable goods like blueberries, vital healthcare equipment like oxygen tanks, and integral manufacturing parts like engine components — assets previously thought to be too impractical or too expensive to track or monitor.

The Need

Numerous individuals and industries rely on real-time tracking to safeguard lives, assets, and financial returns. Their current solutions, however, are limited and can be expensive. People in the healthcare, supply chain, retail and manufacturing require next-level visibility.

Condition Monitoring

Transportation of perishables such as food or medications requires next-level visibility that goes beyond just monitoring the truck's location and logging temperature in the trailer for later retrieval. These situations demand knowing the condition of the items in transport, as well as location, in real time on a per-product or per-palette basis.

Currently, if there's a temperature issue with a shipment of blueberries, the entire load is rejected. That's bad for all stakeholders. The recipient can't sell the blueberries. The producer doesn't get paid. The transportation company and its insurance provider are left to assume the financial liabilities.

Next-level visibility would alert all the parties to temperature problems as they occur so that immediate action can be taken and to localize and address issues so that entire shipments aren't lost.

Asset Tracking

Next-level visibility in asset tracking means being able to cost effectively monitor not just large high-dollar value items like delivery trucks and dialysis machines, but all essential items. With this expanded scope, organizations can optimize their operations and resource allocation. For instance, they can ensure that essential supplies like oxygen tanks (Figure 2) are readily available when needed, enhancing patient care in healthcare settings. In manufacturing, tracking engine parts on their way to and within a factory allows for precise inventory management, reducing downtime and production disruptions. In essence, next-level visibility transforms asset tracking into a strategic tool that optimizes processes, improves efficiency, and ultimately delivers better outcomes across a wide range of industries and applications.

Next-level condition monitoring requires visibility that is:

- Real-time
- Granular (i.e., per-palette)
- Affordable



FIGURE 2. Lower-cost items, like oxygen tanks, also benefit from tracking – especially when deployed in multiple sites like patient's homes.

Healthcare

Next-level patient monitoring:

- Beyond hospital rooms
- Hassle free, no touch system that simply works

In patient monitoring and home healthcare, next-level visibility goes beyond traditional boundaries. It allows healthcare providers to continuously monitor vital signs in real-time, not just within hospital walls but in various settings, such as the emergency room, within the patient's residence, or even as the providers are on their way to visit patients. This comprehensive approach empowers healthcare professionals to offer personalized and proactive care, enhancing patient outcomes.

The Challenge: Visibility for the Next 100 Billion 'Things'

There are currently visibility solutions in the market for valuable, large, and power-connected items. For example, for a few hundred dollars, companies can purchase a telematics device for trucks that communicates location and sensor data via cellular and/or Wi-Fi and connectivity (Figure 3).

Solutions like the above can work for trucks, but when you require next-level visibility into pallets of blueberries, for example, the costs are too high, the form factors too large, and the need to connect to a power source or manage batteries can be cumbersome.

There are low-power connectivity options which have proven effective in communicating with gas meters and tracking wild-life, that could work in pre-determined locations. However, these solutions require large upfront investments for wireless network install and maintenance. Next-level visibility, however, needs to be achieved across the supply-chain from the manufacturer site, through to the transport and the receiving end. It would be a tall order to get such coverage across the different locales.

Upon closer examination, a pressing challenge must be addressed: while existing technologies work to connect the first 10 billion devices (smartphones, tablets, wearables), they face significant shortcomings in accommodating the next 100 billion.

To overcome this limitation, a comprehensive solution is needed, encompassing three vital specifications:

Compact, energy-efficient monitoring devices: Monitoring devices must be small or smaller than a pill-box, and energy-efficient and durable enough to last up to a decade.

Global connectivity: We need visibility across the entire supply chain, indoors, outdoors, and anywhere in the world. The network coverage cannot be limited to predefined regions or areas.

No new infrastructure: The solution should not require the costly setup of new networking infrastructure: no additional wiring, physical gateways, signal amplifiers, excitors and the like.

The solution must also provide security, privacy, and reliability — all of which are critical in any commercial application. While some people might be tempted to believe that they can select only two out of three requirements. Luna provides an innovative solution that seamlessly incorporates all three while also ensuring security, privacy and reliability.



FIGURE 3. Visibility and tracking might seem simple at first glance. Image Source: samsara.com/products/telematics/

Bluetooth for Visibility?

By all accounts, Bluetooth has been an incredible success since it launched more than two decades ago:

Getting smaller and smarter: The technology keeps shrinking and adds more features every year.

Budget friendly: The cost of Bluetooth keeps coming down. The bill of materials for a basic Bluetooth Low Energy (BLE) device has gone from [\\$10 to \\$2 in recent years](#).

Market penetration: Bluetooth is everywhere — [4.6 billion Bluetooth-enabled devices shipped in 2022](#)

Bluetooth covers the essentials when it comes to prevalence (Figure 4), and meets the next-level visibility requirements of being low-cost, low-power, and small-sized. Moreover, substantial resources continue to be invested in enhancing the technology, maintaining rigorous standards, and streamlining manufacturing processes, thus ensuring its promising future.

All that said, Bluetooth is not without its challenges. Originally designed for short-range communication, it excels when you want to pair your headphones to your phone, but it falls short in demanding industrial environments. In manufacturing and health care settings, where time is a commodity and automation is a necessity. Imagine asking a doctor to stop and pair a device when they should be focused on patient care, or logistics personnel having to grapple with dreaded Bluetooth pairing screen — it's simply not realistic (Figure 5). Achieving next-level visibility may involve incorporating Bluetooth hardware, but it must also be complemented by innovative protocols explicitly designed for seamless cloud connectivity.

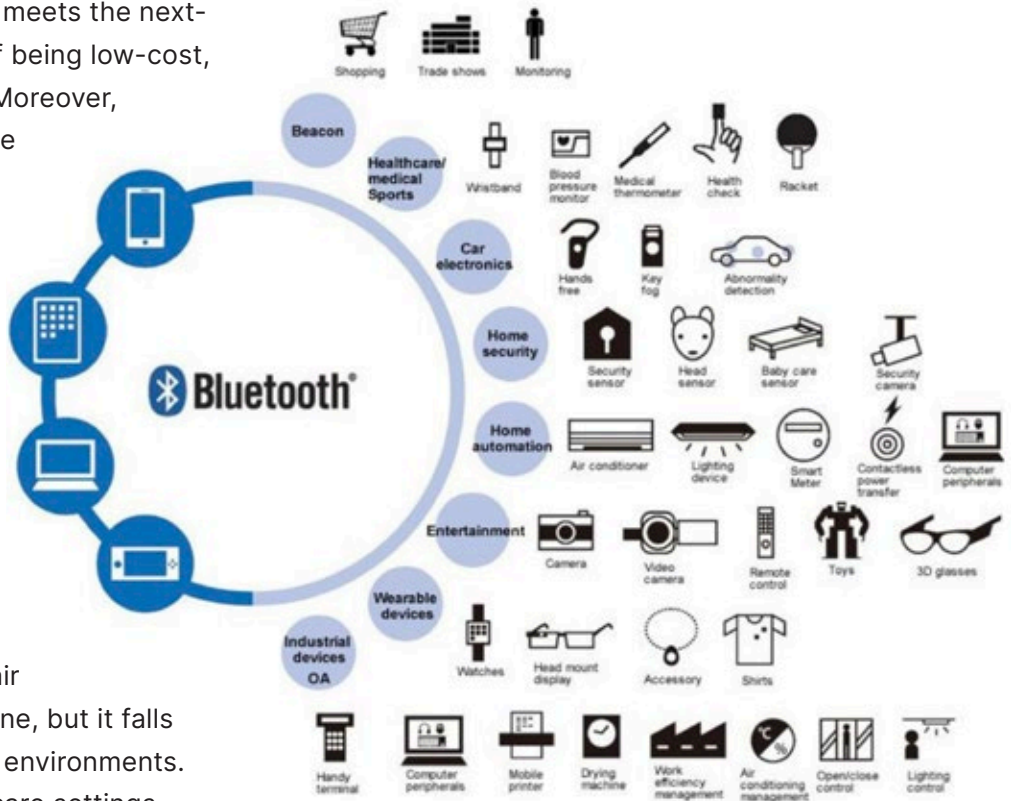


FIGURE 4. Bluetooth is everywhere and enables successful communication, but its communication reach is limited. Image Source: aumraj.com/new-iot-platform-for-wireless-device-bluetooth-low-energy/

FIGURE 5. In life-saving situations, health-care workers should not need to take the time to pair devices.



What's needed is a solution that operates seamlessly without requiring human intervention, prioritizes security, and seamlessly integrates with existing infrastructure.

THE INTERNET MODEL

Fortunately, we can learn from well-established networking models, like the internet, where security and flexibility is provided through layers. For example, when you are at home and want to access your bank account on your computer, the process is structured:

- 1. TRUST AND ENCRYPTION:** Your computer and the bank's servers establish a secure connection directly between themselves, ensuring that your information remains confidential.
- 2. LAYERED COMMUNICATION:** Underneath, there are layers of communication that manage the flow of data. Each layer has its specific job.

- 3. PHYSICAL DATA EXCHANGE:** At an even lower level, the actual devices (computers, routers, servers) exchange information. They do their job without needing to know all the technical details about each other.

The internet's success lies in its simplicity and efficiency. For IoT to reach the same level of impact as the internet of today, we need a secure and structured communication system, especially for Bluetooth devices, which are so widely used (Figure 6).

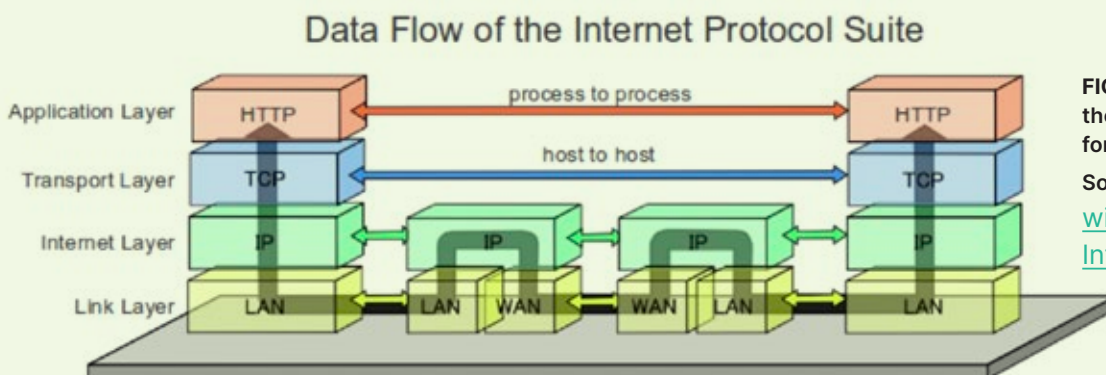


FIGURE 6. Structured and secure, the internet is a good model for next-level visibility. Image Source: en.wikiversity.org/wiki/File:Data_Flow_of_the_Internet_Protocol_Suite.PNG

Luna: Simple, Seamless, Secure

To make next-level vision a reality, Luna has developed a protocol that introduces end-to-end encryption and layers to Bluetooth communication. In essence, Luna delivers the advantages of Bluetooth and the flexibility of internet-like connectivity.

Consider the simplicity of Luna’s solution. Each item to be tracked — IV pump, blueberry crate, or pipe fitting — is equipped with a sensor that receives a factory key that enables end-to-end encrypted communications through the Luna protocol. As the item travels, its associated data is sent automatically, without any user intervention, through neutral gateways and the Luna routing service to the cloud. The data then reaches an end-user application for analysis and monitoring.

With Luna, Bluetooth trackers and sensors establish a trust relationship with the customer cloud (Figure 7) and all data between the two endpoints is encrypted. This robust security measure ensures that data remains confidential, rendering it indecipherable to anyone but the intended recipients as it travels from the Bluetooth device to the cloud.

Luna delivers the advantages of Bluetooth and the flexibility of internet-like connectivity.

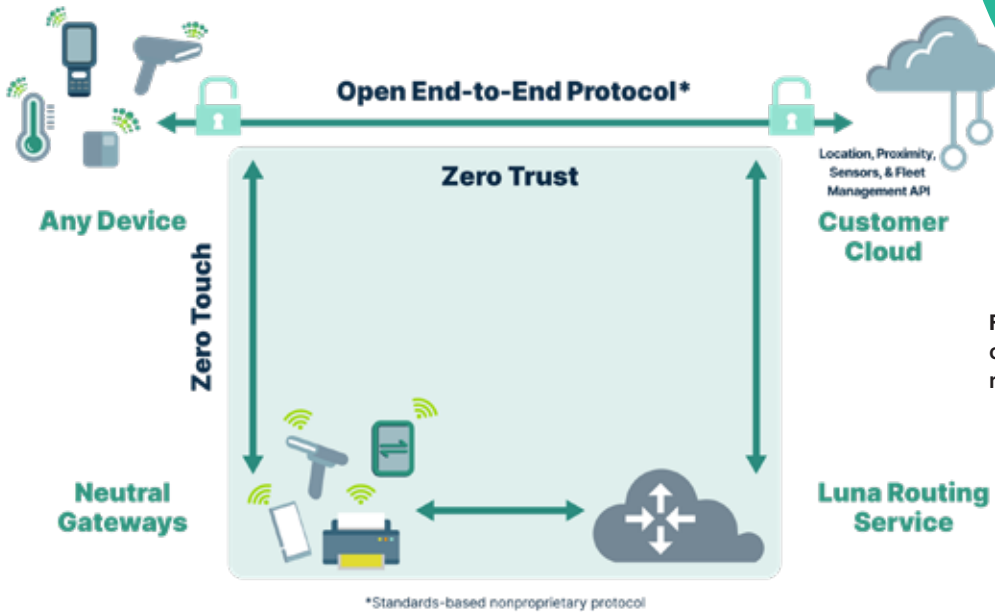


FIGURE 7. Luna provides the convenience of Bluetooth and the reliability of a structured network.

Supporting secure communication between devices and the cloud are a network of versatile neutral gateways (Figure 7). These gateways are equipped with both Bluetooth and Wi-Fi or cellular connectivity, and they come in various forms, from barcode scanners to mobile computers, mobile phones, and a wide range of work devices commonly employed in industrial, healthcare, manufacturing, and retail settings. With tens of billions of such devices in operation, there is coverage exactly where it’s needed — in warehouses, on trucks, within stores, at hospitals, and across manufacturing plants.

The Luna software app plays a pivotal role in this setup by seamlessly transforming iOS and Android barcode scanners, along with mobile work devices and phones, into these essential neutral gateways. Luna has forged strong partnerships with industry leaders like Zebra, Honeywell, and Data Logic, who provide a significant portion of the world’s scanners and workplace devices. So these neutral gateways are not only widely used, but practically ubiquitous across manufacturing facilities, healthcare settings, and retail environments.

In addition to gateway functionality, the Luna solution also manages data routing to ensure that information reaches its intended destination or agents (Figure 8). The encryption process occurs between the tracker and an agent. Each application provider, such as a company offering health monitoring, has its dedicated agent, and none of the data passing through the system is accessible to anyone but the service provider for the agent.

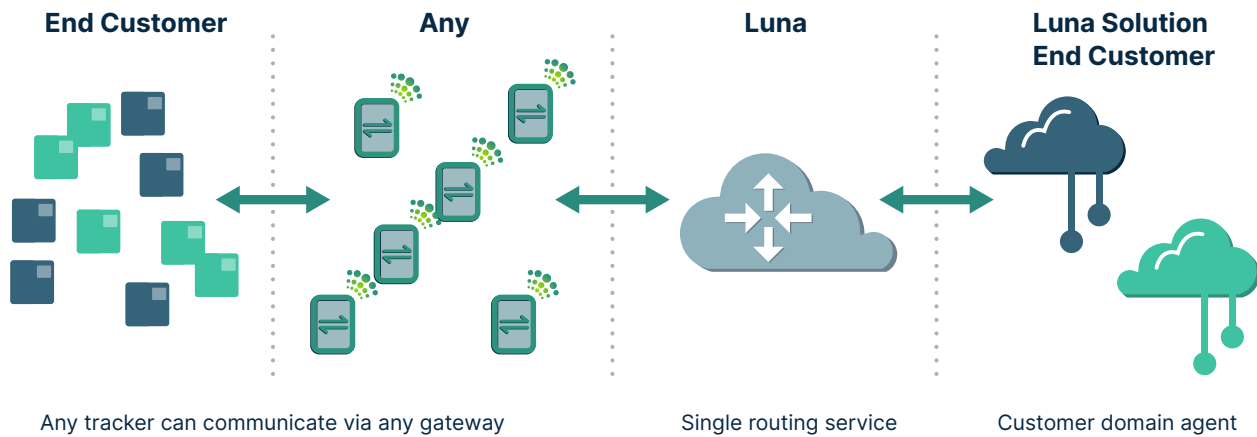


FIGURE 8. The Luna solution manages the route so that the data travels from the tracker (on the left) to the agent (on the right) securely and privately.

A pivotal feature of these gateways is that they are neutral and agnostic. This quality proves crucial, especially when dealing with goods in transit. These gateways are designed to seamlessly operate with zero-touch and zero-trust requirements, meaning no manual intervention or configuration is necessary to establish the network. They efficiently facilitate data transmission without accessing or storing any of the information they handle.

The fundamental difference between Luna and existing Bluetooth protocols has to do with introducing a level of trust directly between the Bluetooth device and the cloud. In a real-world setting, the Luna solution’s differences deliver benefits through

- **Easy provisioning**
- **Enhanced security for location tracking**
- **Secure bidirectional communications:**
 - » Assured monitoring
 - » Multimodal indoor positioning

Easy Provisioning

The Luna solution places an emphasis on using cloud-based automation. When it comes to setting up Luna-enabled devices, a person does not need to be present to push buttons or approve connections. Instead the onboarding or provisioning process can be highly automated.

When you purchase Luna-enabled devices (sensors or trackers), each one comes with a unique factory key, a code that is used to secure communications. For instance, if you bought a batch of 1000 Luna-enabled sensors, you'd also receive a digital file containing all 1000 unique keys. When you receive the 1000 sensors, all it takes is a single press of a button to instruct the cloud system to 'wake up' each device and start the authentication process. This involves a key exchange, so that the Luna-enabled sensors and the application cloud introduce themselves and form a trust relationship. This trust relationship ensures the sensors can securely communicate with the application cloud, making the entire setup hassle-free and efficient. Each of those Luna-enabled sensors then could be placed on, for example, a crate of blueberries to be tracked.

Critical automated steps are executed behind the scenes as communication is established between the Luna-enabled sensor and the cloud.

Enhanced Security for Location Tracking

In traditional Bluetooth beaconing, devices essentially broadcast their identity information into the air. It's a bit like lighthouse beacons (hence the name) repeatedly signalling their presence. The signal is then picked up by nearby mobile phones or dedicated gateways, which add their location to the beacon ID and send this combined data to the asset-tracking application.

Unfortunately, this method has significant security vulnerabilities. Malicious individuals could covertly observe or eavesdrop on, or snoop, the signal to secretly monitor assets they don't own. They also could pretend to be the device sending out the signal, or spoof it.

Luna plugs those vulnerabilities by offering a more secure solution. With the Luna protocol, the device frequently changes its broadcasted identity so that if someone tried to snoop on the broadcasted information or spoof the device's identity, they wouldn't be able to track or impersonate an asset.

All this is possible because the cloud and the device can seamlessly coordinate these ID changes while maintaining continuous communication with each other.

Secure Bidirectional Communications

Assured Monitoring

In the Luna solution, a device and the cloud share an exclusive secret key known only to them, therefore, they can securely communicate and exchange acknowledgments and commands.

One of the most important aspects of bidirectional communication is ensuring a message is received and acknowledged. Think of it like pilots saying “Roger,” truckers using “10-4,” or people nodding to confirm they received a message (Figure 9). This acknowledgment is vital.

In contrast, a sensor that simply broadcasts data and hopes it reaches the right place isn’t reliable enough. It’s like sending a message into the void without knowing if anyone received it.

That’s where the Luna protocol steps in. The sensors signal they have data to send, and the cloud allows a non-trusted gateway to securely pick up—but not have access to—the encrypted information. Finally, the cloud sends an acknowledgment back to the device, reducing the need for the device to send and/or store excessive data.

The Luna protocol is also robust. If there is a lack of internet connectivity, the sensor retains the data and attempts to resend it when connectivity is restored. The other components of the system also exhibit resilience to communication issues. This level of reliability represents a groundbreaking development, particularly for industrial, healthcare, and non-consumer applications, ushering in a new era of consistency and dependability.

Multimodal Indoor Positioning

Indoor positioning is essential for tracking items in places like warehouses, hospitals, and factories, where there are walls and obstacles. But obtaining precise one-meter accuracy indoors is difficult and also requires expensive infrastructure. On the other hand, achieving accuracy within ten meters is relatively simple.

The Luna solution enables users to easily locate, for example, a lost barcode scanner to within ten meters. Then a person with the Luna app enabled on their work mobile device can find the missing scanner by pressing a button — causing the missing scanner to emit a sound and flash (Figure 10).

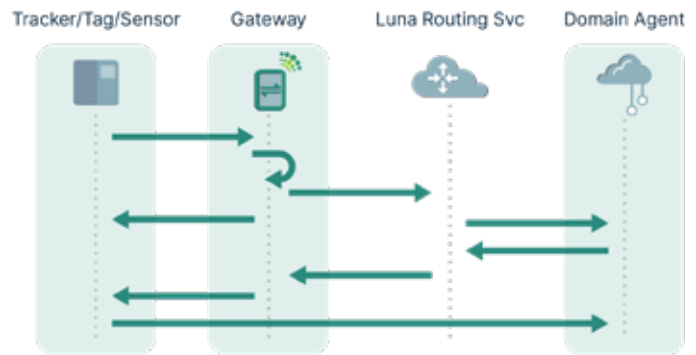


FIGURE 9. Secure and bidirectional communication is central to the Luna solution.

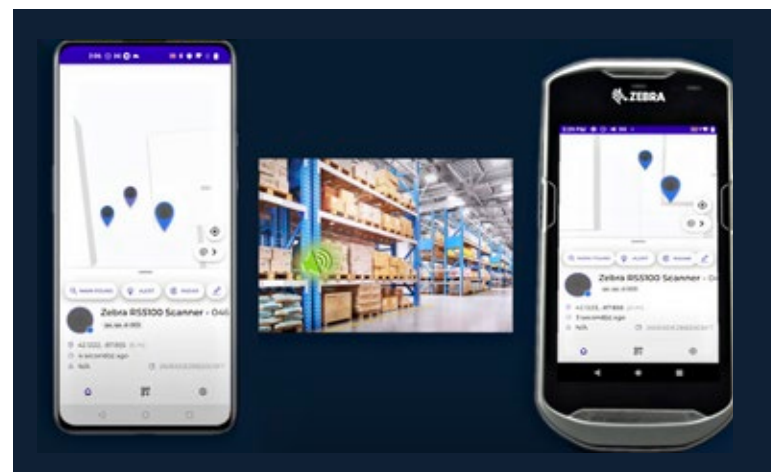


FIGURE 10. The Luna solution’s two-step process helps ensure accurate positioning. Step one: Show location within ten meters of the item. Step two: Initiate an alert sound. See the video demo: youtube.com/watch?v=TL-tlq1OTKI

Use Case

Condition Monitoring of Perishable Goods

The Luna solution brings next-level visibility to the distribution and management of perishable goods. Imagine that a truck is equipped with six Luna-enabled sensors (Figure 11). Luna XIO partners with manufacturers that offer sensors that are compact in size and boast a lifespan of six to ten years, all while continuously gathering and transmitting data at five-minute intervals.

The data, transmitted through the mobile device turned gateway carried by the driver, is fed into the transportation management system used by the transport provider.

This next-level visibility allows for swift action in case of extended dwell times or temperature fluctuations. Immediate corrective measures can be implemented as soon as conditions warrant (Figure 12). Such proactive measures represent a significant stride in the battle against food spoilage and in preserving the integrity of food and pharmaceutical products.



FIGURE 11. Luna-enabled sensors can be strategically placed in trucks to communicate conditions, location, and more in real-time to interested parties.

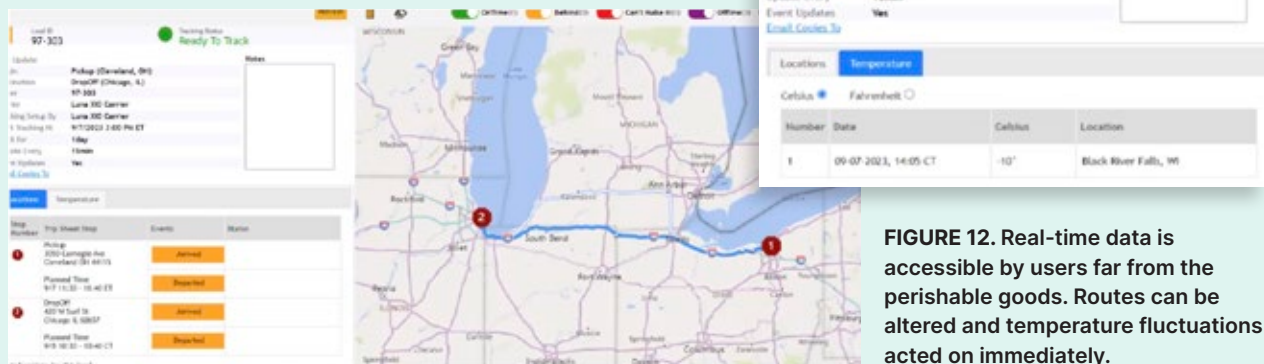


FIGURE 12. Real-time data is accessible by users far from the perishable goods. Routes can be altered and temperature fluctuations acted on immediately.

Use Case

Home Healthcare and Patient Monitoring

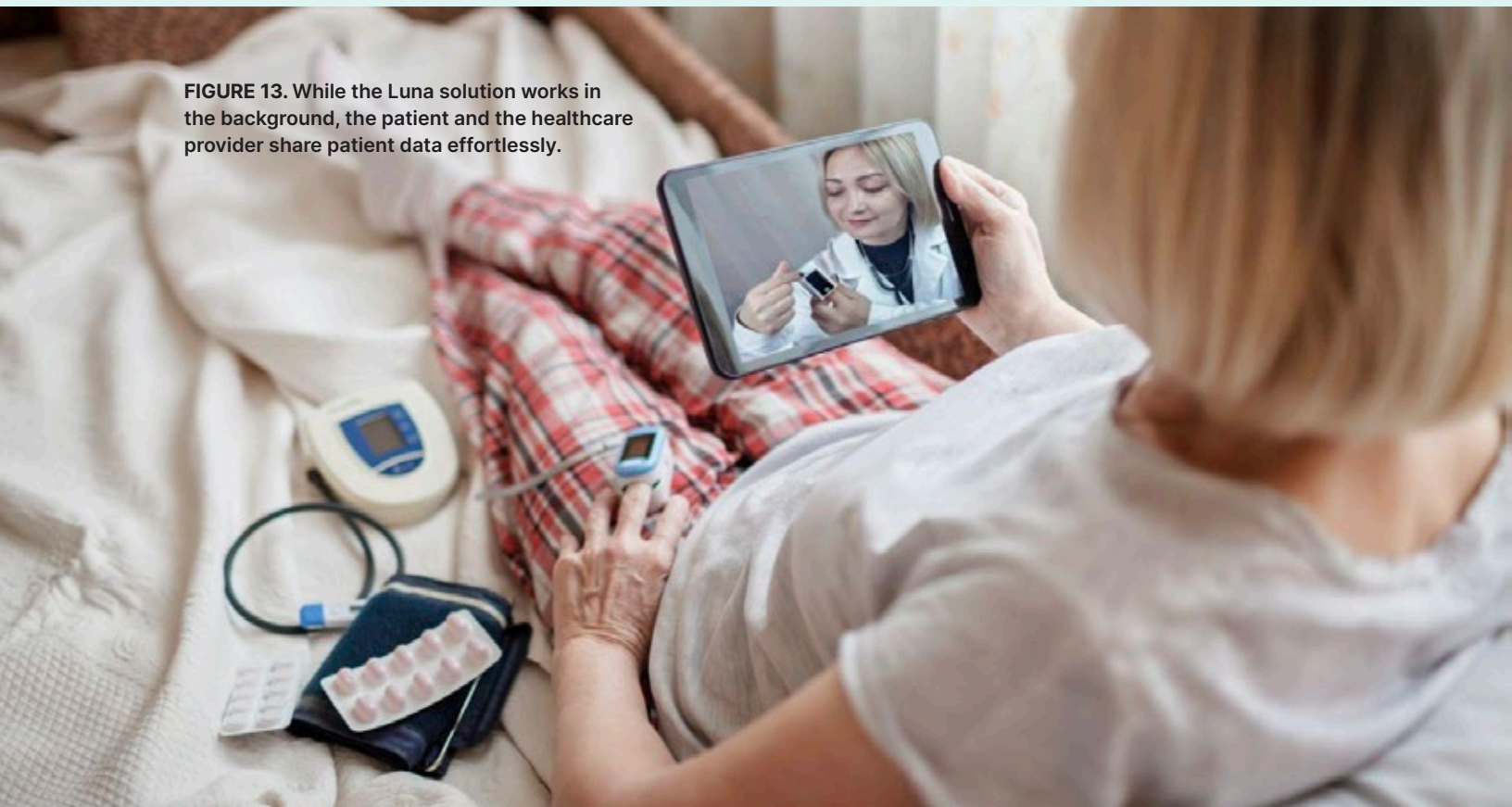
The pandemic has expedited the growth of home healthcare. Even within the confines of a hospital, managing medical equipment and patient monitoring poses challenges. The reality is that this task is multiplied exponentially when you have tens of thousands of patients scattered across the country.

One essential aspect of making home healthcare services possible is asset tracking — ensuring that required equipment reaches its destination precisely when needed. [Luna's asset tracking system](#), which allows devices to be procured from various sources and data to be seamlessly 'connected' from any location, plays a pivotal role in providing visibility into home-based medical equipment.

Even more important than monitoring assets, healthcare organizations need to monitor patients (Figure 13). With the Luna solution, patient data can be effortlessly and securely transmitted in real-time, sparing caregivers the burdens of device 'pairing'.

The entire process operates on a foundation of zero-touch, zero-trust principles, which means that everything operates seamlessly, securely, and without the need for human intervention. All the essential authentication, encryption, and security protocols are automatically managed between the devices and the cloud. This approach guarantees a high level of trust and security while simplifying operations for healthcare providers.

FIGURE 13. While the Luna solution works in the background, the patient and the healthcare provider share patient data effortlessly.



Use Case

Real-Time Visibility for Shippers, Logistics Providers, and End Customers

Currently, truck telematics data predominantly funnel to the transportation provider, (i.e., the trucking company). However, the producer and/or seller who have their brand reputation on the line care the most about the item being shipped.

A typical product journey from manufacturer to end customer involves many players, such as multiple transportation providers, warehouse services providers, distributors, and potentially retailers. Each party has limited access to the other and each has different areas of concern. For example, the responsibility of a transport provider extends only through the time of transport. The manufacturer, however, as a part of protecting its brand, cares about the condition of the goods all the way through to their consumption.

It is therefore highly desirable to have end-to-end visibility with appropriate information parcelled out to the players who care at each step of the journey (Figure 14).



FIGURE 14. Real-time visibility for everyone involved.

Luna enables this end-to-end visibility by providing small cost-effective trackers and sensors that can be affixed to individual shipment pallets or boxes (Figure 15). Luna also provides software-based gateways that are pushed out to the work devices of the personnel in the supply chain. The mere proximity of the trackers and workplace devices, like barcode scanners, assures delivery. The personnel don't have to scan anything as they would with barcodes or radio frequency identification (RFID) tags. The Luna solution then serves the data to the various shippers, logistics providers, and end customers.



FIGURE 15. Drug shipment data is critical to pharmaceutical companies. Luna has the economical solution.

Promising Future Directions

The future of Bluetooth promises to be incredibly exciting. We are currently at the forefront of a hardware revolution with the emergence of miniature devices that can potentially revolutionize industries – printable and tiny (Figures 16).

We are witnessing their integration into printable, flexible form factors. These BLE-enabled labels offer seamless compatibility with any Luna solution, as they effortlessly interface with existing infrastructure to enhance visibility.

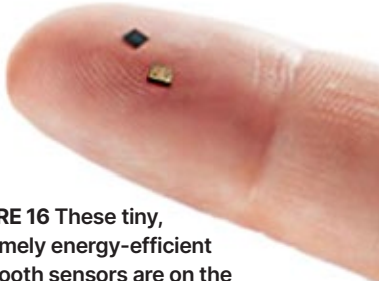


FIGURE 16 These tiny, extremely energy-efficient Bluetooth sensors are on the verge of reshaping various sectors. (SmartBond TINY image courtesy of Renesas Corporation).

Unlock Real-Time Next-Level Visibility

In today's fast-paced world, the need for real-time next-level visibility is greater than ever. Forward-thinking organizations that are able to gain that level of visibility can transform their operations and profitability while also greatly improving their customer outcomes.

We invite you to [connect with Luna](#) to learn more about how we can work together to:

- 1. Elevate Your Condition Monitoring:** Gain the actionable visibility you need to reduce losses in food and pharmaceutical transport, protect your brand and ensure regulatory compliance.
- 2. Revolutionize Your Asset Tracking:** Transform asset tracking into a seamless, efficient experience, reducing downtime and ensuring the security of valuable assets, from healthcare equipment to manufacturing parts. Say goodbye to inefficiencies and disruptions in your operations.
- 3. Improve Healthcare Outcomes:** Monitor vital signs in real-time, ensuring the well-being of patients both inside and outside healthcare facilities. Transform your healthcare delivery landscape by empowering your healthcare professionals with the patient information they need to offer more proactive care.

Together, we can connect the next 100 billion things to the internet and drive positive change. Let Luna be your partner in embracing next-level real-time visibility and achieving new heights of efficiency and success.



Luna is revolutionizing remote connectivity for billions of low-power devices that lack the resources for traditional secure connections. With a focus on seamless integration and secure, bidirectional BLE-to-cloud communications, Luna XIO empowers industries to harness the potential of real-time monitoring and control. The Luna protocol offers innovative solutions to reduce food waste, improve home healthcare, enhance supply chain visibility, and optimize both retail and manufacturing operations.

For more information about Luna XIO, please visit lunaxio.com