The Emerging Smart Multi-Grid™ Wireless Architecture – A Network of Networks

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Smart Grid networks are currently receiving tremendous government attention and funding. The US Department of Energy says the Smart Grid "would integrate advanced functions into the nation's electric grid to enhance reliability, efficiency, and security, and would also contribute to the climate change strategic goal of reducing carbon emissions. These advancements will be achieved by modernizing the utility grid with information-age technologies, such as microprocessors, communications, advanced computing, and information technologies."

In the first phases, Automated Meter Reading (AMR) is the focus of the Smart Grid effort, but more sophisticated sources and uses for meter and sensor data are planned. While powerline data transmission technologies exist and may be used inside homes and business, the wider area communications link outdoors is expected to be primarily wireless.

Isolated Networks Difficult to Fund and Support for Many Localities

To date, many of the pilot projects funded to date treat the "Smart Grid" network in isolation using technologies such as 3G and LTE as transport mechanisms. The wireless and/or wired networks provide only the digital connections that support the functions of the utility grid itself, such as AMR. A new, independent communications network must be installed to support this flow of data.

But the ideal for many localities is not to roll out yet another data network that must be individually managed and funded, but rather to consolidate applications in a single infrastructure that may support multiple public needs.

Some of these public needs might include: video surveillance, public safety communications, traffic signal controls, even public access WiFi networks to bridge the "digital divide", among others. Not only are localities discovering that it will be more efficient to provision and manage a single network that could provide Smart Grid connectivity along with one or more other applications over the same infrastructure, but it doing so allows multiple Federal and other funding sources to be tapped to provide the resources to build and support the network.

This is called a "Smart Multi-Grid™ wireless network" and combines the networking necessary for the better management of the electrical grid with support for multiple other critical local government priorities.

Smart Multi-GridTM Wireless Network Concepts

Smart Multi-Grid wireless networks usually include a smart electrical grid component, typically implemented with intelligent wireless meters, as seen below.

In Figure 1, a large number of individual premise electric meters (or other sensors) are linked to a Collector using data-over-AC or wireless technology (often 900 MHz). In basic Smart Grid networks, this data would then be transmitted to a central site via additional wireless or wired connections.

In the emerging Smart Multi-Grid wireless network model, the data stream from one or more Collectors is linked wirelessly (or via cable) to a WiFi wireless mesh node. The wireless mesh nodes then provide the data link for the Smart Meter Controllers and provide the infrastructure for a wide variety of other applications.

As can be seen in the diagram of the Smart Multi-Grid installation (see Figure2), the addition of WiFi mesh wireless nodes not only offers a cost effective-way to connect the Smart Meter Collectors, but also enables a broad range of other services. These additional services also open the opportunity for other funding sources, including the Broadband Stimulus and Transportation Stimulus programs, along with Smart Grid funding and resources.

Implications for Wireless Designers

To date, the primary focus for wireless designers focused on the Smart Grid has been with 900 MHz and similar lower-frequency bands. This is natural given the broader range offered by 3G, LTE, and WiMAX networks and the generally low-bandwidth nature of the AMR data stream. Especially at 900 MHz, these are largely unlicensed frequencies and can be deployed based on existing cellular telephone data networks.

But with the merging focus on combining AMR networks with other existing and planned networks with much greater data requirements, a hybrid approach is likely to develop. A higher-capacity WiFi network will be chosen by many localities as the backbone to deliver Smart Grid data along with other needs, linking smaller sub-networks based on lower-performance technologies. A new generation of WiFi mesh technology makes possible the long distance multi-hop topologies necessary for these networks to be cost-effectively deployed.

Another welcome aspect of the Smart Multi-Grid model is the ability to off-load traffic from already-overtaxed cellular telephone data networks. This improves the user experience of cellular data users while deferring costly cellular carrier build-outs. That this data off-load can occur over unlicensed WiFi frequencies and be implemented with existing chipsets and drivers is an additional bonus.

Since most carriers are now applying data usage "caps" on their current 3G networks and have announced plans to incorporate similar restrictions for the emerging 4G/LTE roll-outs, end users with burgeoning data requirements will likely drive the deployment of WiFi off-load networks. A benefit to designers of using WiFi

for these off-load networks is that most mobile devices already support WiFi, so no change is needed at the handset, PC, or tablet.

Wireless Design Options

Since Smart Multi-Grid networks include both a cellular wireless and a WiFi component, Wireless Designers may choose connectivity based on the application. Applications that must be broadly interconnected, but have low duty cycles, low data rates, and low susceptibility to jitter may be best suited to the cellular 3G/4G/LTE network component of the Smart Multi-Grid. This might include Automated Meter reading and other Smart Grid telemetry.

By contrast, real-time video and mission critical data streams are often quite sensitive to jitter and have a much higher duty cycle and data rate. Rather than force these data streams onto a one-size-fits all cellular data network with commensurate low performance, connecting them over WiFi provides higher performance and reliability. Such applications as video surveillance, public safety communications, and public data access are all examples better suited to deployment over WiFi networks.

Choosing the Optimal WiFi Infrastructure

Meshed WiFi wireless networks provide broad coverage and reliable re-routing around node loss or failure. These WiFi mesh networks have been around for many years, but the special demands of mission critical applications such as those outlined above require the latest generation of WiFi wireless mesh nodes.

Often called "Third Generation" wireless mesh, these devices are built with multiple backhaul radios to minimize contention, delay and jitter while providing the highest possible performance over the long distances and many hops (node-to-node connections) typical of Smart Multi-Grid Networks.

The most advanced of these Third Generation solutions may be easily deployed neighborhood-by-neighborhood, automatically reconfiguring the network topology for optimal performance. This eases network configuration overhead and allows the Smart Multi-Grid WiFi backbone to easily keep pace with AMR and other Smart Grid initiative roll-outs.

The Smart Multi-Grid Wireless Network

Wireless designers developing products for Smart Grid deployments over the next three to five years should consider the options presented by Smart Multi-Grid hybrid architectures, combining 3G and LTE ubiquity with WiFi capacity, performance and reach. Besides allowing designers a choice of networking technology best suited to the needs of a particular application, the Smart Multi-Grid architecture eliminates the problems of managing multiple physical networks by consolidating Smart Grid and other locality networking needs into a single, cost-effective infrastructure.

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