Game-Changing Business Model: Private LTE for AMI and Smart Utility Programs

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EXECUTIVE SUMMARY

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The landscape of telecommunications options available to support utilities' Operational Technology (OT) solutions is rapidly evolving - at a pace compared only by the changing needs of the OT requirements themselves. As utilities replace first generation Advanced Metering Infrastructure (AMI) solutions with current more feature-rich systems and expand the reach of traditional Distribution Automation (DA), Field Mobility (FM) and other existing solutions; new options are required for device connectivity and backhaul. The potential explosion of ubiquitous Internet of Things (IoT) devices will further change the utilities' needs.

Against this backdrop, utilities are examining their current and future options. Traditionally, most utilities have maintained private core networks comprised of fiber rings, microwave, and radio systems. Utilities also utilize public carrier solutions, private single purpose vendor networks such as for AMI, etc. And a variety of solutions are employed for their Field Area Networks (FAN). But with the rapidly evolving technical landscape and business models available, utilities now have more choice than ever on how to combine public carrier and private networks.

The movement towards 5G and even greater use of LTE is imminent. But how to take advantage of this evolution is less certain. Is there a business case for utilities to use private LTE for the FAN backhaul, perhaps gradually replacing the current AMI or DA with private LTE, or for applications such as smart inverters? The potential cost savings and game-changing business model is worth studying further.

And what about the needs of the future significant numbers of IoT devices? How might utilities leverage the new 4G based low-power narrow band solutions LTE-M and NB1 (NB IoT). The future devices based on these standards promise significantly lower cost, improved battery performance and wide standards-based availability, assuming that the market and vendor support evolves as anticipated.

This paper explores these technology and market trends in more depth and identifies specific business opportunities that are worth utilities examining.

Many large utilities are in their second or third generation of advanced metering infrastructure (AMI); they are greatly expanding their distribution automation (DA) and distributed energy resources (DER) programs and trying to determine the business value proposition of new smart utility internet of things (IoT) applications.

Some of the common communication networking questions facing utilities as they look to expand their operational technology (OT) programs or migrate to their next-generation AMI include the following:

1. How can we "gracefully" upgrade and migrate our current AMI infrastructure to the next generation AMI while also extending the life, to the extent practical, of our existing AMI?

2. How can we supplement our fiber-optic wide area network (WAN) communications with an affordable robust wireless solution to provide communications for thousands of endpoints for our backhaul of AMI, supervisory control and data acquisition (SCADA), DA, DER and the many growing low-power, battery-based IoT applications?

3. How can we address the extensive maintenance needs for our field communications infrastructure considering that the number of endpoints will increase by over 1,000 percent in the future?

4. What will new 5G cellular offer our utility?

5. What is a practical roadmap to maximize our existing automation investments while greatly expanding our "smart utility" programs?

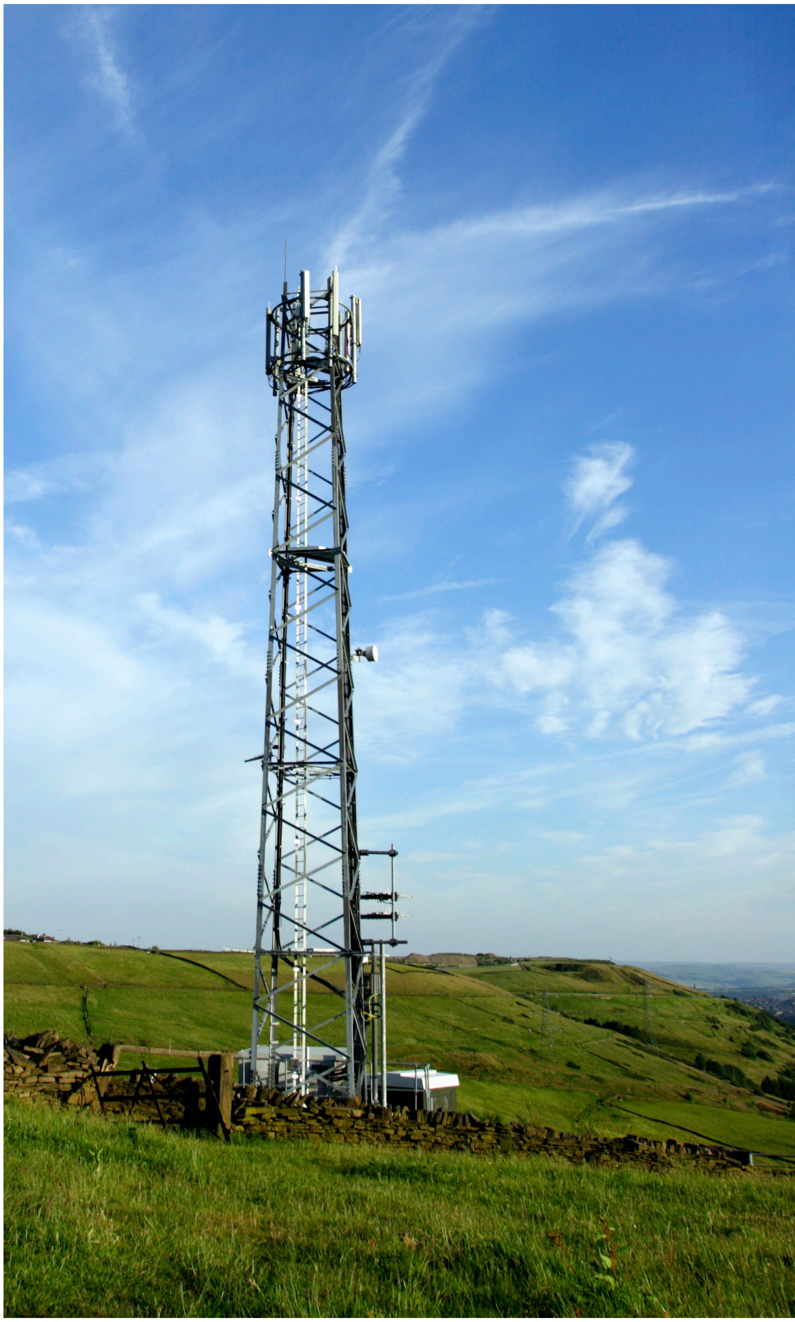
WHAT AMI AND FAN COMMUNICATION CHALLENGES EXIST?

Utilities are faced with communication and AMI challenges including the following:

- On the AMI side, our current system is working fine for metering but is falling short of some of the newer smart utility programs.
- Wireless smart utility networks (WiSUN), while attractive, still require time-consuming integration between the AMI vendors with various third parties.

- In the field area network (FAN) backhaul area, there is a lack of licensed spectrum in the ultra-high frequency (UHF) bands providing high coverage capabilities with sufficient bandwidth to meet the growing needs.
- Vendor communication solutions are predominately proprietary, even private products from vendors that offer native transmission control protocol (TCP)/internet protocol (IP) can't be intertwined with Vendor A endpoints with Vendor B master radios. The master and remote radios need to be provided by the same vendor.
- With cellular, product life cycles are shorter if deploying late in the life cycle, and reliability results are inconsistent for mission-critical applications, especially during major events. In addition, random coverage holes can exist, especially in rural and suburban areas.

On the positive side, AMI technology has significantly progressed over the last 10 years in terms of added bandwidth, improved adaptive modulation to improve coverage, lower latency, and improved reliability. The 2019 version AMI is a lot more advanced than the 2009 version AMI. Also, the AMI vendor community greatly improved the DA backhaul over AMI and expanded the demand response and home automation capabilities. However, many other AMI critical questions exist, such as: Is the one-stop-shop philosophy of putting nearly all field applications over AMI the most optimal approach for the future? Does it really make sense to have a 100 percent private AMI network for metering, DA and demand response? Then use commercial cellular for the mission-critical backhaul? When a utility compares the attributes of cellular with other FAN technologies according to throughput, latency, ease of maintenance, costs, etc., cellular will be ranked high.



AMI technology has significantly progressed to better coverage, lower latency and improved reliability.

Commercial cellular technology has significantly progressed to better coverage, lower latency, and improved reliability time for 80 to 95 percent of locations. The other 5 to 20 percent of time or locations can be problematic, and the problems often surface in major weather conditions when the mission-critical automation programs are needed the most. If commercial cellular will not be selected for the mission-critical smart utility applications, what other options are there?

VIABLE COMMUNICATION TECHNOLOGIES FOR THE FAN

Let's start with the backhaul or FAN for DA, AMI, DER and other field telemetry programs. Today, a combination of communications technologies are being used. Most utilities currently have some type of backbone or WAN connecting their tower sites, offices, data centers and transmission substations with a ring topology high bandwidth, low latency and 99.999 percent reliability backbone. We expect this configuration, usually comprising fiber optics and licensed point-to-point microwave, to continue, expand and become even more robust. For the next tier of the network connecting distribution substations, small operation centers, AMI collectors located in the feeders, DA and DER points, a variety of communication alternatives can be expected from commercial cellular, worldwide interoperability for microwave access (WiMAX) 802.16s at 700 megahertz (MHz), 900 MHz point-to-multipoint (PMP), unlicensed 900 MHz, 2.4 gigahertz (GHz), 5.8 GHz point-to-point (PTP) and mesh. In the last year or so, a breakthrough technology surfaced with the protocol of 802.16s for FAN backhaul, especially in large utility service territories with lower density

of smart utility devices. While this technology would be great for DA and AMI backhaul, it is not appropriate for residential meter reading. We are also starting to see larger utilities evaluate and deploy private long-term evolution (LTE).

WHAT IS PRIVATE LTE?

Simply put, private LTE can be thought of as a utility building its own private cellular network within its territory and using it exclusively for the backhaul communications of distribution SCADA, DA, AMI, DER and other field applications. To accomplish this, the utility needs to identify acceptable spectrum and purchase LTE base station equipment (private cell sites). Possible spectrum options include Citizens Broadband Radio Service (CBRS), 700 MHz A Block and other bandwidths available for purchase. Private cell sites require robust backhaul, and the end devices would also include LTE remote radios interfaced into the DA device, AMI collectors, remote terminal unit (RTU), video cameras and other applications that may exist. The remote utility devices would be routed into the private cell sites. The private LTE system may be managed by the utility's internal staff or by an outsourced provider. The advantages of private LTE include the following:

- Managing to the desired reliability and security levels and also building the coverage to meet the utility's needs.
- More control over the product life cycle.
- An economy of scale by reducing the number of disparate networks to manage.
- Selection from several standards-based LTE endpoint manufacturers which allows more of a more plug and play environment.
- Potentially lower maintenance costs compared to a variety of other communication alternatives.

Initial capital costs may be the largest downside when LTE is compared to other commercial and private FAN technologies. Private LTE costs, however, have been dramatically reduced in recent years and continue to come down. At some point in the near future, private LTE may become the go-to solution for many utilities.

COULD PRIVATE LTE BE EXTENDED FURTHER INTO THE METER OR OTHER HOME OR FIELD DEVICES?

Theoretically, the answer to that question is yes. A utility that elects to build a private LTE network for its backhaul of SCADA, DA, etc., could take this one major step further and privately develop a means to bypass the AMI vendor community in the following way:

- Procuring new smart meters, including the underglass disconnect/reconnect switch but without the AMI vendor-provided module, software or network.
- Procuring the underglass LTE chips from a variety of manufacturers located around the world and some U.S.-based vendors.
- Writing its own software to pull the needed data from the meter, i.e., kilowatt-hours (kWh), kilowatt (kW), voltage, kilovar, other data and various commands similar to what the AMI vendors currently offer or purchase. A meter manufacturer can assemble the meter/modules/radio in a way similar to what has been done for years with the non-meter AMI vendors (Eaton, Tantalus, formerly Silver Spring, etc.).

If the utility prefers to not write its own AMI software in exporting the needed metering data from the meters, it could procure the meter module and software from an AMI vendor, but the utility could still provide its own LTE radio and new smart meter and use their private LTE network for the transport. This is an oversimplified concept description for a highly complex concept that has not yet been developed. However, this is a plausible proposition for a large utility to write its own software that can change the meter intervals; perform commands for connects/reconnects, to turn on/turn offload management switches; perform meter firmware upgrades; capture interval meter reads, demand, voltage, etc. This can be classified as a plausible concept, given the American National Standards Institute metering standards with the raw data provided through the meters.

From a potential cost savings standpoint, with a private LTE as part of the AMI program, the typical AMI components include collectors, repeaters at the customer premise, meters, and AMI modules; part of the module is the wireless chip, antenna, etc. Gven the volume of meters in most AMI deployments, the highest cost components are the meters and modules, and this typically represents around 70% of the total AMI capital costs. What if a utilty could reduce the incremental cost of the end-point by $10, $15 or even more per endpoint and the utility has several million meters?

WHAT IS 5G, AND WHAT ROLE WILL IT PLAY IN SMART UTILITY COMMUNICATIONS?

Over the next couple of years, 5G will gradually be deployed by cellular carriers. The 5G and LTE standards are designed to work together for years to come. 5G and LTE are complimentary worldwide standards with many competitive manufacturers producing large volumes of equipment. This well-established and growing manufacturing ecosystem enable cell phones, tablets, PCs, niche markets such as smart utility applications, automotive, factory automation to home internet and TV programming transport. The spectrum used for 5G and LTE will vary slightly by carrier. It will eventually include retired 3G spectrum (600 MHz to 1,900 MHz) and new spectrum in the higher bands (2,300 MHz to 47 GHz). Both 5G and LTE end devices will contain multiple radio chips and antennas that could vary from the high-coverage UHF spectrum to the wide bandwidth at the GHz level. The bandwidth, latency and coverage will always vary depending on the chips used (tied to spectrum) in the endpoints. Some low power end devices, such as what will be used for gas or water meters might only include radio chips to operate at the low power NB1 portion of today's 4G LTE product lines. These chips can deliver greater receiver sensitivity (radio frequency coverage) than standard LTE and can run for more than 10 years on the battery embedded in the endpoint. However, these chips provide only 50 kilobits per second (Kbps) of throughput and 1.5 to 10 seconds of latency. Yet other applications such as WAN backhaul that require high bandwidth at gigabit speeds and latency of greater than 10 milliseconds (ms) can also be provisioned over LTE with the use of the new high bands 5G spectrum.

WHAT ARE LTE-M AND NB1?

In mid-2017, the carriers released a new product line designed for low power or battery-powered telemetry. Like most new technologies, it went through some growing pains, but we are starting to see some of its promises. These 4G products are generally referred to as LTE-M and, now, NB1. In summary, LTE-M and NB1 are designed for low power IoT applications, low bandwidth, further coverage and tolerable latency. In addition, chip costs will be low for the high-volume LTE-M or NB1 deployments. The AMI vendors that provide solutions for the gas and water industries are evaluating LTE-M and NB1 because the radio embedded with the AMI endpoint needs to rely on batteries for power. The following summary table provides additional attributes:

Available Now	Yes	No
Throughput	150 kbps	50 bps
Latency	10 to 15 ms	1.5 to 10 seconds
Mobile	Yes	No
Power Needed	Less battery drain for large file transfers than NB1	Greater battery drain for large file transfers but still viable for battery use
Expected Cost	More than (NB IoT)	Much less

In summary, some aspects of 5G will operate and perform in a manner similar to the current 4G; other aspects of 5G will be sufficient for very low latency applications with viable use cases to compete with the cable, fiber-optic and satellite-based high-definition TV services. Another important aspect of 5G is the enhanced capability described as software-defined radio (SDR) that could allow changing the carrier and spectrum to be used with the endpoint change from Sprint to AT&T, etc. While many utility-grade private wireless communications vendors also have SDR, it is new for the commercial cellular sector. The bottom line is that 5G will start to become a viable utility communications FAN media around 2020, but will likely have some of the same challenges as today's cellular-provided 4G. Utilities will have to rely on the carriers' decisions about where to build out, how they manage and maintain their network and then compete with the community of users. However, new spectrum/ network virtualization capabilities will exist with 5G, making it optimal when sharing home Internet, TV programming and the massive IoT users. On the positive side, with the literally millions of end devices based on the LTE protocol, we expect price points to be similar to WiFi endpoints, which are far less than the AMI module or other radios from vendors such as GE, Cisco, CamAmp and others.

SMART UTILITY IT USE CASES

Various research organizations have predicted over 50 billion IoT devices will be deployed worldwide by 2025; some forecasts predict 75 billion IoT devices by 2025. While the accuracy of these predictions is uncertain, volume of smart utility IoT devices will grow significantly in the future. The expected utility applications are as follows:

- Field assets such as street light controls. Some organizations predict 75 billion IoT devices by 2025.Home devices such as thermostats and solar inverters.

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- Asset management devices such as smart poles, transformers, and other applications.

These types of assets are provided by dozens of different manufacturers that all want a piece of the IoT value chain. Various business models will eventually surface; some of these manufacturers will embed LTE modems in their devices to sell the data to various potential buyers, such as utilities. Therefore, as we progress into 2020, the trends suggest that LTE will be the leading protocol for the expected millions of IoT and smart utility devices.

CONCLUSIONS

The movement toward 5G and even greater use of LTE are imminent. Does a strong business case exist to use private LTE for the FAN backhaul, for migrating to private LTE for the FAN backhaul and gradually replacing the current AMI with private LTE, for applications such as smart inverters? Business cases have been completed for private LTE for the backhaul of AMI, DA, SCADA, etc., and some are positive; others are not. It is unknown whether a business case has been completed for further extending the use of private LTE into the meters, inverters, smart poles, street lights, etc. The potential cost savings and game-changing business model is worth studying further.