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Smart Networking for the Smart Grid

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It appears 2010 will be a banner year for the "Smart Grid." In 2009, analyst firm IDC estimated $10.75 billion was spent on computer hardware improving the nation's electricity grid, up from $7.56 billion in 2008[1]. With cost savings, secure management and greater intelligence in energy distribution among the many benefits of a smarter grid, it is no surprise that continued improvement of the nation's electricity grid will dominate spending in the utility market during 2010 and beyond.

Critical to the level of intelligence achieved in making the grid smarter is its backbone – the network and communications infrastructure. Indeed, requirements of the communications network are very demanding – encompassing issues such as scalable bandwidths, robust security, high network reliability, availability and cost-effectiveness.

Many in the industry conclude the most cost-effective approach to meet these requirements is leveraging the wide range of transport technologies available, while relying on common open standards, such as IP, to integrate into a single overall network. This article discusses the value that advanced, satellite-based networks can deliver as part of the smart grid communications infrastructure, across areas ranging from substation (SA) and distribution automation (DA), to mobile work flow.

Not Your Father's Satellite

Unknown to some, satellite networks have evolved at a similar or even faster pace than other networking technologies, making huge strides in improving performance, reliability, and cost. In fact, some of the highest availability networks in the enterprise market, such as for lotteries and emergency preparedness/recovery, are based on satellite and its fundamental advantage – ubiquitous coverage. And now when combined with high performance IP and other standards-based capabilities, satellite networks today deliver high-quality private, broadband connectivity.

Indeed, very high network availability, in excess of 99.99 percent, can be achieved through innovative dual frequency, dual access solutions by utilizing Ku-/Ka-band satellite service in conjunction with L-band satellite service as backup. Smart grid network elements, such as remote substations and distribution elements can now be connected using satellite without compromising on the expected benefits driving the smart grid.

Additionally, new satellite technology can cost-effectively deliver benefits such as on-the-move vehicle connectivity, allowing those out in the field to connect directly with headquarters and eliminate costly trips to the office obtaining information. Looking forward, satellite holds the potential to facilitate distribution automation, meaning utility companies can proactively monitor their distribution elements for outages and service demands. Utility managers and technology decision-makers should take into account the benefits satellite technology can deliver for these applications and the benefits they can deliver to smart grid efforts.

A Quick "Spark" on Satellite

Before jumping into utility-specific benefits, it may be helpful to take a quick look at the evolution of satellite communications in the recent past. Satellite communications for commercial purposes began roughly 25 years ago with the advent of Very Small Aperture Terminal (VSAT) technology, passing voice and/or data traffic between multiple locations. Small, back then, typically meant six feet in diameter or so. Six feet is hardly small, but certainly much smaller than the 15 to 40 foot dishes used previously.

The result of drastic reduction in diameter meant satellite communications became a viable means for voice and/or data communications in areas that had limited alternatives.

In subsequent years, satellite technology advanced and dishes became smaller, with transmission faster and less expensive. For example, in the past, speeds of 9600 bits per second using six to 10 foot dishes were considered cutting-edge satellite technology. Today, download speeds of multiple megabits per second are routine using compact, sub-meter size antennas, operating with high performance, multi-user routers on customers' sites, fully integrated with their LAN networks and security firewalls – and with a range of affordable service plans to choose from.

A critical area of continuing improvement is in cost of satellite bandwidth. Access, modulation, and coding techniques are becoming ever more sophisticated, leveraging the maximum throughput out of the fixed amount of bandwidth on a given satellite, in some cases approaching Shannon's information limit. Although transparent to users, these advanced methods have dramatically improved the efficiency of bandwidth utilization, which translates into higher speeds at lower costs.

Certain other mobile satellites operate in the L-band (1-2 GHz spectrum) and S-band (2-4 GHz spectrum); the low frequency enables them to be more resistant to rain fades and to provide mobility services. Companies in this field are introducing portable (laptop-sized) terminals and handhand devices, providing high-quality voice and data communications on-the-move (OTM). Some of these handsets are designed to operate in dual mode – cellular and satellite. Terrestrial cell technology provides coverage where available and satellite elsewhere. These services are well suited for applications requiring portable coverage in even the hardest-to-reach areas and do not require the transmission or reception of large data volumes.

Satellite networks can be designed for residential-grade or enterprise-grade broadband service delivery, or anything in between, just like terrestrial fiber, DSL or cable. But there are significant differences across this spectrum in terms of performance, reliability and cost. When exploring satellite solutions as an option to serve WAN requirements, organizations should correctly identify and evaluate the commercial-grade services offered by satellite providers.

Ku-, Ka-, and L-band services are provided as a fixed satellite service (i.e., the satellite terminal is installed and fixed in one location while it sends and receives information from the satellite). Fixed-mobile – also referred to as transportable – and OTM solutions refer to a car, truck, or trailer equipped with satellite communications technology. In the case of fixed-mobile, the vehicle must come to a stop and the dish unfolds and automatically points to the satellite with the push of a button. In the case of the OTM solutions, communications to and from the satellite can occur while the vehicle moves. Spherical-style antennas are mounted on the roof of vehicles and are 18 inches in diameter and getting smaller – a very appealing feature of OTM antenna design.

How does this all apply to the utility industry? Companies can utilize satellite solutions for a variety of applications: substation connectivity, distribution automation and mobility are three areas where satellite connectivity is especially beneficial.

Substation Connectivity

Satellite connectivity has been used for years to provide Supervisory Control and Data Acquisition (SCADA) connectivity to and from remote locations in the oil and gas pipeline industry and related energy exploration and production applications. The data requirements are relatively low in volume (i.e., as compared to many electric utility SCADA systems) but regular in frequency or periodicity. Private satellite networks served this need well delivering secure, custom network bandwidth profiles and ubiquitous coverage. The solution worked well, both technically and economically, for hard-to-reach SCADA and SCADA-like requirements in these industries.

This still holds true today. Satellite is a great fit for these types of applications and is in use to support SCADA and other applications at substations. The performance of the applications is consistent and effective. However, with the increasing goal of achieving near 100 percent uptime, conventional Ku- and Ka-band satellite solutions fall short.

A typical commercial satellite connection is generally engineered to deliver 99.7 percent to 99.9 percent link availability, which means on average, 0.1 percent to 0.3 percent of the time, a satellite connection will be lost.

That percentage coincides with a certain intensity of precipitation. When it rains or snows to a certain degree of intensity, the satellite connection will drop for the period of that critical intensity. Unfortunately, substation connectivity is most critical during storms where electricity outages increase, thus making a conventional satellite solution not optimal to achieve near 100 percent availability – until now.

With any type of connectivity solution, it is very difficult to achieve 99.99 percent or 99.999 percent availability with a single-thread connection.

To address this problem, many utility companies employ a backup connection, which can increase the availability of any connectivity to nearly 100 percent. So how can the same availability be achieved with a satellite-only solution?

The answer is with a L-band based service that backs up the primary Ku- or Ka-band satellite connection. L-band is in the 1-2 GHz range and is not susceptible to degradation during precipitation. So when the primary Ku- or Ka-band satellite service fades during rain, the backup path, L-band, will be available to pass traffic. The L-band service is usage-based and can be expensive with heavy usage. However, since it is used as the exception, rather than the primary connection, it only is used a small percentage of the time passing low-volume traffic, keeping costs to a minimum. A comparably configured terrestrial solution might cost three times or more for the same level of availability.

Combining L-band with Ku- or Ka-band satellite technology as a high-availability solution can deliver the performance that has always been delivered for SCADA-like applications, but with near 100 percent availability that is required for substation connectivity. Additionally, satellite still provides its inherent advantage – 100 percent nationwide coverage. Simply put, there are no "dark" spots.

Moreover, satellite supports broadband applications such as Voice over IP (VoIP) and video surveillance. Network bandwidth can be tailored to specific requirements and the solution is completely private, meaning no traffic crosses the public Internet. L-band and Ku-band satellite technology has been available for some time, but until now has not been combined in this manner to provide a singular solution. A "perfect storm" of requirements exists such that the traffic profile, the remote locations and the need for very high availability make this an ideal solution for the utility industry.

Distribution Automation

Similar data requirements as those in substation connectivity exist to support monitoring elements along distribution lines. Fortunately, the attributes of private

satellite connectivity also apply well for substation connectivity. However, a dual path, high-availability solution may not be cost-effective. A single, high-availability connection at an access point fed by distribution devices may be a better solution for monitoring and control.

There are a couple of options. One is using the L-band solution. It has a very small form factor, is hardened, can be mounted anywhere and is easy to install. The downside is usage costs. Depending on the volume of traffic, it might be cost-prohibitive to use the L-band solution at all locations. Locations in more densely populated areas are likely better served with an alternative licensed or unlicensed wireless solution. However, in rural, less dense areas, the same wireless technologies may be more costly or unavailable, and the slight premium that might be incurred using an L-band solution may be justified.

The second alternative is to use advanced antenna technology for fixed satellite service. The emerging advanced antenna designs offer a very small form factor, install and point easily, and have the advantage of fixed operating costs. In most cases, availability can be designed to approximately 99.9 percent.

Mobile Workforce

Gone are the days where a company's workforce is not connected at all times. With so many options for field personnel to stay in touch, there is no reason not to equip them with the right technology. So what is the "right" technology? Cellular coverage is quite extensive and affordable but may require multiple providers to cover larger geographic areas. And although cellular data delivers a few hundred kilobits-per-second performance, speed fluctuates and coverage may not be complete.

Radio networks are also a ready option, but are limited in range and bandwidth. So what currently happens if personnel, using cellular or radio networks, are out of range? They typically drive somewhere to find connectivity, certainly not an ideal situation for personnel on location supporting customers with restoral efforts outside of a utility company's immediate service region.

These "dark spots" are where satellite technology can provide the solution. Vehicles, as small as compact cars, can be equipped with fixed mobile or on-the-move satellite technology. The vehicle is equipped with a router which first tries to connect via cellular service, then private radio, and lastly, satellite. The router automatically finds the service that is available, so field personnel are constantly connected. The solution supports all data needs – work orders, dispatch and repair support.

Satellite also supports higher bandwidth requirements than other technologies, such as multi-Mbps downloads – an attribute unique to satellite technology in mobile applications. Finally, the same satellite infrastructure can be used for other aspects of an organization's communications infrastructure, mobile or otherwise.

Conclusion

Satellite networking technology has developed rapidly and now delivers the combination of high performance, availability and security that can greatly aid smart grid efforts for the utility industry. Substation connectivity, distribution automation and smart trucks are three key areas in which a satellite solution can provide the most cost-effective communications solution. Indeed, satellite solutions are an essential part of the multi-technology approach required by the utility industry to achieve an end-to-end, smart grid communications infrastructure – one that is reliable, fast, secure and cost-efficient.

About the Author

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