How cellular technologies can help streamline grid modernization

verizon business

Foreword

Utilities are faced with a plethora of challenges, including demands for greater sustainability, the proliferation of renewables and the rapid growth of electric vehicles (EV) to name just a few. To meet changes in both supply and demand, new approaches have emerged, like micro grids and distributed storage. But the challenges keep growing,

Grid operators need to be able to monitor, predict and react quickly. To achieve this, traditional and siloed components of the grid – such as advanced metering infrastructure (AMI), distributed automation (DA), distributed generation (DG), distributed storage (DS), home energy management systems (HEMS), demand response (DR), and supervisory control and data acquisition (SCADA) – need to communicate near real time, reliably and securely. This will enable operators to manage and control the grid to distribute power in a more efficient, effective, environmentally sustainable and economical manner.

The lack of interoperability, limited capabilities and inadequate security of the proprietary systems – traditionally used for communication with these critical components – mean that they are not up to today's demands. The best option for operators looking to create smarter grids are cellular technologies. Recent advances in cellular technologies make these networks ideal to operate grids in a more unified way, to improve efficiency, reliability and agility.

In this paper, we look at why cellular technologies are the best fit for operators looking to modernize their grids.

+40%

Americans will use 40% more electricity by 2050 driven by widespread EV adoption.

Department of Energy[6]

21%

In 2021, about a fifth of U.S. energy production came from renewables.

EIA[7]

3x

Electricity transmission systems may need to triple by 2050"

Department of Energy[8]

Contents

Use cases for 5G in utilities

The three main use cases of 5G shown below have direct implications and uses for the smart grid.

Enhanced mobile broadband (eMBB)

- 20 Gbps peak speed
- 100 Mbps edge area

Reliable, ultra-low latency connectivity (uRLLC)

- Single-digit millisecond latency
- 10^{-9} error rate

Massive IoT communications (eMTC)

- Potential device density of 1,000,000/ km^2 ($0.386mi^2$)
- High energy efficiency

Support for a multitude of devices

Smart grids are characterized by large numbers of IoT devices – such as smart meters, line sensors, cap bank controllers, fault circuit indicators and transformer monitors. Service quality requires that these can communicate with low latency and high reliability. Massive machine type communications and ultra-reliable, low-latency can meet these needs and support the scale of deployment required for grid transformation.

Service quality and resiliency

Precise generation/distribution control and accurate and timely fault prediction, detection and correction are critical to the smooth operation of the decentralized smart grid. Distributed energy resources (DER) requires millisecond-level parameter detection and control to reduce grid fluctuations. eMTC and uRLLC enabled by 5G offer the most advanced option for increasing operational efficiency and mitigating the impact on service quality of changes in:

- Power quality
- Demand levels
- Environmental factors (especially for renewables)
- Market dynamics

The functionality offered by uRLLC and eMBB is the most cost effective and reliable option for vegetation management via drone, wide area monitoring for line repair, and monitoring physical security via high-definition video. The same capabilities could also support utilities as they make greater use of AR/VR for worker safety and knowledge augmentation, while reducing additional capex outlays.

Mobile edge computing

Changes in both supply and demand are forcing utilities to transform their grids to be more decentralized and transactional in nature. This evolution is becoming even more imperative as EVs become commonplace, renewables make up a greater proportion of generation and distributed generation and storage become the norm. The grid of the future will need to be able to react responsively to local variances and fluctuations caused by:

- Peaks and troughs in generation
- Anomalies in distribution caused by renewables and micro-grids
- Regulatory requirements, including pricing incentive/penalties

Consequently, grids will need to be more collaborative, more agile, self-healing and able to self-optimize. The components that make up the grid will require significantly more local decision-making capabilities. This is backed up by studies carried out by Max-Planck Institute, which have shown that local decision-making and optimization are the best option for decentralized grids.[1]

Edge computing is a decentralized form of computing where data is processed and stored closer to where it's gathered and used — the edge. This has several potential benefits, including:

- **Greater responsiveness**
  By reducing the distance data must travel, latency can be reduced and responsiveness increased.
- **Improved business continuity**
  By enabling processing at local/regional facilities, sites can be kept running even when communication to a primary site is compromised.
- **Reduced costs**
  By pre-processing data at the edge, the volume of data that needs to be transmitted to the cloud can be reduced, cutting connectivity costs.

Mobile edge computing (MEC) is an extension of 5G networks which blends local compute and storage for workloads that are latency sensitive and centralized cloud for backend services support for collaboration, resilience and processing workloads that are latency-tolerant.

5G and MEC provide distinct advantages over any other communications techniques for utility companies. In the following sections we'll look at some of these in detail.

Public versus private

Computing

Public MEC

In general, public MEC solutions are well suited for applications that need broad geographic cloud-computing coverage, or those that must be accessible to the public, such as monitoring of critical assets. The public MEC can substantially reduce latency and lag over the traditional cloud-computing architecture.

Private MEC

Private deployments colocate network, compute and storage on-premises, where the data is generated, providing the highest performance and lowest latency by shortening that last mile even further. This also provides even greater security and data sovereignty over a public deployment when customer or application needs dictate these levels of performance and security. Combined with 5G, edge computing can create an architecture for next-generation solutions that can accelerate grid modernization, support innovation and enable highly agile operations.

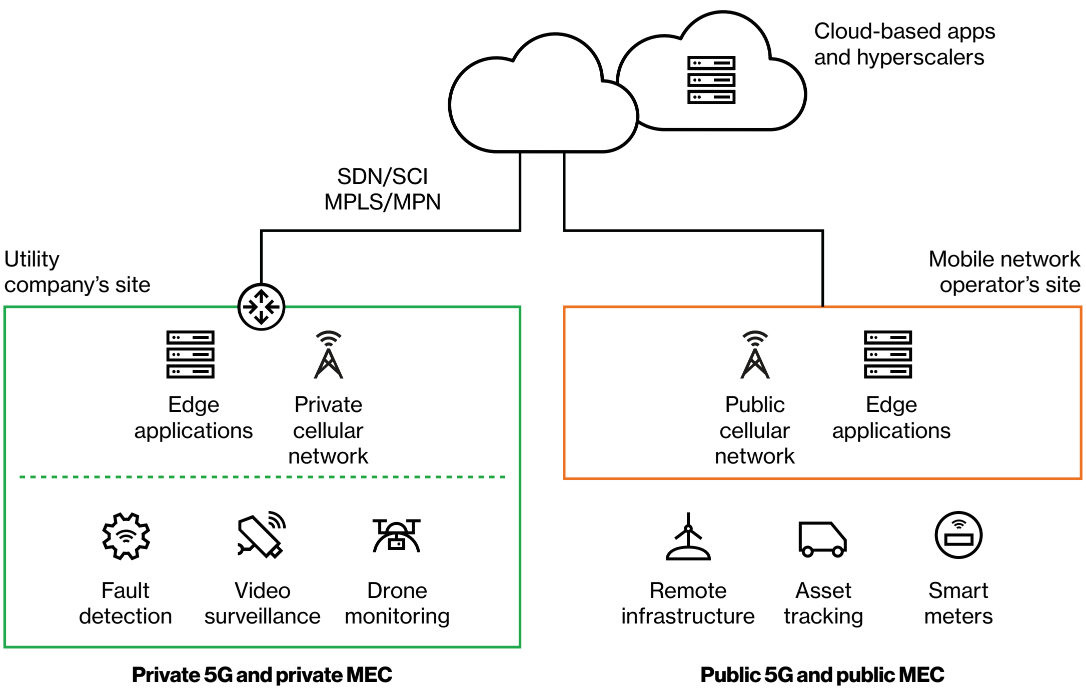

Figure 1: High-level view of public and private MEC using public and private networks.

Secure cloud interconnect (SCI) services enable you to securely connect to your cloud ecosystem, using connections that are completely separated from the public internet.

Multi-protocol label switching (MPLS) is networking protocol built for flexibility and peformance.

Mobile private network (MPN) offers last-mile connectivity to the enterprise's internal network via cellular technology.

A hybrid approach

In a hybrid approach, some devices and applications run on a public MEC and others on a private MEC, with access to an SD WAN managed by an application orchestrator. That way, an enterprise can secure its most important data while optimizing network value. An orchestrated hybrid approach can therefore distribute workloads dynamically across public or private MEC sites over the SD WAN. This maintains some of the flexibility benefits of a public MEC infrastructure while providing the control of a private network.

Networking

Public cellular networks

As discussed earlier, LTE and 5G standards have many inherent security features, so while not private, public cellular networks offer a good degree of protection—more than say Wi-Fi. The key benefit of a public cellular network is the breadth of coverage. Roll outs are still continuing, but networks now cover a high percentage of the U.S. population. This means that public cellular networks are ideal for applications like remote reading of smart meters and tracking maintenance vehicles. But, unlike a private network, coverage and performance is controlled by the MNO. And that's where private networks come into their own.

Private cellular networks

A private cellular network is a wireless local area network (WLAN) that uses LTE or 5G technology and licensed, shared or unlicensed wireless spectrum. It is a dedicated network configured to support an enterprise's specific requirements within a specific geographic area—typically a campus, plant or other facility. Private cellular networks meet the ownership, control and longevity requirements critical for utilities companies.

Key attributes of private cellular network

Seamless

Enables wide mobility range on campus and beyond the campus via controlled remote user access.

Reliable

Delivers consistent, predictable connectivity and prioritized network access.

Secure

Provides built-in 5G security with management and monitoring against threats.

Agile

Supports fast and scalable reconfiguration and digital acceleration.

Easy

Empowers customers to focus on running their business, not their network.

Powerful

Delivers unprecedented performance from high bandwidth and low latency of 5G Ultra Wideband for many demanding applications.

Many utilities already have spectrum that could be repurposed to deploy private cellular networks. For those that don't already own suitable spectrum, service providers can offer licensed, priority access license, and unlicensed spectrum for the purpose.

Network slicing

One of the key transformational aspects of 5G is that it allows for the separation of physical and logical assets and allows the creation of a software-defined network (SDN). This separation of physical and logical assets of the cellular network allows 5G to support “network slicing.”

Network slicing is a technique to create and dynamically manage logical functionally discrete end-to-end networks over the same physical infrastructure. The significance of this for the utilities is that they now can use different network slices for different applications and use cases with associated latency, bandwidth, quality of service requirements with one unified network. This unique capability of the 5G network will significantly simplifies utilities operational technology (OT) deployment, management and security implementation.

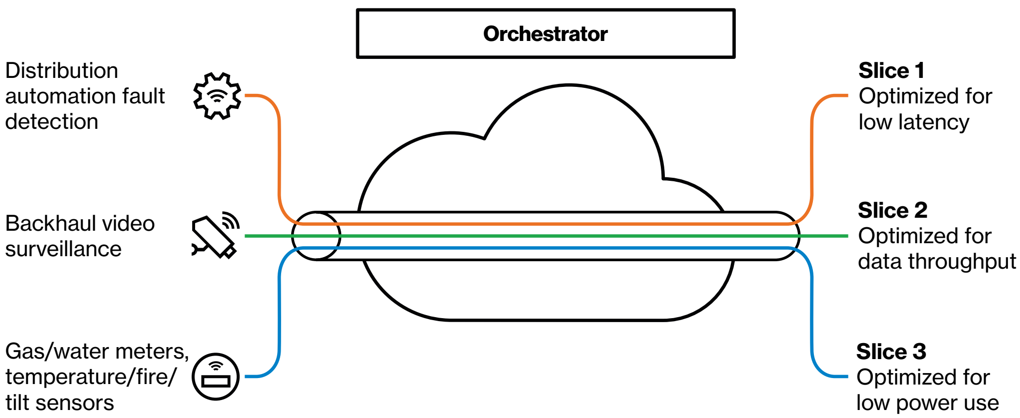

Figure 2: Example of network slicing on a 5G network.

The properties of each network slice can be set independently, enabling quality of service (QoS) based on the application. In the example above there are three network slices, each optimized differently:

1. **Latency**
   Suitable for delay- or jitter-sensitive applications
2. **Bandwidth**
   Suitable for applications with heavy traffic, such as video analytics
3. **Power consumption**
   Ideal for battery-powered devices where conserving energy is critical

In this way, a single 5G network can support multiple very different applications, with the allocation of resources orchestrated automatically.

Layers can also be set to have different security requirements. Authentication, encryption and data isolation can be set depending on the slice and virtualized security network functions, such as a virtual firewall, applied at the slice level.

When using a public network, deployment, management and maintenance would typically be carried out by the cellular service provider. With a private network this could be done by the operator, but again could be handled by a third-party. Outsourcing the management enables the utility to focus on its core operations and meeting its business objectives.

About SDN

Software-defined networking (SDN) is an approach to that separates the control and data planes to enable dynamic, programmatic network configuration. This can simplify network management and help make the network more responsive to changing needs. SDN is to networking as cloud is to computing.

Low-power wide area networks

Utilities have traditionally preferred proprietary low-power wide-area networks (LPWANs) using unlicensed spectrum for their grid modernization efforts. While inexpensive, such technologies do not meet the advanced and complex communication requirements of the smart grid.

LTE introduced true low-power wide-area (LPWA) cellular options for the utilities for latency tolerant and cost-effective communication especially for AMI networks. The LPWA standard introduced in the LTE specification has also adopted for 5G. This will help extend the lifecycle of networks and devices used for metering applications, potentially increasing the ROI of projects.

Cellular LPWA option of either CAT-M or narrow band IoT (NB-IoT) offers clear advantages over proprietary non-cellular LPWA technologies such as WiSUN, LoRA, Ingenu and SigFox. These technologies use unlicensed bands, need significant output power and suffer from power cycle restrictions.

With LPWA the lower bandwidth, frequency hopping and repetition, the link budget increases, enabling better performance in fringe areas and better penetration of in-building and in-ground locations.

The key benefits of CAT-M and NB-IoT over non-cellular LPWA

Improved power efficiency

Power-saving mode enables devices to be set go to sleep – off the network, but not forgotten

Cat-M and NB-IoT are the most cost-effective and reliable options for battery-powered devices, such as smart gas and water meters

Extended DRX enables an active device to check in with the network less often, saving battery power.

Enhanced coverage

Cellular offers better coverage in areas other standards struggle with – such as outdoors and tricky indoor locations such as factories.

5G is highly scalable – the specification can support up to 1,000,0000 devices per km^2 (0.386 mi^2)

Extended coverage and better in-building and in-ground penetration

Accelerated time-to-value/ improved ROI

The device certification process for Cat-M and NB-IoT devices is simpler and therefore less expensive and quicker.

Consistency in cellular standards – the same standards apply to both 4G and 5G – can help improve the longevity of devices.

Cybersecurity

The increased use of communications infrastructure to monitor and control smart grids creates a larger attack surface for malicious actors.

While deploying new communications infrastructure to create a highly interconnected smart grid has many benefits, it also creates more vulnerabilities for cybercriminals to exploit Utilities without a comprehensive security strategy in place could find themselves the target of an attack that could cause widespread disruption, incur regulatory penalties, damage customer loyalty and lead to a loss of revenue.

Key findings for utility companies from the 2022 Data Breach Investigations Report[2] include:

96% The vast majority of threat actors were external agents, just 4% were internal

88% Most breaches came under the system intrusion, basic web application attacks or social engineering categories

88% The majority of attacks were motivated by financial gain, but 11% were classified as espionage

40% Two-fifths of successful attacks includes the loss of credentials information

Cellular networks provide enormous security advantages for the utilities over any other communication networks. The security built into every layer of the 5G network standard – starting with the SIM-based authentication of the end devices and rigorous security practices used by the cellular service providers – provides a strong defense against sophisticated cyberattacks.

5G leverages the security measures built into 4G and adds many additional innovations to help mitigate the dangers, including:

- Support for end-to-end encryption of both in-band user data and out-of-band signaling, making it nearly impossible to intercept information over the air
- Improvements to authentication and roaming protocols to make it harder to use stingers (or IMSIcatchers) to eavesdrop on communications and steal credentials
- Secure edge protection proxy (SEPP) to prevents less secure networks from harming the 5G network they are connected to
- Data isolation, using network slicing, helps to reduce the spread of attacks and attackers' ability to move laterally to compromise other systems

86%

Research commissioned by Bridewell in 2021 found that the vast majority of critical national infrastructure (CNI) organizations had detected a cyber attack on their operational technology (OT) or industrial control systems (ICS) in the previous 12 months.

Bridewell[4]

93%

And almost all of those admitted that at least one attack had been successful.

Bridewell[5]

Conclusion

Cellular technologies present utility companies with a clear path to simplify and accelerate their digitalization efforts. They offer secure, reliable unified networking that can support the multitude of use cases and applications, with their varying requirements, needed for grid modernization.

Adopting private cellular networks will enable utility companies to retire legacy proprietary networks that are disjointed, hard-to-maintain, difficult-to-scale and vulnerable to growing cyber threats. And as grids become more decentralized and complex to meet changes in supply and demand, the advantages of cellular networks over other communication techniques will become even more evident.

Next steps

Are you ready to meet evolving market expectations and serve increasingly sophisticated customers? We have technology solutions that can help utility companies to deliver resources more efficiently and cost effectively.

Verizon makes an ideal partner for utility companies looking to create private cellular networks due to our expertise in:

- **Designing networks**
  We've designed cellular networks than span complex and varied environments, from dense urban areas to wide-open plains.
- **Network innovation**
  Verizon is an acknowledged leader in LTE and 5G. We hold a number of patents and can claim many firsts in the field of cellular technologies.
- **Managing networks**
  We manage wide area networks for over 4,500 enterprises around the world. And our cellular networks have been repeatedly recognized for their performance and reliability. In July 2022, Verizon was awarded the RootMetrics® US Overall RootScore® Award for the 18th straight test period—more than any other carrier in the report's history. And in RootMetrics' August State of 5G in the U.S. report, the independent mobile analytics firm announced that Verizon provided customers the most reliable 5G experience in the U.S. for the third consecutive test period.[3]
- **Application ecosystem**
  Verizon has an extensive ecosystem of partners that specialize in applications including automated guided vehicles, intelligent video analytics and condition-based maintenace. ICSA Labs, an independent division of Verizon, provides device testing and certification services.
- **Service integration and management**
  Verizon has invested heavily to build our Digital Engagement Platform (DEP) to enable our customers to simplify and automate the manaagement of their networks.

To find out more about Verizon's services for energy and utilities companies, visit

verizon.com/energyutilities

Verizon invested $52.9 billion to purchase a minimum 140 megahertz of C-band spectrum across the entire contiguous U.S. Our 5G Ultra Wideband service now covers more than 175 million people—over half the U.S. population—and should reach nationwide coverage in the first quarter of 2023.

References

1 Max-Planck-Gesellschaft, “Electricity: A smart grid, simply self-organized, decentralized, and hack resistant.”, ScienceDaily, 4 February 2015

2 Verizon, Data Breach Investigations Report, 2022

3 **Based on rankings from the RootMetrics® US National RootScore® Report: 1H 2022. 18 consecutive wins based on the RootMetrics® United States RootScore® Reports: 2H 2013-1H 2022. Most reliable 5G network based on more first place rankings in RootMetrics® 5G data reliability assessments of 125 metro markets conducted in 1H 2022. Tested with best commercially available smartphones on three national mobile networks across all available network types. Your experiences may vary. The RootMetrics award is not an endorsement of Verizon.**

4 Bridewell, Majority of CNI Organisations Experience Successful Cyber Attacks, 2022

5 Bridewell, Majority of CNI Organisations Experience Successful Cyber Attacks, 2022

6 Department of Energy, Biden Administration Launches $2.5 Billion Fund to Modernize and Expand Capacity of America’s Power Grid, May 2022

7 EIA, FREQUENTLY ASKED QUESTIONS, 2022

8 Department of Energy, Biden Administration Launches $2.5 Billion Fund to Modernize and Expand Capacity of America’s Power Grid, May 2022

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