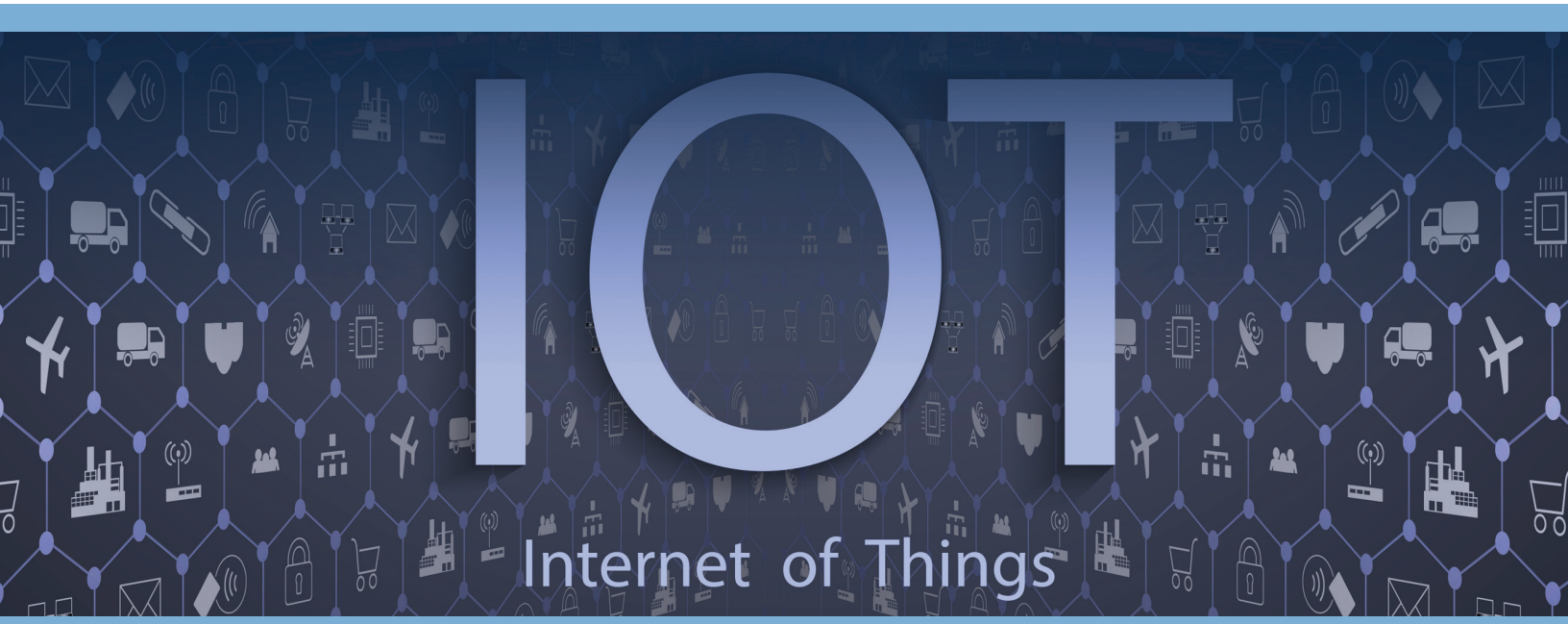


By Victor Mejia, *Product Manager at Nextivity Inc.*

Cellular IoT: An Opportunity for Billions of New Deployments

> *"The Internet will disappear. There will be so many IP addresses, so many devices, sensors, things that you are wearing, things that you are interacting with, that you won't even sense it. It will be part of your presence all the time. Imagine you walk into a room, and the room is dynamic. And with your permission and all of that, you are interacting with the things going on in the room."*
>
> —Eric Schmidt, *former CEO of Google*

The demand for LTE-based Internet of Things (IoT) connectivity continues to gain momentum alongside the increasing need for connected equipment. According to Ericsson (2018) there will be more than 3.5 billion cellular IoT devices in market by 2023, making cellular technology a major communication enabler of IoT.

There are a number of competing technologies on the market to connect IoT devices. Many of the wide-area technologies, such as Sigfox, Weightless, and LoRa, are not LTE based. That is an important distinction because LTE-based IoT can be overlaid on existing LTE networks as a software upgrade. It is therefore much easier—and less costly—for the cellular operators to deploy.

The Advantages of LTE-based IoT

LTE-based IoT (LTE Cat-M and NB-IoT) devices offer a number of advantages over standard 3G and 4G devices: extended battery life, lower cost, and better coverage. Device battery life is extended when the improved signal environment allows devices to transmit at a substantially lower output power. The total cost of wireless is improved when the solution leverages an existing carrirer network; rather than creating one with your IT department. This is not to say Cellular IoT is the most economical for every deployment, but it is for certain types. To explain the better coverage from cellular IoT, there are two basic elements to look at:

Link Budget: Better coverage is delivered primarily because of a substantially better link budget, which is an important measure for power calculation. Link budget calculates the power received at the receiver (device) and accounts for gains and losses along the way. It is used to indicate how weak the signal can be from the tower to the device (and vice versa) for the system to still operate (communicate).

Larger Coverage Capability: Standards bodies have worked to ensure a better link budget for cellular IoT. It is about 20 dB (~ -164 dB) better than standard 3G and 4G technologies (~ -144 dB), ensuring coverage to an area approximately 7x larger (in an open environment). This 20 dB link budget improvement also results in better in-building signal penetration.

However, in spite of the improved link budgets and wider coverage areas, LTE-based IoT devices are still subject to the same in-building cellular signal penetration and coverage challenges experienced by any mobile phone user inside the building. A 2017 Zinwave study showed that 74% of workers have "frequent" or "sometimes" bad cellular coverage.

While operators continue to struggle to provide good in-building coverage from outdoor towers, a business cannot afford to have its mission-critical business functions inoperable "frequently" or "sometimes" because of a poor cellular connection. The impact on non mission-critical operations could also reduce the overall productivity of a company. To take advantage of the benefits of LTE-based IoT, there should be good and reliable cellular coverage throughout a building.

In-Building Cellular Coverage Options for IoT

There are three ways to deliver coverage indoors to provide the necessary quality of service for IoT: wired to router, wireless mesh, and dedicated cellular signal amplification.

Wired to Router Network

For many applications, this very simple solution will suffice. If the on-premise IoT solution is simply making use of a wide area, wireless-enabled router or gateway in which the on-site sensors and nodes are connected via wires, then an antenna can be run to the exterior of the building. To provide coverage to a single fixed point, this is a workable option.

However, for the antenna to pick up signal, there must be some service available to the exterior of the building. There are also some limitations around equipment placement—the antenna run cannot be too long due to the attenuation of the signal over the length of the coax cable.

Wireless Mesh Network

Some IoT networking technologies implement a form of mesh capability, allowing for a 'string of pearls' style approach to coverage. In this model, each network node becomes both a sensor and a gateway for other devices.

Some applications can leverage this capability quite well. 802.15.4 (Zigbee) is one such networking technology that makes use of mesh capability. However, there are two main weaknesses with this approach in extending the IoT network and coverage.

First, because each node becomes a full-time participant in the communications path, they need power all the time. This makes a mesh network very difficult to maintain when relying on battery power. Battery life for a node can decrease from 10 years to only a few months, depending on where it sits in the network and how often it's used. Keep in mind that if a single node goes down in the network chain, all of the nodes after it are incommunicado. This is mostly a non-issue where nodes are powered, as with most smart home applications, for example.

The second issue is latency. Each node introduces latency into the network architecture, which can impact message time out and cause problems with real-time applications.

Dedicated Cellular Signal Amplification

Ideally, for IoT implementations, the technology used to amplify the signal simply relays the external coverage internally with delays that are so minimal that it is invisible to the cellular network. For mission-critical business solutions that rely on real-time communications, this is important. Introduction of noise into the system will also negatively impact a network's performance.

Nextivity developed proprietary processors used in their line of Cel-Fi signal amplification systems to address noise and latency concerns. Cel-Fi smart signal boosters and active DAS hybrid products offer a network-safe guarantee and are approved by the Federal Communications Commission to boost signal up to 100dB, 1,000 times greater than allowed with wideband BDA repeaters.

Unlike mesh networks, these dedicated cellular signal amplification systems don't do any other work so they can operate when needed, waking only when prompted or on a timer.

Cel-Fi: Enabling Cellular IoT

As the market expands, costs are plummeting, for both equipment and service, and the ease of installation makes these systems a desirable solution for IoT applications in a myriad of industries and applications, such as: construction sites, solar farms, vending machines, oil and gas remote sites, law enforcement, and public safety.

Following are examples of case studies showing.

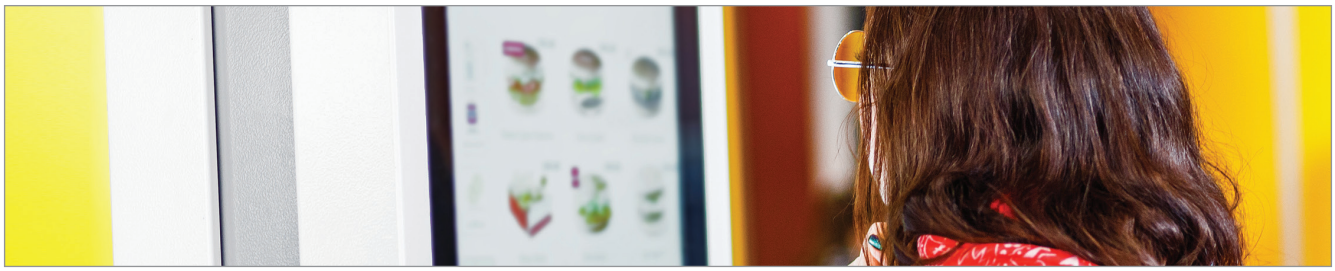
Construction Sites

An Atlanta based Digital Surveillance & Security company often faces coverage challenges when securing construction company jobsites. When working on a dam restoration project, they were able to deploy their solution at the job site which was in a remote part of the county at the edge of the network. By enhancing the cellular coverage with Cel-Fi GO, they were able to employ real-time digital monitoring capabilities to protect the construction materials, equipment, and assets on the job site. With the additional benefit of creating coverage for the workers and their gear. The site housed up to $6 million-worth of equipment. Cel-Fi GO created a coverage bubble for the Digi industrial switch and the 4G Sierra Wireless Ruggedized router, resulting in real-time video capturing and monitoring. Not only did this minimize risk to the equipment, it also provided 9-1-1 capabilities to help mitigate safety and compliance concerns. Now, the customer is able to make decisions quickly based on real-time video footage.

Solar Farms

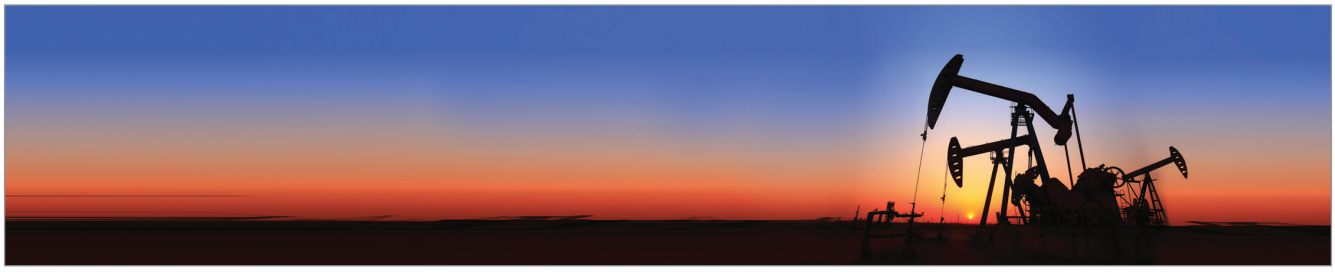
A power company that operates a rural solar farm lacked a strong, reliable signal to transmit video back to its central office, putting the company at risk. With the deployment of Cel-Fi GO, the company achieved a stable cellular signal for strong site-to-site connectivity over 3G and 4G/LTE networks, providing the continuous visibility it needed while ensuring that its critical video surveillance and communication equipment were constantly connected.

Vending Machines



A major soft drink manufacturer deployed new cellular IoT-based vending equipment that communicated to their route managers the current inventory levels and whether the equipment was operating correctly. The system was designed with cellular-based routers, but when deployed the lack of in-building coverage limited national deployment. Nextivity was called by the carrier to address the problem with Cel-Fi.

Oil & Gas



In pipeline, land-based, and platform drilling sites, cellular-based monitoring tools have been deployed for safety reasons to measure performance and output. Cel-Fi GO has been deployed alongside to ensure cellular coverage to these mission-critical data feeds to the headquarters. In recent advancements workers wear wireless-enabled body cameras, so that remote engineers and technicians can help troubleshoot fixes for workers on the ground.

Law Enforcement

As we look to protect and serve, advancements in law enforcement include body and dashboard-based cameras that rely on cellular. Cel-Fi GO in mobile mode has been deployed in both local and federal law enforcement vehicles to provide coverage to boost signal in hard-to-reach places.

Public Safety

Emergency response command centers rely on monitoring and imaging equipment in disaster zones like floods, earthquakes, and fires. Military and safety agencies have used the Cel-Fi GO to boost cellular coverage to enable these mission-critical systems.

There was no cellular signal in the equipment bay at the Fire Department in Denton, Texas Fire Station 2. Each fire engine was equipped with a cellular-connected mobile deck computer (MDC) that kept call logs, but these were inoperable until the engines were outside the station. Cel-Fi QUATRA as installed and the lack of coverage was immediately resolved.

Corporate Secure Payment Processing

In addition to wanting to provide typical voice and data services over the cellular network—for example, enabling employees to communicate with one another between buildings, or for personal reasons—Charter Dura-Bar metal services building and iron foundry have industrial-sized vending machines that contain various tools and supplies. Employees working on the factory floor must enter a personalized code to access, for instance, protective gloves or specific parts they need to operate a piece of machinery. The company's credit card is then processed in real-time for these purchases.

Payment processing was running over Charter Dura-Bar's network. But because the vending machines were operated by a third-party company, the security team wanted to separate this function from the company's IT network to mitigate security risks in the event of a breach. Cel-Fi QUATRA as installed throughout the facilities and provided sufficient cellular signal for the payment processing to be taken off the company's WiFi and moved onto the cellular network.

For more details on how Cel-Fi GO or Cel-Fi QUATRA active DAS hybrid have enabled IoT applications, please visit (www.cel-fi.com/products).

About the Author

Victor Mejia is the Product Manager at Nextivity. He specializes in indoor network deployments for commercial and public safety networks. In 20 years of his professional career, he has successfully led several projects for Huawei, American-Tower, Movistar, Comba among other tops players in the wireless industry across North America and Europe. Victor holds an MBA diploma from the University of Oviedo in Spain and is a level 3 iBwave certified engineer. For more information, contact **hello@cel-fi.com** or visit **www.cel-fi-com**.

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