REIMAGINING THE FUTURE WITH PLTE FOR UTILITIES

VALIDATED IN THE PGE CONNECTED UTILITY LAB

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Introduction

There is no industry vertical in such urgent need for innovation as the energy industry. According to the National Council of State Legislatures, costs to modernize the grid will top $2T by 2030. Most utilities in North America and Europe must be 70% - 100% carbon-neutral starting in 2030 and be project complete by 2040. Concurrently, utilities are being asked to decommission large, fossil-fuel based generation assets. This decommissioning is occurring at a time when electricity demand is spiking with new loads coming from EVs and consumer equipment in the home.

To support the demand for clean energy, the grid is literally being turned inside-out with the "last mile" (consumers residential households) becoming the "first mile" as they begin to put power back onto a bi-directional grid. For the first time in the grid's 150-year-old history, there will be a two-way flow of generation. This will advance grid modernization efforts where more devices will need to be connected and controlled by utilities to balance distributed energy resources in real-time. However, with the "electrification of everything" in a bi-directional grid, many utility executives are asking how they will meet growing demand and decarbonization goals at the same time, without sacrificing reliability?

To connect critical grid devices, utilities have historically relied on a combination of public cellular, fiber and proprietary wireless networks (for example RF mesh) in what is commonly referred to as a Field Area Network (FAN). The FAN is a network that connects a utility's fleet of field assets (e.g. from meters to energy storage systems, reclosers and sensors) to support mission critical grid operational systems. Without FAN connectivity, a utility cannot connect devices to gather data, maintain situational awareness, respond to emerging operational situations, or have the control required to deliver uninterrupted field operations. Without this connectivity, real-time systems such as Advanced Distribution Management Systems (ADMS), Distributed Energy Resource Management Systems (DERMS) and wildfire detection technologies cannot function accurately. For most utilities, there is a growing realization that connectivity is now in the critical path for delivering reliable, clean energy and meeting decarbonization goals.

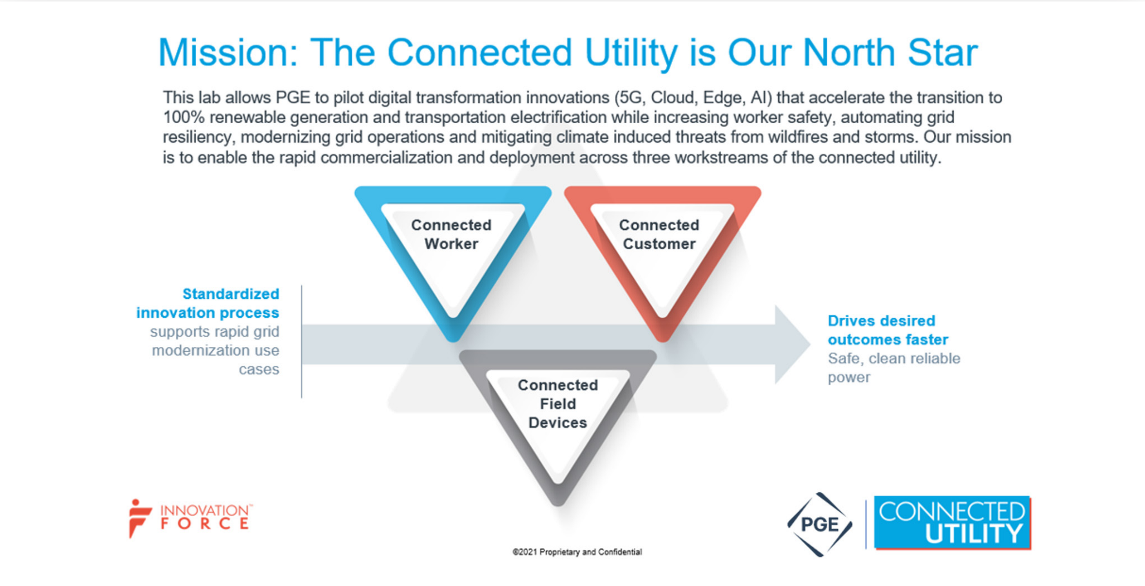
The connectivity question is causing utilities to think differently about the way communications technologies can support their FANs. Proprietary wireless networks have been limited in their ability to scale, are expensive and lack the standardization necessary to avoid obsolescence. New, standards-based 5G networks are becoming more ubiquitous and affordable, but can they be trusted to be "utility-grade"? Despite the promise of cellular, will utilities be able to deploy and support private cellular networks to meet their required timeframes?

This whitepaper offers learnings from a 5G test lab hosted by PGE |Connected Utility Lab that was driven by a mission to push the "art of possible" from 5G and cellular-based networking technologies. This whitepaper shares the learnings from the first year of the two-year lab effort and offers a reference architecture to help utilities understand how they can leverage 5G private mobile networks to meet the decarbonization goals of 2030 and beyond.

The Connected Utility Lab: A 5G Innovation Sandbox Allows Utilities to Think Differently.

Portland General Electric (PGE) must be 80% carbon-free in their electricity delivery by 2030. This deadline encouraged them to think differently about their FAN and, as a result, they began curating a technology ecosystem to innovate around the art of possible for 5G and cellular networks, which were becoming a more essential part of their overall grid operations. This lab, called the "Connected Utility Lab", grew out of the need to test cellular technologies to support grid operations without sacrificing reliability or performance.

The Connected Utility Lab was a unique concept from its onset because it looked to partner with industry thought leaders like Intel, Google, and T-Mobile who were paired with new disruptive 5G startups that were introduced into the lab ecosystem from incubators like the 5G Open Innovation Lab (5G OIL). Using an innovation ecosystem model introduced and managed by InnovationForce, these parties came together to collaborate with PGE and rapidly experiment with 5G as an augmentation of their FAN.



For utilities looking to rapidly deploy new field assets for major initiatives, such as grid modernization, decarbonization, electrification, clean energy transitions and wildfire mitigation, cellular networks present a very attractive option to accelerate time-to-production – but could they meet reliability, bandwidth, and latency needs? The ecosystem in the lab worked through questions like: How could PGE support as much as a 10X increase in the number of devices predicted to be connected in the future-state grid? What role could 5G/ cellular play? How could cellular be trusted by utilities? What benefits would 5G bring through standardization, affordability, or reliability overall? How would data be used and needed? Could cellular be secured via private networks and at what cost?

These questions were rolled into problem statements that resulted in respective solution framing documents and became sixteen (16) use cases to be conducted in 90-day field trials over the course of a 2-year period.

How to Test the "Art of Possible" in a 5G Context

5G is the fifth-generation technology standard for broadband mobile networks and has been steadily deployed by various cellular companies across the world. But how could it be tested? The four (4) main considerations a utility typically asks before deploying 5G/cellular into their FAN includes:

1. Can it meet network performance requirements around bandwidth, latency, stability, and reliability for the most mission critical use cases, such as SCADA?

2. Can cyber security controls be applied to varying degrees, such as: network segmentation, end-to-end encrypted transport pathways, end point isolation, and network security monitoring?

3. Is there strong and reliable wireless signal available to provide required coverage for field device endpoints across varying terrain, such as hills and trees?

4. Can my FAN scale quickly at a low cost, and can it be supported and maintained in a more cost-effective way while standing the test of time against obsolescence?

To learn through field trial experimentation, test plans were devised around four (4) key factors: latency, bandwidth, error rate, and wireless range.

- Latency: This reflects the time it takes for data to move from an endpoint to another node in the network. As the number of field assets for utilities continues to grow, and demand for more real-time data exchange along with it, low latency is very important to maintain operational situational awareness, understand field device endpoint health and minimize the time to complete critical network transactions. Latency is typically represented by the physical distance and time between network nodes that are communicating with each other.

  For lowest latency needs, point-to-point communications protocols such as proprietary wireless mesh have been used in FANs. However, with the standardization, ease and ubiquity of cellular networks, utilities are turning to lower latency through the use of pLTE (Private LTE networks) that they can deploy and maintain at the edge for use cases. Because pLTE networks are expensive to install and maintain, they can be selectively used in key locations to augment a FAN or replace the proprietary wireless mesh.

» Bandwidth: This reflects the rate of data transferred between two endpoints in the network. This is typically measured in megabits per second (Mbps). 5G provides bandwidth capacity improvements and offers an advantage over proprietary wireless mesh or point-to-point systems. Until recently, most utility field sensors would only need to send small data commands and not large data packets. However, new needs are driving more data, including video, imagery, surveillance, automation, robotics and AR/VR – all of which are starting to show signs of growth in and around the substation edge.

Higher bandwidth provides utilities with a network that positions them to support a fleet of field devices remotely, in addition to the field asset's main function. For example, if a utility were to connect smart grid devices, such as modern Recloser devices, the utility would now be able to quickly execute remote firmware updates across the fleet. Firmware updates are becoming increasingly common in smart grid fleets due to enhancements that need to be made in operations from field learnings over time. If a utility has thousands of endpoints, it is very important to execute upgrades quickly to maximize field device performance without having to complete a truck roll to each device. This saves the utility time while maximizing operational capability and lowering OPEX.

Finally, ADMS systems have the ability to send more data to the tablets and computers of workers in the field, but without increased bandwidth, this data cannot be uploaded or received as it may be required for the system. This may not be a disadvantage on a good weather day, but could prove more treacherous on a bad weather day when the field is trying to send data to operations and vice versa.

5G networking can provide improved bandwidth for each endpoint. As data-hungry applications start to increase, having higher bandwidth networks is creating a need for utilities to begin to layer 5G cellular into their FAN strategy.

» Wireless Range: This refers to the physical distance a wireless communication signal can travel. Lower frequency bands such as 450MHz can propagate much further than a higher frequency band such as 6GHz (or above). Although lower frequencies have the benefit of being able to travel reliably at longer distances, they transfer data at lower bandwidth speeds and may not be able to support some of or all of the higher bandwidth use cases described above. The higher frequencies travel at shorter distances and transfer data at higher bandwidth. This is another point to consider around the use case needs to ensure that the right network can support the right devices and use cases in a utility's service territory

In the utility context, we see the advantage of proprietary wireless mesh that can communicate point-to-point in long ranges – for example, when trying to send small data bits to sensors along a distribution line. However, this would not fare well for data hungry applications that must transmit between an edge device and cloud. Or perhaps a collector that gathers aggregated data from many devices to a cloud might want to have the option to transmit the large amount of data using the cellular network. Here it is again important to see that this is not a competition of one wireless system to replace another, but rather a solution for the specific use case and need to help decide the wireless strategy that most efficiently can be leveraged for the function that best supports grid reliability.

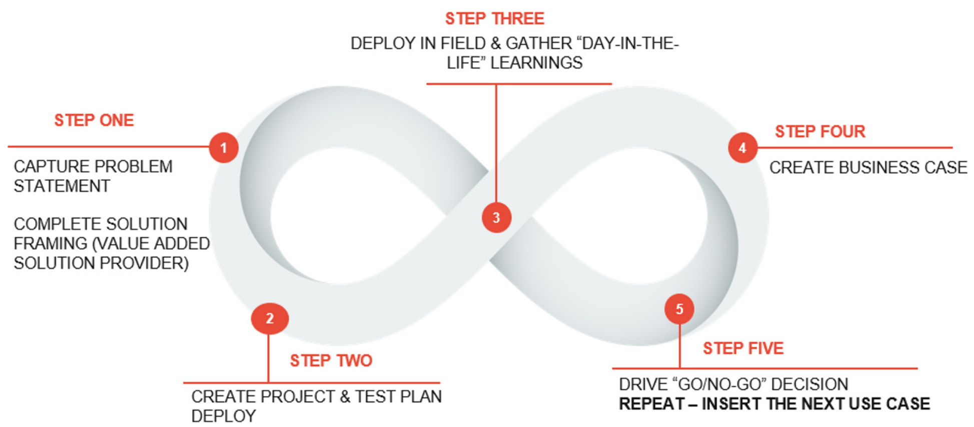
Understanding the characteristics of how a utility wants their use case to perform is the most important consideration for the choice of network. Solving the use case problem will drive what network is best fit for purpose. As illustrated above, some use cases may require high bandwidth, others may need low latency across longer ranges, and sometimes the need is to have both when it comes to collecting data and sending it to the cloud. Knowing the need can help utilities develop the right wireless networks to field, and through experimentation, learn what is the right fit in their service territory. This experimentation, for example in a 5G test bed environment, can be the best influencer around the design of the FAN and should be constantly evolving to support any wireless network type, for the needs of many use cases.

Table 1: Examples of Use Case Categories Under Test in the Lab

Use Case	Latency	Reliability
System protection and control applications	sub second	99.99%
Smart metering (AMI)	seconds – minutes	99.90%
Distributed Energy Resources	seconds	99.99%
Vegetation Management (video, surveillance, drones etc.)	seconds	99.90%
Connected workers tablets	seconds	99.00%
EVs	minutes	99.00%
Smart city (e.g. street lights)	minutes	99.00%
Physical security	seconds	99.00%

How PGE Tests 5G Use Cases to Drive Innovation

In the PGE Connected Utility Lab, use case problem statements are identified as a first step to understanding wireless network requirements. Subsequently, solution framing documents along with test plans are developed to test against these needs. Field trials and "day-in-the-life" learnings are gathered for each individual use case in the Connected Utility Lab, and shared with all lab participants, utility decision-makers and ecosystem partners. By understanding the business and technical needs from the beginning, the right networks can be evaluated to support the form, fit and function required by the grid modernization use case.



The PGE Connected Utility Lab created a five-step process to rapidly test cellular networks and experiment to find learnings that solve use case challenges. These steps are outlined below.

- Problem Statement: the business unit owner would document the problem they were trying to solve (e.g. to get real-time situational awareness to operations, we would like to test hands-free AR/VR technology that would allow field crew to show operations what they are seeing in a bad weather event or disaster).
- Solution Framing: the problem statement would be shared in the innovation ecosystem and a solution would be found. In the solution framing document, the 5G or communications manager would make sure to ask questions that would capture the bandwidth, latency and wireless range needs as well as additional network characteristics that would support the FAN strategy.
- Project and Test Plan: working together, PGE's SMEs and the solution provider would devise a way to test the technology in the field in 90 days or less. The test plan would specifically call out the wireless network characteristics they want to test in the field to get an accurate picture of network performance.

- Field Trial and Day-in-the-Life Learnings: with the technology being trialed in the field, we can learn how it performs in real-life. These learnings were captured by the appropriate personnel like field crews or others that are conducting the test as part of their "day-in-the-life" work experience. This feedback is captured in the field test but also in interviews with those who participated in the trial to uncover any learnings that might add to how the team thinks through the ultimate desired end state. Here it is important to gather if the new technology presented a solution that was better than the current way of working. If it was, were there any financial benefits (e.g., OPEX savings) that could be gathered from the learnings in addition to the technical benefits?
- Business Case: a quick business case is created to support the capital investment required and any OPEX savings that were realized in the field trial and day-in-the-life learnings. This quickly can show if the use case is presenting a financially better way of working over the current state method.
- Go/No-Go Decision: every quarter, go/no-go decisions can be quickly made on the use case experiments to determine if a better way to solve problems has been discovered. This allows the ecosystem of innovators (solution providers and utility business unit owners) to all learn from their experiments to quickly understand the "art of possible". The emphasis here is not on "failing fast" but "learning fast" – for the benefit of the utility and the industry (share use case learnings inside-out) to rapidly meet 2030 goals together.

This process was facilitated by InnovationForce working with PGE innovation managers. Learnings and documentation were captured in an online Innovation Hub where progress was measured in a dashboard that showed how use cases were progressing. Workflows around the problem statement and solution framing steps were created when templates or intake surveys could be used to capture data from multiple lab participants and encourage real-time collaboration. All of this was created in a Microsoft Teams environment which was chosen as the underlying technology platform to help scale and automate the innovation lab process to support the 16 use cases in a two-year period. This became important as the scale started to grow in terms of the number of use cases being explored (there are now up to 100 use cases) and the number of innovators involved inside PGE and outside partners (there were over 100 innovators participating in the lab).

Types of Cellular Networks – Private Versus Public Networks

There are two primary approaches to creating cellular networks: 1) public based networks offered by the wireless carriers and 2) private networks created by business enterprises (e.g. utilities) for their singular use.

Public networks can support a utility's FAN by using a carrier's SIM in a grid device, thus allowing data to be transferred over the public carrier network. While convenient and fast, there are many security, reliability and high data cost issues that potentially create OPEX concerns and hinder this approach.

On the other hand, private networks lock cellular service down to the specific business entity, like a utility, using that network. Within private networks there are two main deployment types – pLTE or private mobile network (PMN). The traditional method has been a pLTE network which requires the utility to buy, operate and maintain the network. This hardware-based approach requires radios, towers, leasing or buying spectrum and more that is expensive and time consuming. Today, new options have emerged that take a software-based approach to create a private network similar to pLTE for the sole use of that utility, but without the need to buy, deploy and maintain a radio/tower infrastructure. These software based approaches are called private mobile networks (PMNs) and are faster, more scalable and more affordable than pLTE. We explore each in more detail below.

A Closer Look at Private Networks: pLTE and PMNs

Private networks allow utilities to lock down their cellular network for their use only. To implement, utilities can take a hardware centric or software centric approach.

- Hardware-based approach / pLTE Networks: this type of network requires the utility to purchase all the network components, as well as deploy and maintain the network. Components include radios, towers, spectrum, and SIMs. While attractive for the security benefits gained from a purpose-built network designed entirely for that utility, these networks are expensive to build and maintain, and can take decades to deploy fully across a service territory. In the case of PGE, they estimated it would cost up to $500 million dollars to deploy, 10 years to deploy and about a $500M OPEX spend to maintain the network over a 20-year period.
- Software-based approach / Private Mobile Networks (PMN): these networks use software to deliver a similar network to pLTE but without the hardware. Instead of buying a standalone radio/tower infrastructure, software that is deployed behind the utility firewall can allow utilities to securely leverage the existing carrier network. Like pLTE, these networks are intended for the private and single purpose use by that utility. The key differentiator is that instead of deploying towers and acquiring spectrum, software defined PMNs allow utilities to leverage the existing radio towers maintained

by the various cellular carriers in their service territory. In a software defined PMN, data from devices can be transmitted over the existing carrier radio network in a protected way. These networks have special SIMs and software that belong to the utility for their individual use. This allows the utility to control the IP addresses that are defined for use by the devices on the PMN, resulting in seamless integration with all of their existing IT/Security procedures and policies.

A Closer Look at Public Networks

Public networks are offered by the cellular service provider, and they provide utilities with a generic SIM to use the network. If utilities want to protect their data, they can add VPNs, authentication, and additional layers of security. Utilities will typically purchase an Access Point Name (APN) from their carrier. An APN is a gateway between a GSM, GPRS, 3G, 4G, or 5G mobile network and another computer network, frequently the public Internet. A mobile device making a data connection must be configured with an APN to present to the carrier. These networks can be managed by utilities, but control continues to lie with the carrier meaning that when reliability issues need to be resolved, the carrier's response can impact uptime. In addition, any networking changes needed by the utility to support new applications or changes to the existing APN require engagement of the carrier. In addition their APN service does not allow for the extension of utility customer FAN subnetting and network policies to the public mobile network domain . These changes can often take weeks to complete and negate the ability for the utility to have the agility and control of their devices.

Hybrid Networks

As we have demonstrated, for most utilities' FAN, there is no one size fits all wireless solution if you let the use case, device and need drive the network decision. Additionally, having flexibility through a diverse portfolio of wireless network options will increase reliability and resiliency.

For example, a utility may already have a wireless mesh network to support point-to-point sensors or meters. This investment may be capitalized over 20 years and needs to be maintained for some time. However, given the needs of high-bandwidth, low latency applications being introduced to support modernization of the grid, utilities may want to augment their FAN with a mix of cellular based public and private networks. For some use cases that require very low latency at the edge, pLTE might be needed in specific locations. For the rest of the service territory, public or PMN options might be more feasible. In areas of poorest coverage, some utilities are leveraging network connectivity using satellite. Again, the strategy to future-proof the FAN is to look at it as a hybrid network where any wireless network could be utilized as an option but managed as one single network.

Trusting Cellular – Utility Grade Concerns

The utility industry has adopted cellular networking technology, but to varying degrees given concerns of cyber security, reliability, and obsolescence. While these concerns may have slowed the adoption of public network options, they can be alleviated with private network options.

Cyber Security

Concerns: For many utilities, leveraging public networks that are open to other users is not an option due to risks associated with their sensitive information traversing a public, consumer based, mixed use networking infrastructure. Locking down network access to endpoints is difficult to manage mainly due to VPN management. Additionally, when devices are mobile like tablets, they are deemed "untrusted" and can open up threats if non-utility users gain access and enter the network. Utilities have the ability to manage these with VPNs, creating no-trust networks and offering multi-factor authentication, but the required systems can be very demanding for utility staff to support and keep running, especially as the number of endpoints increases.

Overcoming the concerns/learnings: Have a plan that starts by understanding the level of security threat an application poses to better understand what's required to mitigate risks at the network level. For example, when grid devices are locked in a protected area and transmitting non-sensitive information, using a public network or a public network with a VPN might be acceptable.

In other contexts, the sensitivity and criticality of the data may require the need for a private network (pLTE or PMN) which can only be used by that utility. Understanding what data and device protection is required in the form of encryption, device authentication, location and access are all important when selecting the right type of network and the ways to protect that network. In the Connected Utility Lab, the team evaluated security on an individual use case basis to better understand how to select the right network for testing.

Reliability

Concerns: Utilities commonly desire an uptime of 99.999% due to the importance of the operational technology interactions that rely on these critical networks. But some devices and use cases might require less (see Table 1). Reliability requirements for specific use cases could be aligned with the individual carrier offering the network (unless in the case of a pLTE network where the utility would own, operate and maintain the network). In many agreements, the carrier's SLA is "best effort" vs. an uptime specification such as 99.999%. Additionally, utilities will want guarantees that they receive priority access on a public or shared network in a disaster. This fear alone has precluded many from taking advantage of the benefits of cellular on a large scale.

When considering carrier reliability, the key questions include:

a. Is one company better in one geographic part of the utility service territory vs. another?

b. What is the network performance / coverage of one company vs. another?

c. What does our historical data tell us about the percentage of devices in the field communicating today? Is there a failure rate in certain areas due to poor coverage?

d. Will I be able to demand priority over consumers in a mixed-use network in a state of emergency?

e. What happens when a service carrier loses services in a disaster? Do I have built-in backup options?

Overcoming the concerns/lessons learned: A private, single-use network (pLTE or PMN) can help utilities overcome the above issues. Additionally, in the case of PMNs, some now offer "multi-carrier" options meaning the utility can create a private network that leverages the optimal carrier infrastructure that is best suited for the location and need. Furthermore, because there are multiple carrier networks, service can fail over to a secondary network when the primary network fails to guarantee a higher level of reliability. This is a very unique option in the ability to drive higher levels of network performance and reliability.

Obsolescence:

Concerns: Cellular networks are known for evolving to the next "G." This evolution comes with the cost of migrating all current field assets from one "G", such as 3G or 4G, to a new "G". The inability to provide forwards/backwards compatibility in the way the network is being used creates recurring financial and time investment demands that make a lot of utilities hesitant to invest in cellular networking recurring financial and time investment demands.

Overcoming the concerns/lessons learned: Cellular networks are based on an open 3GPP standard allowing devices and networking equipment to be forward and backwards compatible to "any G". While SIMs may need to be replaced in devices, and radios or network gear may require firmware upgrades, the network can continue to be used instead of a complete replacement,therefore making it a "future-proof" solution.

The Software-Defined PMN: A Reference Architecture for Utilities

Before creating the Connected Utility lab, PGE completed a paper exercise to determine the costs to build a capital-intensive pLTE network that they would own and manage. The CAPEX investment required approached $500M, but more importantly, it would take 10 years to build and cause them to miss their 2030 decarbonization deadlines. Additionally, the cumulative OPEX to maintain this network over the 10-year period could cost as much as the initial CAPEX investment. While the reliability and cybersecurity benefits were desirable, the business case was a non-starter.

Inside the Connected Utility lab, the innovation team began exploring software-based alternatives to pLTE that could deliver similar results. These software-based private mobile network solutions were disruptive because they could create private mobile networks in "any G" over any carrier's radio infrastructure. Instead of building and maintaining towers, a 3GPP compliant, software-defined, cloud native private mobile network could be installed behind the PGE firewall. Data path visibility from the device to the termination point in the cloud resulted in an improved security solution compared to the public cellular options.

Figure: Typical Utility Current State Architecture

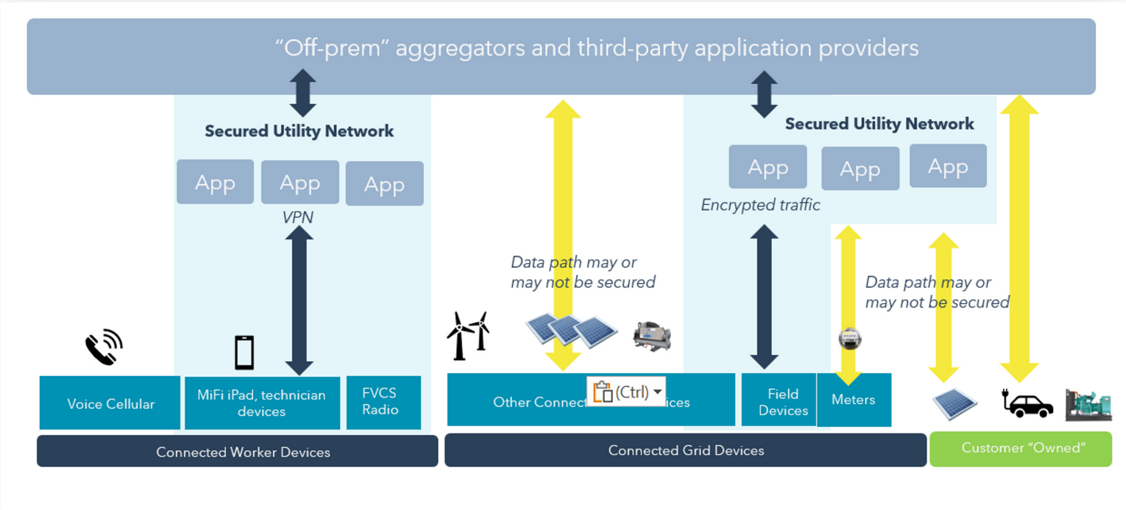
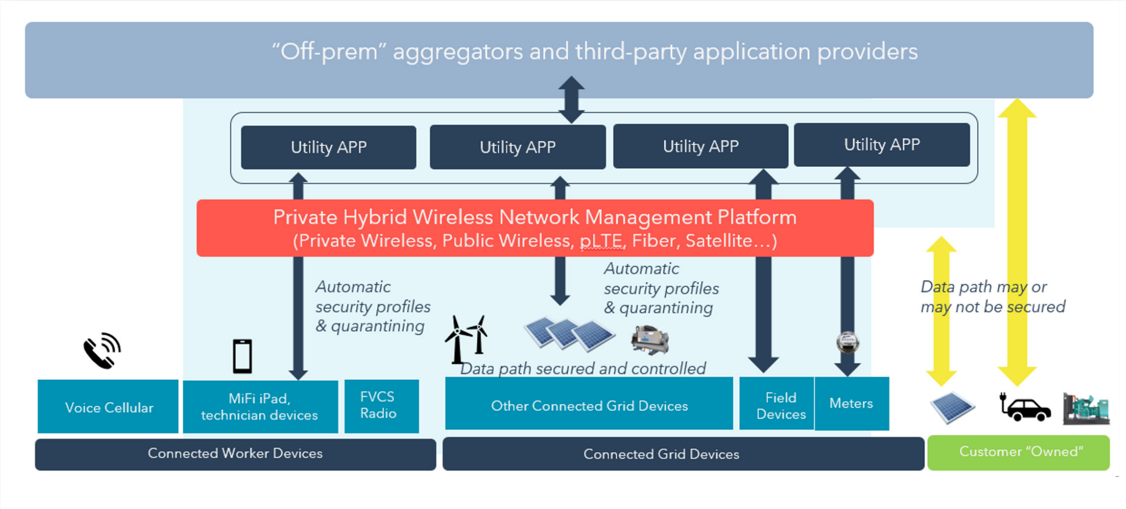


Figure: Desired State Architecture with Data path Control and Device Quarantining across Any Type of Private Mobile Network



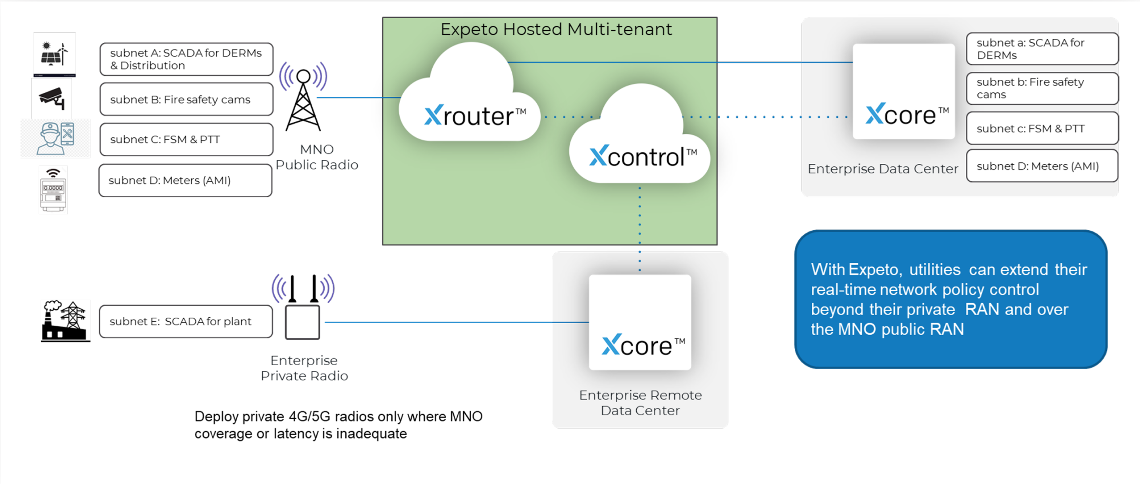
Software defined PMNs allow utilities to develop and support their own wireless networks on their own terms – open to any G, any radio network, any cloud whether needed remote, on-premises, or at the edge — but always secured behind their firewall. These networks become an extension of a utility's highly secure corporate FAN, and their enterprise security policy remains unchanged, thus uniquely enabling full control of their own data and devices. The software and cloud-native approach simplifies the expansion, control, security and management of all grid endpoints. Network segmentation that supports different classes of devices allows utilities to segment their meter data from their reclosers or grid field devices. All SIMs would be owned and managed by the utility.

In short, software defined PMNs provide the affordability, speed, scale and security needed to overcome the traditional obstacles to utility-grade cellular while supporting existing IT, security policies and seamless integration with the utility corporate network.

Solution Reference Architecture

Below is a high-level reference architecture (Figure 1) of the Software Defined PMN deployed using the Expeto NeXtworking platform at the PGE Connected Utility lab.

Figure: Expeto NeXtworking Platform Provides a Software-Enabled Hybrid Private Mobile Network Solution for Utilities Leveraging "Any G"



The Expeto NeXtworking Platform for Utilities

To test the advantages of software defined private mobile networks, PGE selected the Expeto NeXtworking platform.

The Expeto platform is based on an IT-centric methodology which allows a utility's telecom team to partner with IT to easily and securely manage any flavor of cellular based network deployed in a FAN. This allows the utility to be proactive with a flexible network architecture that supports specific use cases and device needs. Through a cloud-based management console, a utility's IT team can provide real-time management of all networks instead of spending time troubleshooting reliability issues with mobile network operators. Overall, this increases a utility's cyber security and reliability posture across the use of hybrid cellular networks, from pLTE to PMN. The platform enables new efficiencies and capabilities for utilities using cellular to drive mission critical grid operations.

Key features and benefits include:

1. Streamlined operations with standards based APIs and a single pane of glass management system to configure, deploy and manage all networks and policies (e.g. private IP subnetting) – across all cellular based networks in the FAN.

2. Allow any type of cellular network deployed by the utility to be managed as if it was one single network that was an extension of the utility local area network. The PMN networks are implemented in the Expeto xCore platform which is deployed behind the PGE firewall with full data path control from SIM to cloud.

3. Improved resolution time for network issues that can be easily corrected by the utility, rather than waiting for them to be addressed by the wireless service provider.

4. Increased security fostered by reducing the number of attack vectors with a controllable approach to deploying cellular networks that starts behind the firewall.

The high-level architecture shows the end-to-end components PGE deployed to create a software defined PMN based on the Expeto NeXtworking platform. The components include:

1. Expeto xRouter™: A configurable cloud-based service that manages connections to public mobile networks, ensuring secure routing and global data control while also enabling dynamic network segmentation. This component ensures secure data path control of connections from SIM to cloud.

2. Expeto xCore™: A complete 3GPP-compliant mobile network core that supports 3G, 4G, and 5G bands and is fully containerized for ease of deployment configurations. Deployed behind the utility firewall, xCore creates the WAN integration and edge control functions to grid devices in order to develop private mobile networks for use only by the specific utility.

3. Expeto xControl™: A multi-tenant administration UI that provides a single control plane for all networks on the platform. xControl is the centralized management interface that provides endpoint geolocations and network policy management.

These components are delivered as one platform that can be easily managed by a utility to operate and maintain their own private mobile networks without the need for support from a service provider. It is delivered as a "software-as-a-service" platform that can be capitalized and bundled with data packages to allow utilities to use their mobile service providers of choice. The data bundles are competitively priced and packaged to support millions of devices.

Advantages of the Expeto platform include:

1. Simplified Management and Increased Cyber Security: the Expeto platform offers class A, B, and C network encapsulation to create a service layer that provisions field endpoints with internal network subnet IP addresses. This simplifies network management across network administration and increases cyber security capabilities. It also guarantees that devices are being securely managed on private subnets as an extension of the utility FAN.

2. Multi-Carrier Solution Overcomes SLA & Reliability Concerns: The Expeto platform offers data services from multiple carrier networks to overcome SLA concerns. Expeto offers a multi-carrier solution that provides seamless connectivity by supporting multiple service providers,resulting in the desired level of reliability based on the specific use case need.

3. Future-proof/Standards-based to Overcome Obsolescence Concerns: The Expeto platform is 3GPP compliant and standards-based to support cellular service on a single, secured network management layer. This support is forward and backwards compatible with "any G" (3G / 4G / 5G) and public and pLTE networks, all of which are managed from a single management interface.

4. Management of Hybrid Networks: The Expeto platform allows utilities to streamline operations with a single pane of glass management system to configure, deploy and manage all cellular based networks. Standardized IT policies are seamlessly applied across those cellular networks in the FAN. The PMN becomes a simple extension of the utility LAN.

Utility Benefits of the Expeto NeXtworking Platform

This reference architecture unlocks a number of benefits for the utility:

- Rapid deployment
- Scalability
- Reliability
- Improved cybersecurity
- Easier management

Further details are provided below for each of the above benefits.

Affordable, Rapid Deployment

Utilities are in the business of multi-tasking, often to the extremes. This typically occurs as a balancing act of working capital investment activities that deploy new assets while also working to shift focus to emergent operational situations.

The question for most utilities' is would they want to divert effort toward building and maintaining their own private networks? In the case of the PGE Connected Utility effort, it was determined it would take them 10 years to build a pLTE network, which would cause them to miss their 2030 decarbonization deadlines.

Instead of building a separate radio network, PGE decided to leverage the Expeto platform to deliver their software defined private mobile networks. Tested in the lab, the team proved Expeto could be deployed faster as a software directly in the PGE AWS environment secured behind their firewall. This approach allowed PGE to stand up a software defined private mobile network in a matter of days versus years. Rather than needing to deploy towers, hardware, and spectrum, Expeto was tested and proven to deliver a similar result – but deployed exponentially faster, easier to manage and far more affordable.

Overall, software defined PMNs could be deployed exponentially faster, were easier to manage and far more affordable.

Scalability

Utilities often desire to build a network that can scale in performance and support increasing numbers of endpoints because it is a challenge to invest the additional money and time to upgrade physical infrastructure across a service territory. 5G networking offers utilities rapid scaling capability in terms of deploying an increased number of field assets while also maintaining network performance due to an IoT design that is inherent with 5G networking.

As a software-defined and cloud native solution, Expeto allows utilities to deploy (and secure) networks faster and easier from a cyber security architecture perspective. The software can be deployed in the cloud behind the utility firewall, as well as containerized to be deployed in the field and/or hardened to sit in a grid edge computer deployed at a substation. This allows utilities to deliver the required amount of bandwidth or latency into the field, where those characteristics are needed.

Reliability

Today's major utility initiatives are demanding an increased network performance in the form of higher bandwidth, lower latency, and reliable wireless coverage. 5G networking infrastructure is increasing the number of cell towers to keep the network performance spec consistent. This increase in physical infrastructure creates a high availability environment to support field endpoints for maintenance and other outage situations that increase the likelihood of endpoints remaining connected.

Expeto offers a novel solution by providing a "multi-carrier" or "omni-carrier" solution to improve network reliability. This is achieved with a unique set of SIMs with profiles that can be defined or programmed according to the use case needs to use certain carriers and/or failover to a backup carrier if there is a failure with the primary service provider. This allows utilities to leverage and trust cellular networks in a way that was previously considered impossible . The multi-carrier option offered in the Expeto platform allows utilities to overcome the reliability concerns of the past and begin to think about the art of the possible with cellular in the future.

Cybersecurity

What separates Expeto from a standard Telco carrier solution (e.g. a consumer public network or pLTE), is the combination of functional network routing from the Expeto core deployed behind the utility firewall with security features along this path that can be leveraged in the management of the private mobile network. These security features allow logical, software defined networks to be created and extended to the edge in the field, enabling utilities to seamlessly apply their own security controls to these networks. Key features include:

1. Network segmentation: The Expeto platform enables separate and isolated purpose-built zones for specific business functions and risk levels such as an ADMS zone or an AMI zone. This segmentation provides greater network control for the utility. Utilities can rapidly make key changes to transport paths such as:

   - Detecting and isolating suspicious endpoints
   - Creating new trusted and segregated network zones
   - Configuring network transport and security policies for new network zones in real-time without the need to engage the service provider

2. Internal subnet addressing allocation for field devices at the edge: With the ability to allocate internal, private subnet addressing defined by the utility to field devices at the edge, utilities can realize a much simpler and more precise network management practice. From a security perspective, security policies can be defined with greater precision across various network security controls.

3. Auditing and security logging: Expeto provides the utility security systems logs required for regulatory compliance so that an auditor could analyze traffic logs from certain head end applications and endpoints.

Standardized Management of Hybrid Networks

With Expeto, all cellular based networks deployed in the FAN can be easily managed by the utility as if it was one single network that was an extension of the utility local area network. The revolutionary breakthrough allows utilities to deploy the network as required for the use case need and device type. OPEX costs and management activities can be reduced since the utility can manage all cellular based networks as a single network using one simple, standardized approach.

Conclusion

5G networks can be software defined to allow unprecedented deployment speed to rapidly support more grid edge devices at a lower cost. Standardized 5G networking, coupled with a software defined networking service layer offered through solution providers like Expeto, now opens new scalability and control capabilities for utilities looking to transform legacy networks into an IoT-enabled FAN with ease and lower costs. These networks are simple for utilities to manage and are capable of rapidly meeting 2030 decarbonization goals and beyond.

With the rush to modernize the grid to meet decarbonization mandates and scale connectivity to a 10X increase in number of grid devices that are being added in not just the field or substation, but also behind-the-meter, utilities must think differently about how they connect and secure their networks. Private mobile networks based on 5G offer a scalable, fast and secure way to achieve these goals. Thanks to the experimentation and learnings in the PGE 5G Connected Utility lab, the utility was able to demonstrate the versatility of a new disruptive technology from Expeto and think differently about the way they could affordably create software-defined cellular networks that augment their FAN.

PGE would like to thank its Connected Utility ecosystem partners: Expeto, Intel, T-Mobile, Google, the 5G Open Innovation Lab and InnovationForce, and offers this whitepaper as a joint collaboration to share and advance grid modernization learnings within the utility industry.
For more information visit www.expeto.io and www.theconnectedutility.com to learn how your utility can adopt this reference architecture as part of your FAN strategy.

About the Connected Utility Lab

The PGE | Connected Utility Lab is supported by industry partners Intel, T-Mobile, Google, the 5G OIL, Innovation Force and Expeto who are helping Portland General Electric (PGE) find new technologies and approaches to dramatically reduce costs and accelerate results. By integrating the latest 5G technologies, PGE is able to reap the benefits from software, the cloud and real-time predictive grid analytics to the edge to get the most out of their current-state grid edge investments. But more importantly, PGE has been able to expand their innovation ecosystem to rapidly accelerate and scale next-generation solutions that will power grid modernization. Through the Connected Utility Lab, they continue to work within a vibrant industry ecosystem.