Capturing Edge Data Through Cellular Networks

The advancement of Industry 4.0 is largely thanks to the development of the Internet of Things (IoT), which has created a digital bridge between physical components. "Connecting physical items such as sensors, devices, and enterprise resources to the internet are major attributes for industrial manufacturing in Industry 4.0," as stated in *Logistics 4.0: Digital Transformation of Supply Chain Management.*[1] Before the internet and IoT, systems that weren't physically connected couldn't operate together.

Collecting Data: Then & Now

Measuring tides is a good example of how the latest Industrial Revolution has changed the way we collect, share, and use data. Early on, the U.S. Coast and Geodetic Survey deployed self-recording tide gauges. A pen attached to a wire-and-pulley system would scribble on a constantly rotating paper drum to track changing water levels. Contrast that to today's sea level measuring tools: they use radar off-pier to determine water level; this data is then converted and stored digitally. Finally, the recorded data is shared wirelessly to geostationary satellites.[2]

Technology has rapidly–and radically–changed the way we are able to capture data at the "edge." Edge data refers to the information collected and processed at the edge of a network, close to where that data is generated. Where before that data had to be manually collected, IoT minimizes latency by nearly instantly sending data to centralized data centers or the cloud. What used to take days or weeks is now measured in milliseconds.

SOURCE: CLIMATE.GOV.

The closest component to this edge data are sensors–recording anything from temperature to liquid flow rate–and input/output (I/O) devices–gateways or controllers. Data is captured by the sensor and sent through the input of the controller. The data can be locally processed and outputs on the controller can be used to perform conditional logical control at the edge (a primary feature of ControlByWeb® edge controllers). Otherwise, data is converted to a readable format, such as MQTT, and shared with a central system, such as a cloud server or remote data center.

Edge Data Transfer Technologies

One of the key components of the journey of edge data is how the data is transferred from gateway to central system. There are a number of modern technologies that fill this role:

- **Ethernet.** A wired networking technology that provides reliable, high-speed data transmission. Requires a physical Ethernet port connection between each end point.
- **WiFi.** A wireless networking technology that enables devices to connect to the internet over short to medium distances; commonly used in offices and urban areas due to widespread availability.
- **BLE (Bluetooth Low Energy).** A wireless communication technology designed for short-range, low-power applications. Ideal for consumer applications and battery-operated IoT devices.
- **Cellular.** Mobile networks (e.g., LTE-M, NB-IoT) that provide wide-area coverage and reliable connectivity, suitable for IoT applications that require remote monitoring and mobility.
- **Mesh Networks.** A network topology where devices (nodes) connect directly and dynamically to each other, creating a robust and self-healing network, ideal for smart city applications and large-scale sensor networks.[3]

Of these, cellular networking offers the most expansive coverage. Within milliseconds, data recorded offsite can be shared with a central system hundreds of miles away.

Cellular Stands Out in Industrial IoT

Early IoT applications used 2G and 3G networks to transfer data. These were useful to system integrators thanks to widespread coverage and reliable connectivity. 4G and 5G LTE networks significantly expanded the potential of data transfer with increased bandwidth and lower latency for complex use cases.[4] Even though 2G and 3G networks are more ideal for IoT applications, they have largely been shut down by cellular service providers in North America.

LTE-M (Long-Term Evolution for Machines) and NB-IoT (Narrowband Internet of Things) were developed specifically for IoT. They offer low power consumption with improved coverage and often better in-building penetration. They're ideal for the smaller, frequently shared data packets produced by edge IoT devices. NB-IoT, Rel 13 (which is offered in the U.S.) is the narrower of the two technologies, offering a simpler network structure and much lower data rates. LTE-M consumes slightly more energy, but allows for 1 Mpbs data packets and handover between cell towers.[5]

> 4G and 5G networks do have their place in edge data applications: Offshore operations in the Gulf of Mexico and North Sea are adopting 5G for improved signal integrity, indoor/outdoor connectivity, and fidelity.[6]

There are two common ways to integrate cellular networking into an edge data solution. An industrial router can be installed in near proximity (right on the DIN rail if it's compatible), acting as a cellular gateway between the input module and larger system. Alternatively, a cellular-enabled controller with an embedded eSIM offers an all-in-one solution, both collecting input data and forwarding that data.

Is Cellular Networking Right for You?

There are many benefits to using cellular networking in an IoT application, as well as drawbacks worth considering.

Benefits	Limitations
• Cell networks offer **easy scalability**, supporting a large number of devices which can be increased later without significant cost or complication. • There's **no need to hardwire**, which may be difficult or impossible in certain instances. (Even in urban areas where cabling abounds, it could by physically inaccessible.) This allows integrators to **avoid high up-front costs** associated with routing and channeling. • Cellular-enabled IoT controllers from ControlByWeb can use cell as a failover to Ethernet or vice-versa, **increasing redundancy** in case of system failure. • System administrators can push software and SIM updates, set up devices, and adjust settings fully remotely, offering **greater longevity** compared to systems that can only be accessed from shorter physical distances.[7] • Cellular controllers can provide an **out-of-band connection** to other cellular devices; if a 4G/5G modem loses connection, an LTE-M-enabled controller can independently power cycle the system, including the modem.	• There's a risk of **reaching data limits** and **incurring overages**, but this can be mitigated by optimizing data usage and picking the right cell plan. • **Power draw** may be significant (though LTE-M has largely solved this issue). • Managing multiple devices on various networks may **increase complexity.** • There may be **insufficient cellular coverage** in the application area. • While costs may be lower initially, **recurring service fees** do add up over time; it may be cheaper to pay more upfront to save money years down the road. • There's a **dependency on carriers** to maintain towers and infrastructure. This is no problem in metropolitan areas where multiple towers overlap, but it may be a concern in rural locations that are dependent on a single cell tower.

It should be noted that significant advancements are being made in IoT and OT security. It's understood that these devices and systems can be a critical entry point for bad actors. Identity security company CyberArk recommends focusing on three key elements to increase the security posture of your system in their *The Three Phases of IoT and OT Security* white paper:

1. **Discovering devices.** Review the landscape of devices in use by your organization. Cameras, printers, teleconference equipment, operational technology, etc.
2. **Securing credentials.** Implement a process to ensure credentials are secured and rotated regularly. Store them in a secure vault to avoid attacks on hard-coded credentials.
3. **Updating firmware.** Ensure devices are regularly updated with the latest firmware and patches. Unpatched vulnerabilities are a common entry point for attackers.[8]

Where Cellular Makes Sense

With these benefits and drawbacks in mind, here are practical industrial applications where cellular networking is the clear choice for data transfer.

Independent operations. Larger organizations with well-established IT and OT systems will often require extra hoops to jump through to add third-party hardware or software. Cellular allows for a fully independent edge data solution that doesn't need to integrate with any existing network. It's ideal for independent system integrators to quickly deploy an all-in-one solution for clients without all the red tape.

Physically remote. One of the strongest cases for cellular is the ability to capture edge data in remote locations with no Ethernet—let alone a power source. LTE-M offers low-power, widespread coverage. It's practical for battery or solar-powered solutions such as security camera trailers, river water level monitoring systems, or remote machine monitoring. Anywhere you have cell service, you have the capability to capture and use edge data.

No existing infrastructure. Urban areas abound with Ethernet wiring, WiFi and BlueTooth devices, and power outlets—but they are often physically or virtually inaccessible. Cellular service is abundant in cities and integrators often have their choice of LTE-M, 4G, and 5G for their application. LTE-M is ideal for efficient data usage and power consumption. 4G is particularly useful for seamless indoor/outdoor connectivity, offering better object and wall penetration than 5G while supporting more than sufficient speeds for IIoT.

Versatile Controllers for Edge Data Capture

As stated above, a crucial aspect of capturing and using edge data is the gateway device bridging the gap between sensors. Ideally, you want something that offers the right features without adding unnecessary complexity or cost. A traditional programmable logic controller (PLC) may offer the most I/O and raw processing power—but at the highest cost. And, while a simple network gateway may fit the bill, they lack any additional features or the ability to offload processes from a central system.

ControlByWeb IoT controllers strike an ideal balance, allowing for data capture while bringing logical control to the edge. They feature a web-accessible, embedded interface that uses drop-down menus to quickly and easily establish logical control at the edge. (This is great for redundancy and monitoring when a central system experiences downtime.) There's no software, making them secure by design. ControlByWeb modules also use an open REST API for easier integration, plus industrial protocols such as MQTT, Modbus TCP/IP, and SNMP.

> **Consider ControlByWeb** for your next edge data project, cellular or otherwise. You have the option of controllers with cellular connectivity, WiFi capability, or Ethernet to best match your application. There's a lot of capability to uncover with these "micro" controllers.

Industry 4.0 and Beyond

Ultimately, cellular networking is another flexible tool in the toolbox of IoT system integrators alongside a bevy of sensors, devices, software systems, and protocols. It's a cornerstone of edge data capture within Industry 4.0—and cellular developments are promising for the future. While security considerations are top of mind for any application, there are many steps system administrators can take to assure they're within an organization's acceptable level of risk aversion.

Advancements in edge data capture and control have revolutionized the way we interact with the world around us. It pays to stay informed of the latest technologies to maintain a competitive advantage and capitalize on what's available in the modern marketplace.

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