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SMART GRID TECHNOLOGY DECISIONS:

Key considerations when migrating away from a power line carrier system

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Compelling reasons to migrate

They were trailblazers.

Utilities and municipalities that originally installed Power Line Carrier (PLC) systems were seen as visionaries. They saw the value of implementing an Automatic Meter Reading (AMR) system, the efficiencies it can bring, and the way that it dramatically improved operations. These first adopters received tremendous value out of their systems.

PLC systems use electric power lines to communicate with endpoints in the field within a utility's service area, basically a wired communication system. These systems have performed well over the years, but have had trouble supporting the requirements needed to enable a smarter grid. They have not kept pace with the new Advanced Metering Infrastructure (AMI) capabilities afforded by wireless technology.

The primary benefit of a PLC system, and often the reason that many utilities chose PLC in the first place, is that it uses the existing utility wires to transmit data. Depending on the topography of a utility's region, this architecture was often a cost-effective option for automating billing reads. However, after achieving the initial benefits of PLC systems, utilities have observed several limitations.

These include:

- The amount of data received from the meters is extremely limited;

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- During distribution feeder routing changes, it's difficult to provide continued operations. Missing reads pile up when the system is not functioning;
- Outage information support is inadequate, often during the most critical time. This impacts a utility's ability to respond and restore power to customers properly; and
- There is a lack of real-time visibility to sensors and meters from across the entire utility service area directly affecting day-to-day operations.

There are additional limitations that are less about PLC's infrastructure and are more related to the vendor-customer relationship including: end-of-life worries, vendor support issues, and access to spare parts is increasingly problematic. Many vendors have pivoted to invest more heavily in radio-frequency (RF) systems rather than their legacy PLC technology.

The value of AMI has moved beyond mere acknowledgment to general acceptance. AMI systems bring utilities improved safety, increased customer satisfaction and a significant reduction in operational expenses. Couple this with next-gen smart grid capabilities, and it's clear why utilities are embracing AMI technology.

Smart options to go wireless

The AMI market has moved primarily to wireless communications as the infrastructure for delivering today and tomorrow's benefits to utilities. In the transition away from PLC, the two dominating wireless approaches in the industry are:

1. Publicly available spectrum signals carried over a mesh network architecture; and
2. Private, licensed spectrum signals transmitted over a point-to-multipoint network architecture.

Both approaches offer substantial advantages over PLC—positively impacting multiple areas within the utility. For example, the significant increase in data point retrieval and the reduction in missed reads will substantially decrease the number of estimated customer bills. Engineering can also utilize the increased amount of data from across the system to better monitor and control the health of the grid resulting in significant cost savings. Transitioning from slower to faster reads maximizes data collection and greatly assists in grid operations.

MESH NETWORK

In a mesh network, radios communicate to each other with messages hopping from meter-to-meter. Each point on the network can receive, store and transmit signals to other network points in many different directions. This network system architecture blankets an area with coverage and offers some redundancy in the case of problems. Conversely, there are inherent problems with this design.

Mesh networks use unlicensed spectrum for their communications and operate on public radio frequencies which are open and available for anyone to use. Often, you'll find RF interference from common products that use the same spectrum band: garage door openers, cordless phones, and baby monitors are just a few examples. And, these noise levels are expected to increase in the future.

Operating in public RF spectrum reduces the range a mesh endpoint can transmit due to the relatively high RF noise ground floor and low output power. Endpoints require multiple hops through other endpoints to connect to a collector take-out point, before sending their data back. This design is especially challenging in rural locations where there may not be another metering endpoint for many miles.

Mesh providers continue to add applications, protocols and data rates to improve the network, but these new features are not always backward compatible. This causes problems since the meters are the communication network. An unintended consequence of this network design is that utilities are often forced to replace existing meters and collectors to fully realize the new feature's capabilities.

There are also significant infrastructure differences between the two networks. In a mesh-based system, a utility typically installs between 20-100 mesh collector takeout points for every one base station deployed in a point-to-multipoint network. This additional infrastructure investment has to be made in order to reach the same number of meters as one base station. After the initial installation expense with mesh, utilities must also maintain the increased number of devices across their service area for the life of the system. Overlooking this daily operational cost is a common problem.

POINT-TO-MULTIPOINT ARCHITECTURE

A point-to-multipoint system operates on FCC primary-use licensed spectrum and is planned and designed differently than a mesh network. With this architecture, a collector, or base station, communicates to many endpoints directly within a large coverage area. These endpoints are often meters, but also can be load control modules, lighting modules, or distribution automation endpoints. Before installing a point-to-multipoint system, a propagation study is used to determine optimum base station deployments to ensure maximum coverage area and communication redundancy. This network design is ideal for many different topographies but particularly excels in rural areas.

By operating on licensed RF spectrum, point-to-multipoint systems can transmit much further, with twice the transmitting power of a system operating in public frequency band. With this network design, the increased range enables each endpoint to communicate directly with a base station without having to hop from endpoint to endpoint to send their data back to the headend software. The point-to-multipoint design also dramatically reduces the number of times an endpoint has to transmit its data to be received by the utility. Point-to-multipoint endpoints only need to communicate a few times a day. Conversely, a mesh network transmits more than 10,000 times a day to transfer a similar amount of data. These differences are a critical distinction when looking at an electric grid that is becoming more dependent on real-time data and control needs. Point-to-multipoint systems also can listen and send messages at the same time-a true two-way (duplex) network. And because licensed RF spectrum networks are private, each utility is assigned an RF bandwidth range that only they can use. These licensed RF channels are protected by federal regulations, and interference can be mitigated quickly and efficiently with the full backing of the United States government.

In a PLC network, outage information is compromised when the distribution network is disrupted—a pole down, for instance. Because meters have a last-gasp capability, point-to-multipoint architecture enables a much higher outage success rate. Each endpoint transmits its power outage message to the network without having to rely on a neighboring endpoint's communications path to the takeout point. During outage and power restoration events, utilities have seen a 33% reduction in service restoration times due to the increased amount of useful outage information.

As a network architecture solution, a point-to-multipoint system can support today's applications while being able to add new functionalities, data rates, and capacity on the same system. Moreover, by supporting every generation of product and solution on one network, existing assets can continue to be utilized while new technologies are being implemented. Utilities shouldn't need to go back to the Public Utility Commission, City Council, or members to request funding for new applications; instead, utilities can build business cases around the new endpoints and applications they will be deploying on the network they have.

Getting ready to go wireless

Once a utility has decided to shift away from PLC and has chosen a wireless network architecture, there remains a crucial next step. They must determine how to realize the benefits of AMI migration fully.

There are three primary methods:

1. Upgrade by distribution feeder (sectored approach);
2. Targeted upgrades where PLC system is degrading (step-by-step approach);
3. Complete system installation.

There are advantages and disadvantages to each. However, all require the installation of a new wireless communication infrastructure first.

1) Upgrade by distribution feeder (sectored approach)

This deployment option is a strategic and planned approach to installation of the new network. In this model, meters are replaced in a systematic, scheduled way—usually one distribution feeder or substation at a time. Since PLC systems are line based, this method works very well. By upgrading every endpoint along the entire feeder at once, it helps ensure that the communications transition from PLC to AMI wireless is smooth. This allows the utility to replace both the PLC meters on the feeder and PLC substation equipment simultaneously. A huge benefit of this method is that legacy PLC hardware can then be used as replacement parts for remaining sectors within the utility's service territory. This same approach can be used for new substation installations as well, freeing up the utility from having to install the PLC equipment in these facilities.

With the sectored approach, there are key implementation differences depending upon the network architecture. For a point-to-multipoint network, the sectored approach is accomplished by establishing the communications network first across the utility's entire service territory. Upgraded meters can immediately start communicating with the point-to-multipoint communications network—regardless of where the endpoints are located. By starting with full coverage at the time of installation, it safeguards against data loss which could directly impact daily operations.

For mesh systems, utilities have the challenging task of upgrading all the electric meters in the distribution feeder or substation coverage area at once. This wholesale transition is needed to make sure that there is enough 'hopping' coverage to form the mesh and function properly. If there is a problem with developing the mesh coverage, there will be missed meter reads and a lack of data.

2) Targeted upgrades where PLC system is degrading (step-by-step transition)

Many utilities with older PLC systems are increasingly experiencing failures with their existing system. These failures are often scattered throughout the service territory, making it hard to concentrate on one specific area for upgrading. In this case, the best strategy is to install the entire communication infrastructure up front. The utility can then target upgrades for the worst performing sections of their existing PLC system first with new solid-state wireless enabled meters. Once these areas have been taken care of, the utility can continue to replace the rest of the PLC system over time. The ability to install new meters anywhere in the service territory allows for tremendous flexibility during the rollout process.

A primary advantage of this migration method is that utilities can continue to use their current network while also while also upgrading targeted areas with advanced wireless technology. Utilities are also afforded the opportunity to review current internal processes and adapt them to the new system in a controlled and organized manner.

From a financial standpoint, the utility can also continue depreciating assets from the existing PLC system for the areas that continue to perform satisfactorily.

This method is challenging for mesh architecture. Forming the actual mesh communication network has to be carefully organized in order for it to function as intended. With mesh depending upon meters transmitting to each other via short hops, it severely limits a utility's options for targeting the failing areas individually. Utilities are unable to replace failing meters or add new services to the network if they are outside the mesh footprint.

3) Complete system installation

Installing an entire system at once is sometimes needed due to massive PLC system failure. The primary benefit of a complete system installation is that once the upgrade has been completed, the benefits can be fully realized system-wide. It also eliminates the legacy PLC system's maintenance problems and performance issues.

For mesh systems, this approach is preferred since the communications network is the meters themselves. PLC meters are replaced with mesh meters as quickly as possible. As more and more meters are installed, the mesh network can form and provide some overlapping support. The downside is that until enough meter locations have been replaced in an area, the coverage remains weak. Additionally, all end-to-end software conversions at the utility have to be completed at the same rapid pace.

In a point-to-multipoint network, the communication network is the base stations. With this system, the new communications system is overlaid on top of the existing PLC system, without impacting the current network's operation. Once the base stations are in place, PLC meters can be replaced in any order, anywhere within the network. All newly installed meters have the ability immediately to communicate to the point-to-multipoint system.

A key consideration when making the transition to AMI is that it not only applies to migration of metering endpoints, but also to new solutions. Realizing the benefits of Demand Response, Distribution Automation, smart lighting, Conservation Voltage Reduction (CVR) and other sensors that are not supported on the utility's PLC system is a crucial piece of the puzzle. With any of the installation approaches, the utility can quickly recognize tangible benefits such as increased data visibility and greater operational efficiency.

Conclusion

Utilities are balancing the needs of being a customer-focused organization while navigating how to successfully implement solutions that need an intensive amount of data. PLC endpoints have constraints on how often they can communicate, are limited due to their low transmitting frequency, and are bandwidth constrained. There are obvious data limitations. The latency in the data transfer is especially problematic when looking at solutions such as outdoor smart lighting, Demand Response, and Distribution Automation. As communities look to leverage utility networks to create smart city solutions, PLC thwarts this vision from the outset.

A two-way, point-to-multipoint architecture implementation maximizes connectivity and application, providing the most straightforward and cost-effective transition from PLC, regardless of which deployment method is chosen. It allows for gradual installation, without service or capability disruption giving utilities the opportunity to transition from PLC to wireless systems at their schedule and pace. This architecture is ideally suited to migrating away from PLC smoothly and efficiently with a low infrastructure build-out and system-wide coverage up front.

In addition to the increased power, extended range, and higher reliability, point-to-multipoint enables targeted strategic deployment of endpoints beyond the electric grid, actualizing the various components of Smart City connectivity. PLC has reached the limit of its potential. It's time to move off the wire and improve service function and capacity, along with cost-effectiveness and customer satisfaction.

To learn more about migrating away from PLC, visit https://sensus.com/communication-networks/sensus-technologies/flexnet-north-america/

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