The Industrial 4G LTE Starter Guide

How to Connect Industrial Sensors and Devices Over 4G LTE

MOXA®

The world is moving towards Internet-connected devices and equipment. There will be a period of time as we figure out how to enable this connectivity for a wide range of devices, applications, and environments.

4G LTE offers many advantages as an easily deployed method to connect a large number of industrial devices and sensors to the Internet. However, there are situations and considerations to be aware of so you can avoid issues with industrial protocols, data plan overages, private IP address issues, and more.

In this guide we go over the scenarios where 4G LTE makes the most sense, the challenges you'll most likely encounter, and some practical tips that will help you avoid the most common pitfalls.

We hope you find this guide useful and wish you the best of success on your project.

- *The Moxa Team*

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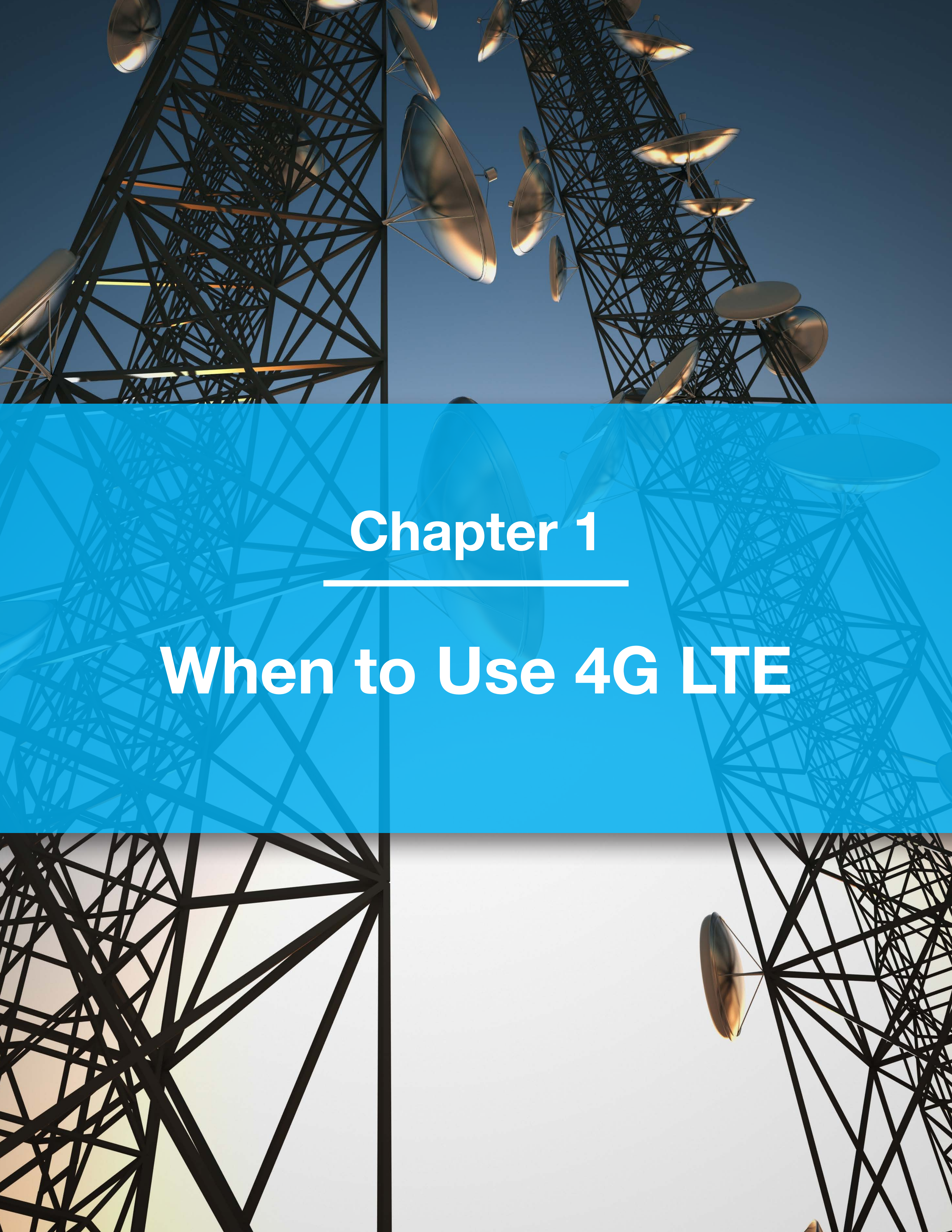


Chapter 1

When to Use 4G LTE

If you work in the industrial sector as a system integrator, software house, OEM, or end user, you're going to face the need to enable network connectivity to industrial sensors and devices. With the rise of the Industrial Internet of Things, this demand is now expanding to include Internet connectivity for data from these devices to be collected and leveraged by cloud-connected services.

Many are foreseeing a future where nearly every device and piece of equipment has a connection to the Internet. By some estimates, this means 16 billion industrial devices connected by 2020[1]. Collecting data from these devices in real-time means **overcoming these challenges**:

- Devices are often not designed for data communication and need special retrofitting or outright replacement.
- Devices are often installed in locations and facilities with limited or no communication infrastructure available.
- The locations and facilities that already have some form of connectivity are not equipped to handle a massive increase in the quantity of data.
- There are severe costs to any effort that involves interrupting operations, trenching new cables, or replacing existing equipment.

1. Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020. http://www.gartner.com/newsroom/id/2636073

When system integrators and users are evaluating their need for 4G LTE connectivity for field devices, they are usually trying to accomplish one or more of these goals:

- Gather real-time performance and environmental data from **multiple sites over a wide geographical area**
- **Monitor and manage deployed devices** on behalf of customers and make that data available to them
- Establish IP-based communication in locations that **do not have an easily accessible wired or wireless infrastructure**

In many cases, different types of wireless communication can be used to mitigate some or all of these challenges. The 4G LTE networks offered by Verizon, AT&T, T-Mobile, and other wireless carriers are fast, widely deployed, and able to support data transfer rates that rival traditional Wi-Fi.

It's no wonder that as operators scale-up their efforts to connect their devices to the Internet, 4G LTE is often a very attractive option, especially under certain circumstances.

Let's take a look at some different forms of wired and wireless communication technology that are available to achieve these goals.

Comparing Options for Remote Connectivity

Technology	Advantages	Challenges	Best Suited For
Satellite	You can connect from anywhere on the planet.	Satellite communication requires a very costly investment in specialized hardware and antennas. Bandwidth is extremely expensive.	Connectivity to ocean-based oil rigs and vessels, passenger aircraft.
900 MHz Radio	There are no data plan or trenching costs. This is a very cost-effective way to establish low-bandwidth remote communications without other infrastructure.	Bandwidth is extremely limited, and the hardware is expensive and difficult to maintain. Most implementations are proprietary and require additional engineering work for IP-based (network) communication.	Low-bandwidth monitoring of remote locations.
Fiber Optic	You get by far the highest and most reliable bandwidth possible.	The extremely high cost of trenching and fiber optic cable makes this overkill for most applications involving monitoring of existing assets.	New permanent installations of high bandwidth network backbones.
Leased Line	When available, leased lines (land lines) are the most inexpensive way to get a reliable high-bandwidth connection to the Internet.	If you don't have access to an existing leased line, it's often difficult and/or expensive to establish and manage new lines.	Internet connectivity for the whole facility or control center.
Wi-Fi	High bandwidth is supported, and for many facilities, Wi-Fi is the easiest and most cost-effective to deploy.	Wi-Fi requires an existing network/ Internet infrastructure and is not effective for long-distance communication.	Short-range connectivity within a facility or small geographic area.
4G LTE	Where available, this is easily deployed in multiple locations for high-bandwidth Internet connectivity, with very low equipment and installation costs.	4G LTE coverage is not available in all areas, and monthly data plan costs can add up quickly.	High-bandwidth data communication to and from multiple remote sites.

4G LTE has already proven to be enormously valuable in a number of industries, in situations where other methods of connectivity would have been much more difficult and expensive.

Environmental Monitoring

Organizations varying from government agencies, renewable energy providers, industrial farms, and security companies have a growing need for environmental monitoring and surveillance stations that can collect live on-site video and sensor data. These stations may be equipped with devices such as an IP camera, humidity sensor, rain gauge, and more.

4G LTE has become a very attractive option because it supports high bandwidth and two-way communication, and is easily deployed in multiple remote locations without additional wiring or network infrastructure.

Both existing and new monitoring stations can implement automated data collection and transmission, greatly increasing the quality and frequency of data collected while reducing effort and manpower.

Remote Communications for Intelligent Transportation

A combination of factors has made 4G LTE a great option for remote communications for transportation-related applications.

- There is a strong need for smart, connected devices in nearly every aspect of the transportation sector.
- Buses and other vehicles on the road are trending towards greater connectivity and automated operation.
- Existing traffic monitoring and control devices need to be upgraded to Internet connectivity to achieve live centralized traffic management, and the devices themselves need to be monitored and managed.
- Nearly all devices are located in metropolitan areas with excellent 4G LTE coverage.
- High bandwidth communication is necessary to support video surveillance requirements.
- High traffic locations and intersections make it necessary to minimize the effort and expense of installation and maintenance.

Solar Power Monitoring

Companies that serve the solar power market or are engaged in their own solar power generation efforts need to monitor things like power output, power consumption, temperature, system health, string status, etc. With 4G LTE, a vendor or engineer can easily collect data without affecting or relying on the site's private Internet connection or Wi-Fi network. Moreover, this approach is easily scaled up to a large number of sites, each with its own 4G LTE connection.

Factory Monitoring Systems

Plant operators are increasingly finding value in systems that help them monitor and manage device usage, energy consumption, and demand response. The software supporting these systems is quickly moving to the cloud, and providers of these solutions need to be able to collect the necessary data at a plant and bring it to their cloud-connected database. 4G LTE-based solutions make it possible to provide an easy, drop-in solution to plant owners that will not affect or disrupt the communications network used for plant operations.

Chapter 2

Common Deployment Challenges

High Data Plan Costs

Unlike many other connectivity options, 4G LTE requires a data plan, with costs per megabyte paid on a monthly basis. With live data collected from connected sensors and devices, the costs can accumulate very quickly. It is entirely possible to generate terabytes of data in a single day from weather sensors that measure temperature, humidity, pressure, and visibility.

A single sensor generating 5 KB of raw data/sec can accumulate 13 GB of data in month. Verizon's basic M2M data plan was recently advertised at $99.99[2] for the first 5 GB of data and $0.0003/KB afterwards. This means a potential monthly cost of $2499.

2. Verizon Machine to Machine Data Plans. 7/6/2016. https://www.verizonwireless.com/biz/plans/m2m-business-plans/

The cost of your 4G LTE carrier's data plan may need to be carefully weighed against the cost of trenching new lines or installing other options for connectivity.

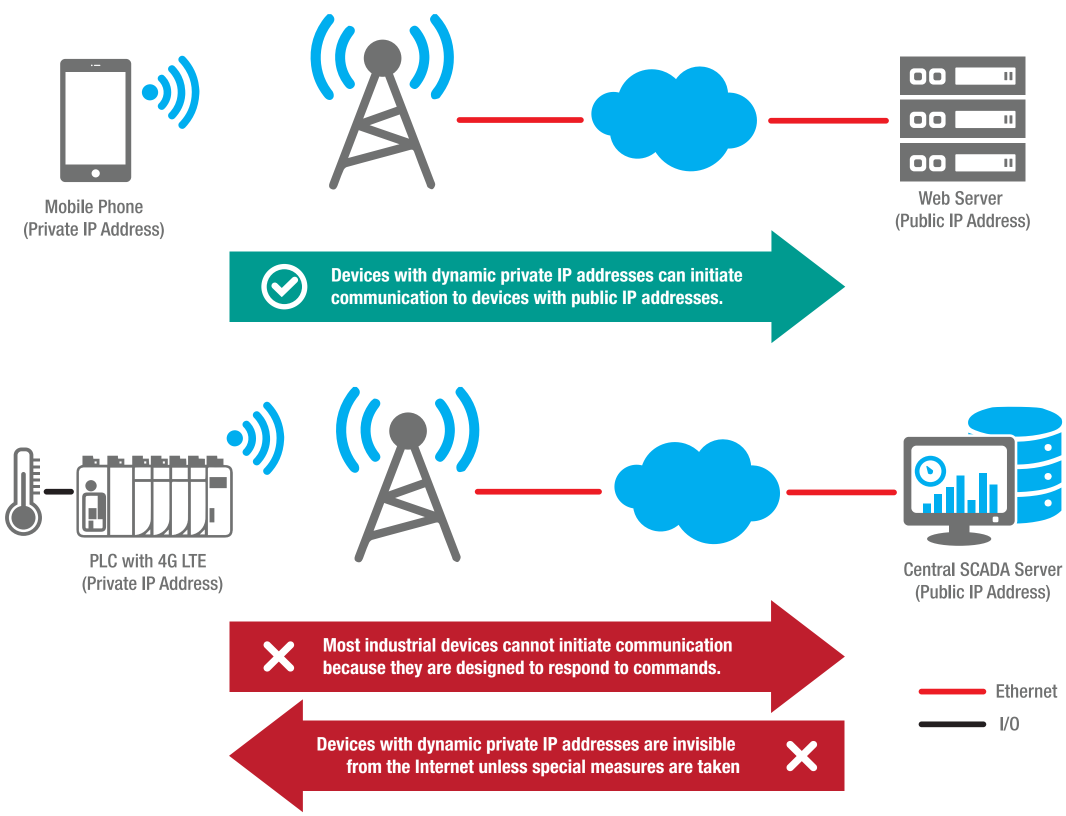
Rather than transmit raw data, many users of 4G LTE are exploring edge computing as a way to compress and process data before transmission, which can lead to significant savings in the data plan costs. Wireless carriers are also aware of the demand that the Internet of Things will create for them, and several (including Verizon) are already offering special data plans tailored for industrial users.

Issues with Private IP Addresses

For anyone who has connected industrial devices or sensors to the Internet, private IP addresses are a familiar and surprisingly thorny issue. For those who are not familiar with the issue, it involves aspects of IP-based communication that we normally don't have to worry about as Internet users.

When a user connects to the Internet using a device such as a cell phone or home PC, the connection is provided by an Internet Service Provider (ISP) or wireless carrier. The ISP or carrier assigns each device a private IP address that is not visible or accessible on the Internet. In order to exchange data over the Internet, the user's device must first initiate communication to a known public IP address, such as a website or app store. The Internet router or gateway then coordinates between the private IP address of the internal device and the public IP address of the external device and routes the requested data between them.

Industrial Devices and Private IP Addresses



Since the vast majority of industrial devices and sensors are designed to respond to commands rather than initiate them, this presents an issue for IP communication. A user or master device on the Internet will not be able to initiate contact with an industrial device or sensor that is assigned a private dynamic IP address.

To address this private IP address issue, wireless carriers may offer a virtual private network (VPN) service. With a VPN, all of your devices, both slave and master, are assigned fixed private IP addresses within the same network so they can communicate directly with each other, even when in physically different locations. Industrial users also have the option of setting up their own routers and IP address assignments to create their own VPN.

Complexity of Working with Different Protocols

When connecting industrial devices and sensors to a 4G LTE network, it's not enough to just consider the wireless connection. The nature of the device and the data being requested also needs to be considered and accounted for.

The communication protocols used by industrial devices and sensors are fundamentally quite different from the http, ftp, and SNMP protocols that are common in the world of networking. At a device level, you may need to navigate multiple Modbus IDs and timeout values, and decide if or how those devices will be accessed further up the network. You may need to integrate your data collection efforts with an existing SCADA network and/or OPC server. These and a host of other considerations will all have significant implications in how and where you set up 4G LTE connectivity, and what additional devices are necessary at that location to collect the data you need.

If you're not familiar with both industrial and networking communication standards, you or your engineer will need to spend the time and effort to learn specific protocols, or spend the money on industry-specific solutions that handle the device-level protocols for you.

As a reference, individual Modbus drivers for a popular OPC-based software package range from $990 to $2800 each[3]. The documentation for another popular industrial protocol (EtherNet/IP) is about 1300 pages for the first volume[4]. In the next few years, you may find that the choice will get easier with all of the work now being done to develop common communication standards for data sharing between IT (Information Technology) and OT (Operations Technology). Then again, the proliferation of new devices may mean even more decision points and factors to consider.

Putting Data in a Usable Format

Even after you have established a 4G LTE connection to your devices and worked with different protocols to get the data you need from those devices, that raw data doesn't have value until it is in its final format and platform. This generally means in a database where the data can be read by a piece of software and shared to different users in the form of analytics, performance dashboards, status updates, etc. The true value of getting those devices connected is what you can do with the data that is collected.

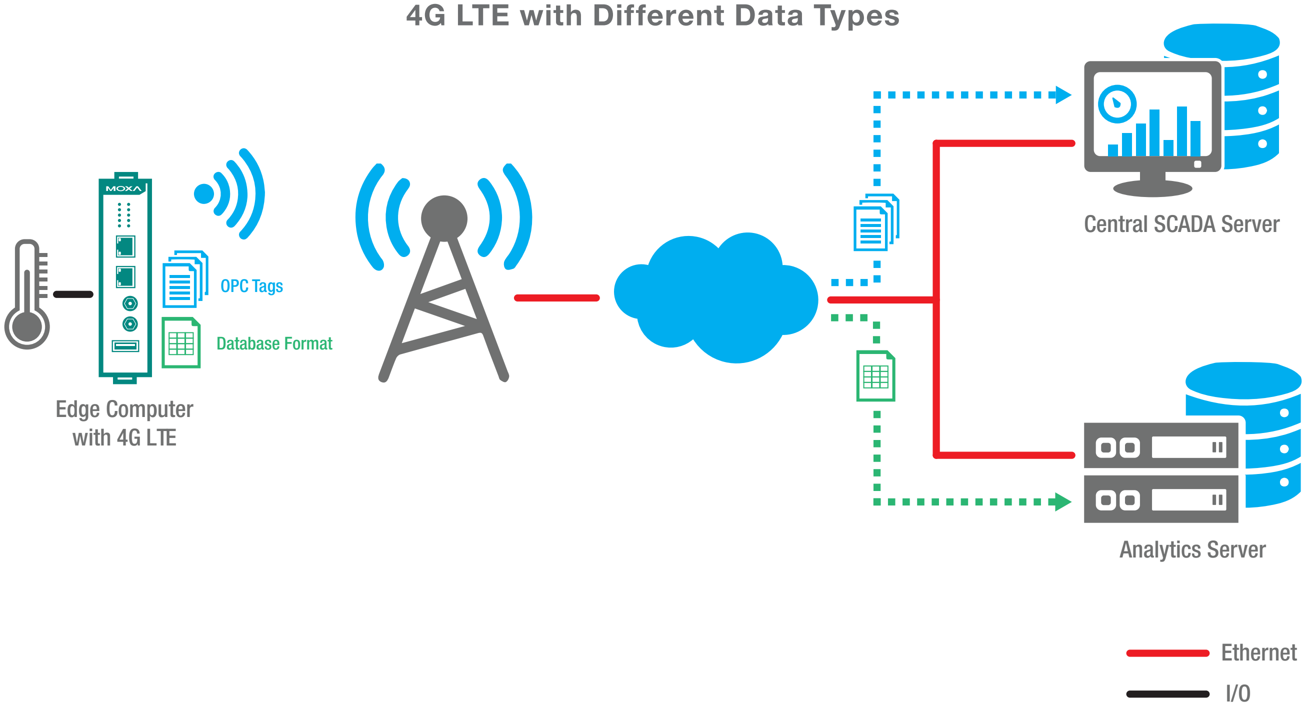
For industrial devices and sensors, the sheer quantity and variety of raw data that can be collected can present a major challenge when formatting and processing data. Data loggers and data concentrators have been used as an intermediate device to collect and forward data, but it is often in a proprietary format that needs to be further converted for use in your desired software platform.

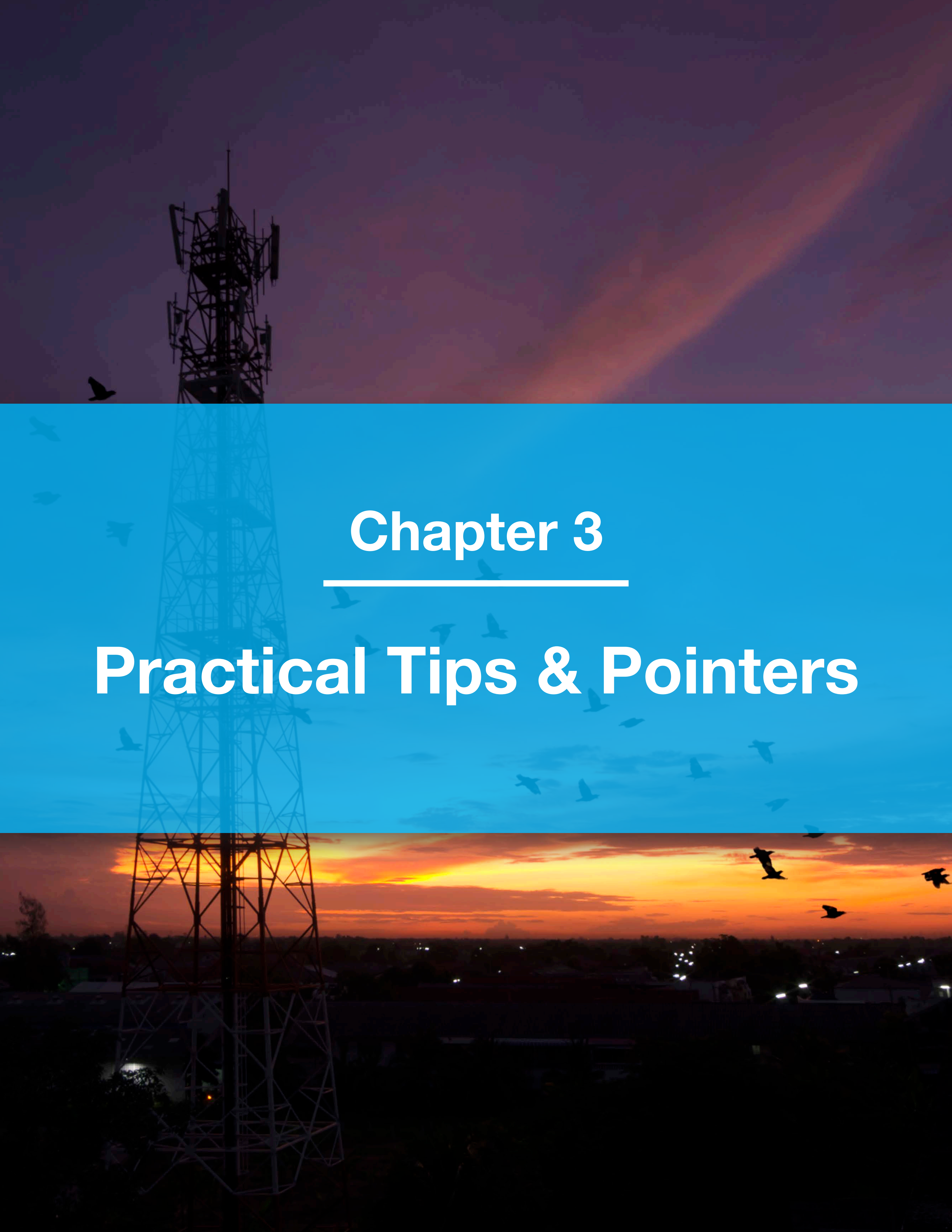
3. KEPServerEX Price List. Kepware. 07/07/16. https://www.kepware.com/products/pricelist.pdf
4. CIP Network Library for EtherNet/IP Volume 1. ODVA. 07/07/16. ftp://ftp.heapg.com/ARCHIVE/AB-OCS/Ethernet%20IP%20CD/CIP/Vol1_3.3.pdf

Each organization and application has its own requirements for the type of data that is needed, and there are numerous judgment calls to be made. *What are the specific data values required, in what format, and at what time interval? What are the short term and long-term storage requirements for this data? What are the different options for processing and formatting that data, and what are the pros and cons of each approach?*

There are different ways to address the challenge of data formatting. For example, if you want to make data from remote sensors available to a SCADA software package, one option would be to use 4G LTE to connect your PLC to an Internet-connected OPC server. However, if you plan on leveraging advanced analytics software to gain insight from this sensor data, you will likely need special conversion and processing to put that sensor data into a usable database format. For your specific situation and architecture, you will need to look at the advantages and disadvantages of handling this at the device level or the system level, before or after the data is transmitted over the 4G LTE network.

4G LTE with Different Data Types





Chapter 3

Practical Tips & Pointers

With a clear understanding of the strengths and challenges of using 4G LTE with industrial devices and sensors, you'll be better equipped to plan your deployment or upgrade and avoid some of the common pitfalls. Below are some general pointers based on successful deployments in various industries.

Use open industry standards as much as possible.

The world is changing fast, and the industrial space in particular is poised for major disruption. Even the largest, most stable manufacturers may be left behind as smart sensors and innovative software enable exciting new applications and business models.

As much as possible, you want to make sure your selection of hardware and software does not limit your current or future options. This means giving added weight to factors such as interoperability, open standards, and wide 3rd party support.

Some warning signs to watch out for include:

- Devices or software that only support a vendor's proprietary protocols
- Expensive service contracts or modules required to support other communication standards
- Data and device support locked within a closed ecosystem controlled by a single company
- Lack of participation or support of other industry standards

In many cases, a proprietary solution may still offer the best value for your situation. If you face this situation, remember to take steps to retain control over your operational data.

Use edge computing or data logging to process and format your data locally.

In general, avoid using 4G LTE to simply retrieve raw data from a device or sensor. Plan on having that data collected, cleaned-up, and processed locally, so that it is already in its most useful format before it is accessed over 4G LTE. This kills a few birds with one stone. You save money on data plan costs, and you save yourself the trouble of processing and formatting a lot of data from multiple sites in the control center.

There are a lot of options to achieve this, but at the very least, it requires that you have a device with some smarts and storage space on site, not just a slave device and a 4G LTE modem. You may connect a 4G LTE modem to a data logger or an embedded computer, or look for combo units that offer both 4G LTE connectivity and data logging capability.

Find ways to streamline data flow and operations.

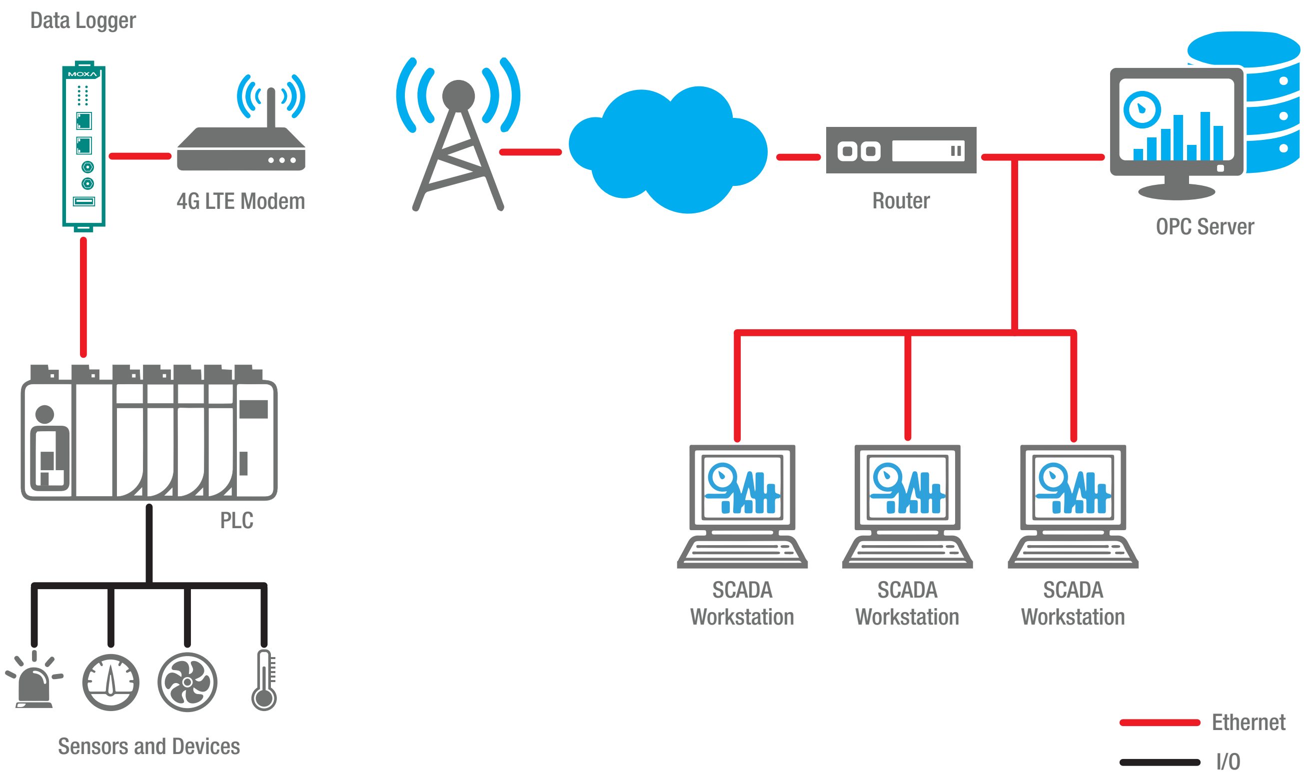
There are many benefits to a streamlined data flow and more efficient operations. We have seen a number of system architectures that simplify deployment and make it easy to get access to the necessary data.

The architecture that works best for you depends on your situation. On the next page there are a few examples for your consideration.

Working With Existing SCADA Systems

If you need your devices and sensors to be rolled into an existing SCADA system and software, don't poll those devices directly over the 4G LTE connection. Use a data logger to poll the devices locally and use OPC tags to make this available to your SCADA software. The latest OPC Unified Architecture (OPC UA) standard offers a number of features to ensure streamlined data flow even at large scales within an industrial operation.

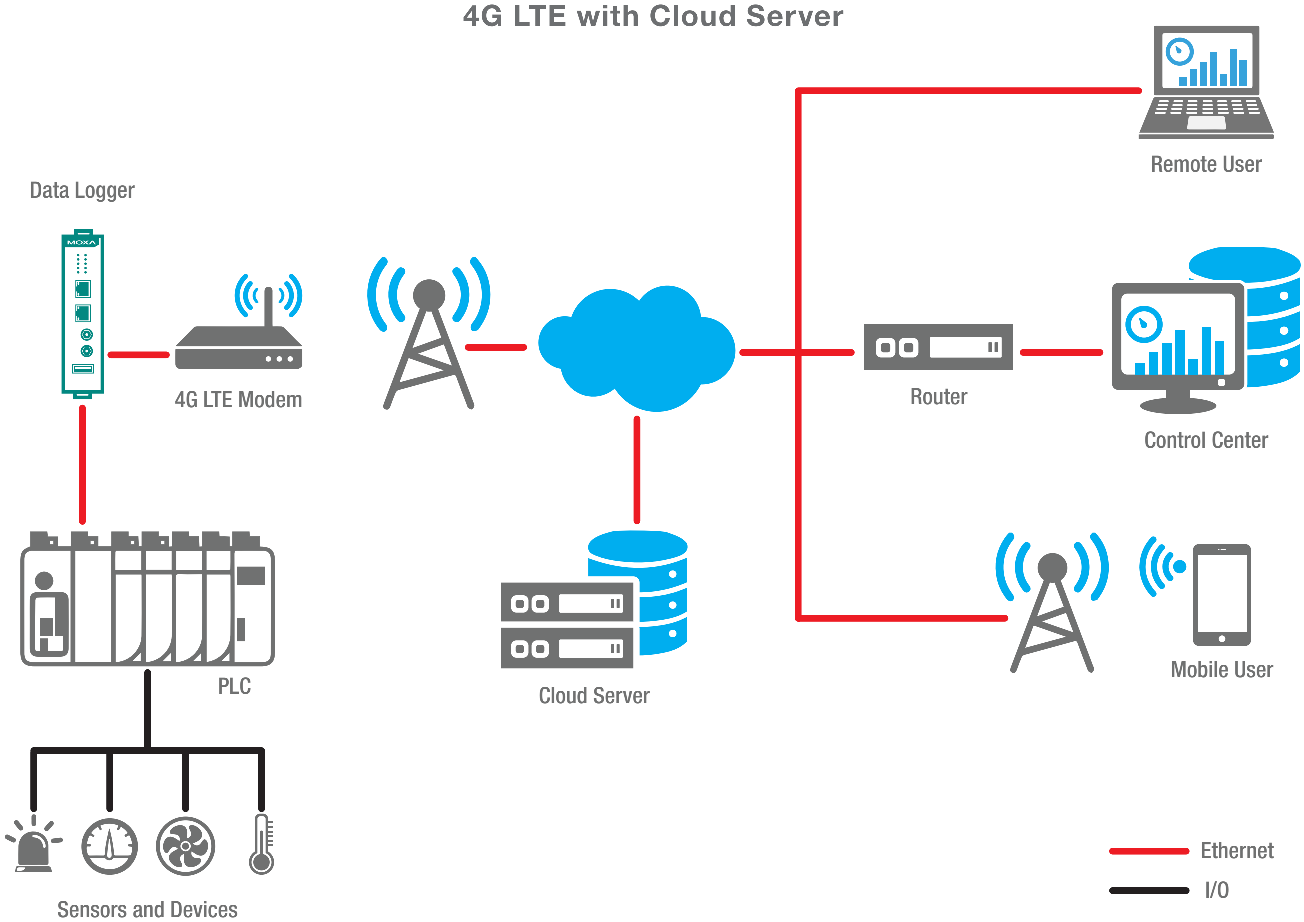
4G LTE with Data Logger and SCADA



Hosting Data in The Cloud

If you are collecting data from multiple sites to share with a designated piece of software, use a cloud-connected server to host that data. At large scales, you can consider a third party provider such as Amazon Web Services, but you can also choose to install your own server on a public IP or within a VPN. For each site where you are collecting data, you will need something like a PLC, data logger, or embedded computer that can collect and/or push data through your 4G LTE module or router to the cloud server.

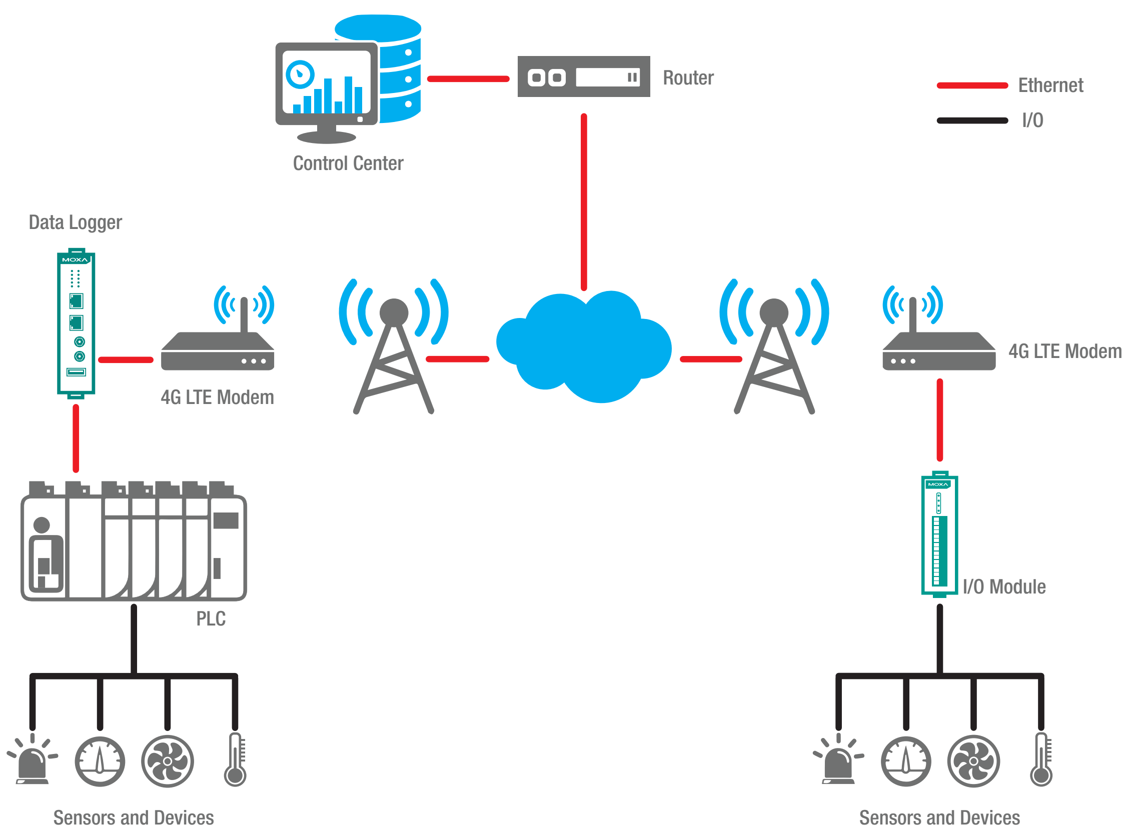
4G LTE with Cloud Server



Light or Occasional Data Collection

If your data requirements are light and you are working with only a few sites, consider storing the data locally at each site. Instead of using a cloud-connected server, you can place a data logger on-site to collect data. You could even do without the data logger and PLC and simply have your software poll a remote I/O module through the 4G LTE connection.

This kind of simple architecture makes sense for applications with low data requirements or when you simply need to be able check status and make updates from time to time, e.g., remote weather monitoring, remote device management, monitoring of billboards or vending machines. If you need historical data, you can make arrangements to upload the local data file directly to your database at regular intervals.



4G LTE with Local Storage Only **4G LTE with No Storage**

Be strategic with your hardware.

In this new world of connectivity, there are many different ways to accomplish the same goal. For example, you can build your own communication platform from scratch, using inexpensive consumer-grade components like the Raspberry Pi. With talented programming and engineering, and with enough time, it's possible to develop your own custom solution to just about any communication challenge. However, you will have to consider what your organizational goals and capabilities are.

Proven off-the-shelf solutions already exist for many communication requirements with hardware sourcing, manufacturing, certifications, heat dissipation, etc. already figured out. For most industrial users of 4G LTE, the communication hardware is not the major expense or the major source of revenue. Often, it makes economic sense to minimize the resources spent on hardware development and troubleshooting, unless you face specific space and power constraints that no existing off-the-shelf hardware can address.

Here are some of the devices you may encounter or require as you connect industrial devices and sensors to a 4G LTE network:

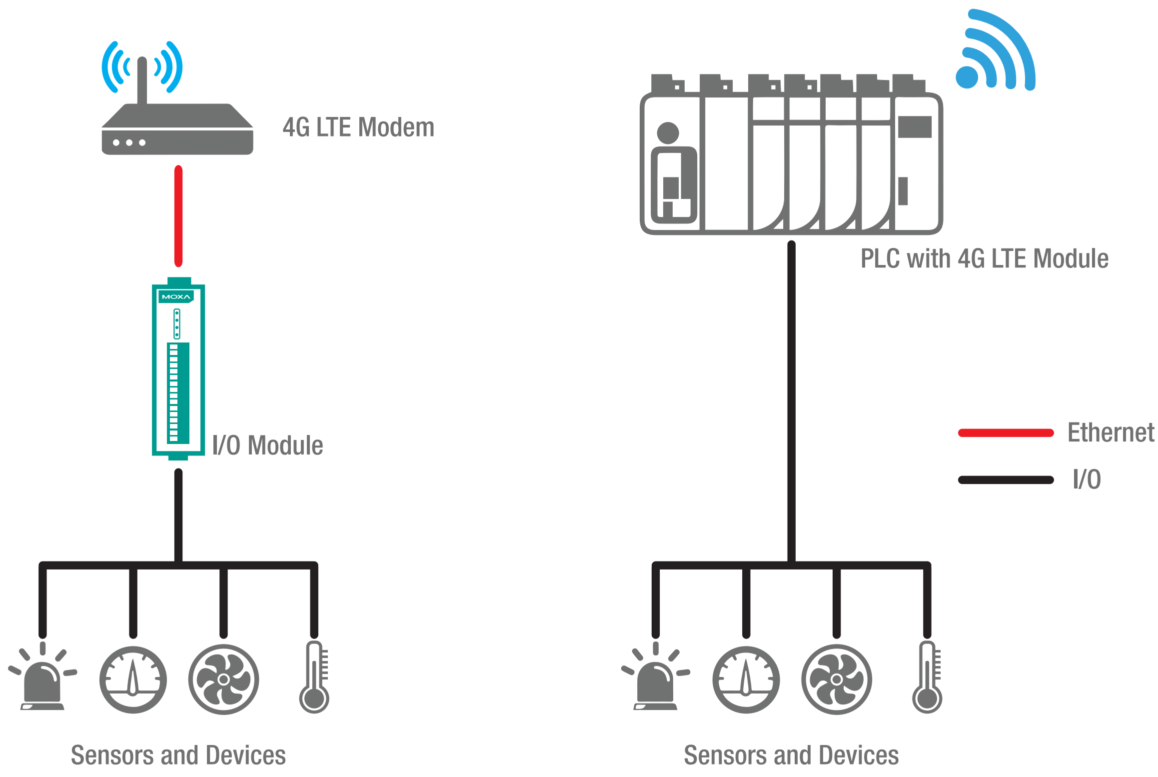
Connecting to 4G LTE

For your 4G LTE connection, the natural choice would be to install a **4G LTE modem** on site. Since these modems are designed to provide Internet access only, any protocol handling, data processing, or storage would need to be handled by a separate piece of hardware such as a data logger, PLC, or embedded computer. Some 4G LTE modem providers have added storage or I/O functionality to their product line-up, but the functionality is extremely limited and not usually able to replace the need for some sort of controller on-site.

Collecting Data from Sensors

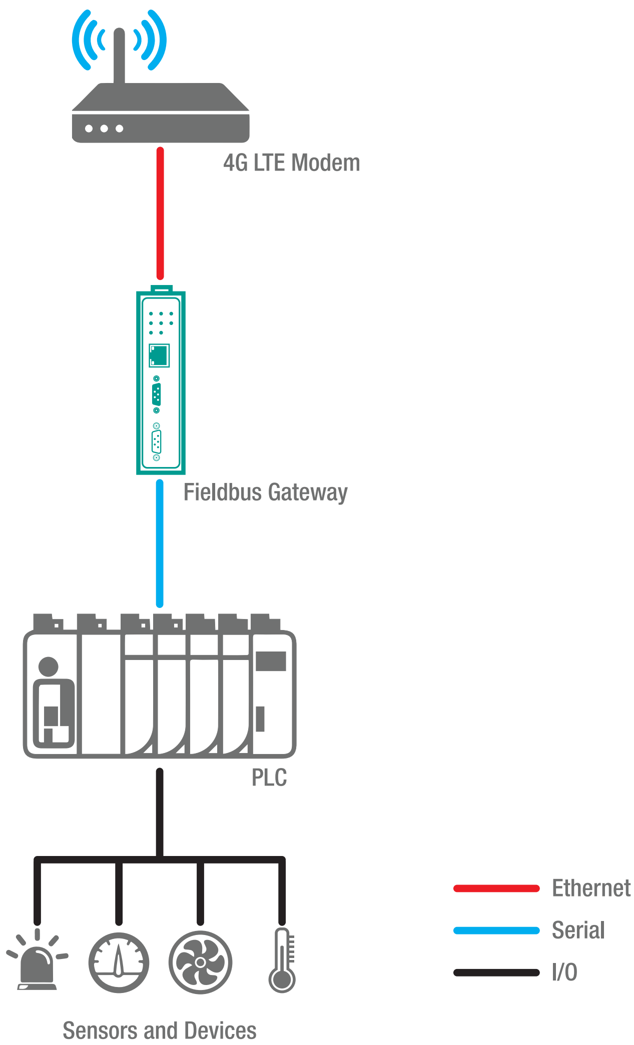
To collect data from sensors on site, you have a number of options. You can connect those sensors to an **Ethernet I/O module, RTU, PLC, data logger**, or **embedded computer**, depending on a number of factors including type and quantity of data, frequency of sampling, and amount of processing/control/customization required.

NOTE: Manufacturers of these units may also offer options for 4G LTE connectivity either built-in or as an add-on module. This can reduce the amount of hardware required, but there may also be a trade-off in flexibility and performance. Just as 4G LTE router manufacturers do not specialize in industrial devices and I/O, industrial communication manufacturers generally do not specialize in cellular communications.



Collecting Data from Devices

Many industrial devices still use serial ports for communication and control, which means a conversion to Ethernet is necessary before their data can be transmitted over 4G LTE. If you need to connect to such a device, you will likely need a **fieldbus** or **protocol gateway**, which is designed to enable Ethernet-based industrial protocol communication with a serial-based device. You can then send properly formatted commands to the device locally through the protocol gateway or over the 4G LTE connection.



Good Luck!

As we've demonstrated, 4G LTE offers many advantages as a means to connect industrial devices and sensors to the Internet. The key to unlocking the full advantages of 4G LTE is making the right choices to fit the nature of your application, the type of data that you ultimately require, and the existing devices or system architecture that you are dealing with.

While there is no single approach that is ideal for all situations, the background and basic tips we've outlined should help guide you towards a smoother deployment and more efficient use of your data plan.

We hope you found this guide useful and wish you the best of success on your project.

If you have any questions or if you would like to discuss your specific project requirements, feel free to contact us at **usa@moxa.com.**

- The Moxa Team

About Moxa

With almost 30 years of experience in communications technology for industrial automation, Moxa is one of the world's leading providers of solutions that enable connectivity for the Industrial Internet of Things.

Our edge connectivity, industrial computing, and network infrastructure products have helped connect more than 40 million devices worldwide in industries including: factory automation, smart rail, smart grid, intelligent transportation, oil and gas, and marine.

We pride ourselves in helping our customers harness the power of automation network convergence and making their operations smarter, safer, and more efficient.

As an active member of multiple industrial associations including the Industrial Internet Consortium, SunSpec Alliance, EtherCAT Technology Group, ODVA, Modbus IDA, and PROFINET International, we strive to promote open standards and interoperability.

Visit **moxa.com** to learn more about us and the different communications solutions that are tailored to the needs of industrial users, system integrators, and OEMs.