AMR/AMI Infrastructure

White Paper

Abstract

AMR (Automatic Meter Reading) and AMI (Advanced Metering Infrastructure) allow customers to make real-time choices about power utilization. These initiatives also enable utility companies to increase the effectiveness of the regional power grids by managing demand load during peak times and reducing unneeded power generation. This white paper discusses past and current initiatives for AMR and AMI, as well as technology, scalability and deployment, vendor neutrality, security, and manageability of these initiatives.

Historical Background

AMR (Automatic Meter Reading) and AMI (Advanced Metering Infrastructure) initiatives have been ongoing for many years, particularly in electrical distribution, but also in gas and water. The primary drivers in North America for AMR originally were to reduce the cost of collecting data (decreasing the need for meter readers) and to increase the accuracy of data collected. AMI initiatives have risen to prominence with federal policies (Energy Policy Act of 2005); deregulation and the separation of generation, transmission and distribution; energy services; increased awareness of the capacity limits of the various regional grids; and increased interest in "green" power.

The goal of AMI is to allow customers to make real-time choices about power utilization and for the utilities to be able to mitigate demand load during peak times, reducing unneeded power generation and increasing the effective capacity of the regional grids.

Previous Solutions

The most significant challenge facing the utility industry today is defining an optimal communication link to serve demands of SmartGrid initiatives. Many solutions for AMR and AMI have been tried, with varying degrees of effectiveness. Most of the widely deployed systems in the North American market have been optimized for meter data collection only (AMR), limiting the ability for utilities to control any devices at customer locations or to reliably collect time-based metering data (AMI) to monitor load shedding.

Current Initiatives

Because of the limitations of the initial AMR implementations, the trend in the past several years has been toward defining methods of communication that can allow for two-way and real-time data collection. Most AMI architectures require a combination of public and private network services, in an effort to leverage existing deployed technology and to optimize operational costs.

Both wireless and wireline technologies are considered for communication to the customer site, and various wireless technologies are considered for communication between devices (meters, load controllers, thermostats, HVAC handlers, and gas and water meters) that are located at the customer locations.

Power line carrier based technologies can be considered in some implementations for electric metering, and for some customers, use of existing network-based wireline infrastructure (DSL or T1) is satisfactory. However, the most generically available solution for reaching the customer premises is wireless transmission, either cellular, proprietary RF or satellite.

Technology Background

Until now, solutions that provide time-based interval energy metering have either been cost prohibitive or technologically deficient for high volume residential deployments. As a result, intelligent metering and communication solutions have been limited to the commercial and industrial segments of the industry. In addition, many residential solutions have been highly proprietary, limiting the ability to communicate with many devices inside the home.

Newer technologies, principally in the short-to-midrange RF arenas, offer promising methods of providing pervasive connectivity. The new RF options available focus on use of the 900 MHz and 2.4 GHz frequency bands. Since these frequencies are open, the ability of manufacturers to build products that can be produced on a wide scale provide critical cost savings, making true AMI affordable. In particular, development of the ZigBee® open standard for inter-device communication provides a mechanism for multi-vendor installations to effectively communicate.

A quick review of the basic options follows:

- 900 MHz – This frequency band has been desirable for its ability to penetrate within buildings and through moderate amounts of vegetation. A variety of vendors offer capabilities in this space, however the lack of a common communications standard makes all of these solutions proprietary, and will effectively impede their adoption for applications where multiple vendors have to create products to work together. 900 MHz frequencies are generally only available in the Americas and Australia. The EMEA (Europe, Middle East, Africa) market has a similar band in the 868 MHz range, though bandwidth limitations have prevented significant deployment of metering solutions at this frequency. Proprietary point-to-point, point-to-multipoint and mesh capabilities can be implemented in the 900 MHz/868 MHz bands.

- 2.4 GHz 802.15.4 – The 2.4 GHz band is usable in most parts of the world, providing the ability for equipment manufacturers to have a single product that can work anywhere. The 802.15.4 partial standard defines communication methods that are suitable for point-to-point and point-to-multipoint devices (but actual implementations will be proprietary to each vendor).

- 2.4 GHz ZigBee – ZigBee is built on top of the 802.15.4 framework, and provides a fully published interoperable standard that has been implemented by multiple vendors. Products that implement ZigBee based communication can share information with any other ZigBee device. Additionally, ZigBee provides a mesh infrastructure, so messages can be relayed between devices, minimizing the signal penetration limits of the 2.4 GHz frequency band.

These technologies differentiate from Wi-Fi® in that they are optimized for low data rate, low power consumption, low-cost chipsets suitable for embedding into sensors, monitors and meters.

Scalability and Deployment Issues

The limitation of simply using cellular connectivity to reach each device is twofold: the cost of the equipment required and the cost of data over the cellular WAN. Cost-effective solutions require development of a model where a limited number of WAN interconnects provide consolidated access to a large number of inexpensive devices. Further, while the requirements of AMI involve tracking data in real-time, there is a significant advantage if the system deployed can reduce the data transmission cost. For example, the utility needs to know the total amount of power being consumed in a subdivision in real time, but does not necessarily need to poll each house in real time. However, if a curtailment condition exists, the data needs to be communicated to each participating house.

Vendor Neutrality

Developing a system where multiple vendors can interoperate is necessary for AMI to be successful. Structures are updated by contractors; different companies' equipment will be selected for different structures; new technologies for co-generation will be developed and with net metering will have to be tied in to the system; and other utilities' metering systems may want or need to use the infrastructure, as may home automation and security systems. These requirements call for a solution that implements an open multi-vendor standard.

Security

AMI implementations require effective and proven encryption to ensure system integrity, yet the requirements for effective AMI solutions require interoperability. Simultaneously, methods must exist to easily deploy communication channels to additional endpoint devices. Further, effective methods have to be implemented to prevent access to the uplink network.

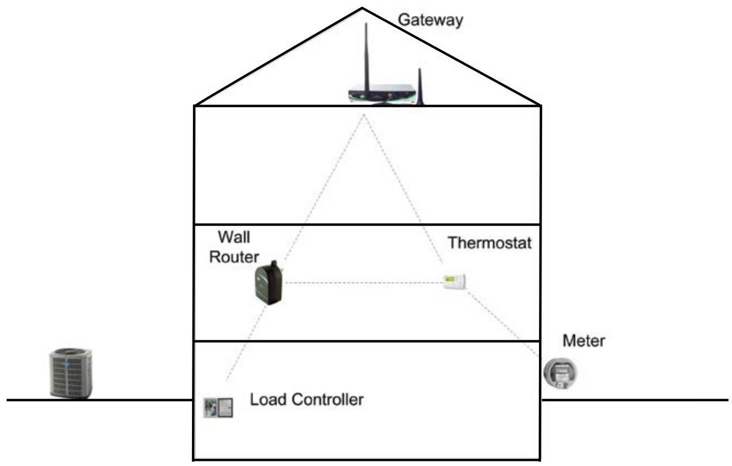
Manageability

Complex, multi-layered systems require flexible methods to provide end-to-end connectivity, from end devices, to aggregation points, to the data uplink. Given the variety of different devices that may be utilized, the uplink point is the most logical place to focus the intelligence to monitor all of the end points and to aggregate the data, and to send alarms for emergent conditions (power loss, tampering and loss of signal from an end device).

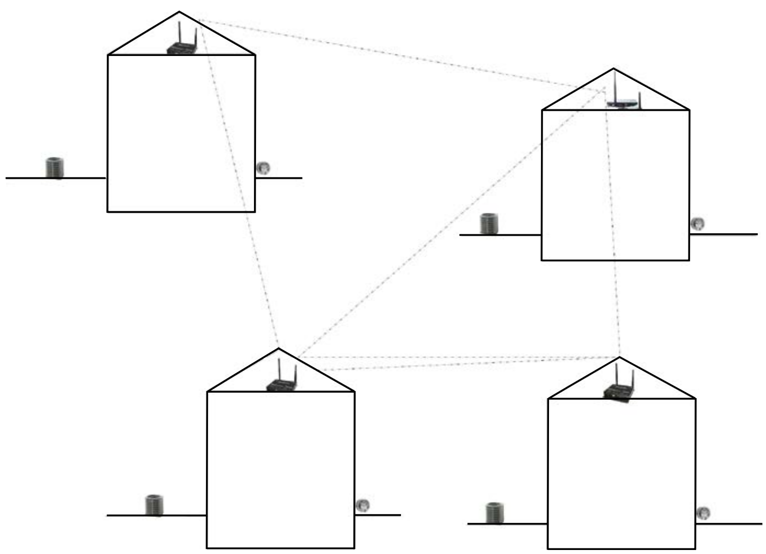
Positioning the uplink point is crucial. If a wireless connectivity model is desired, then it makes sense to have an uplink point that can be located at sufficient height (whether inside a physical structure or pole-top mounted) where better reception and transmission are possible. This becomes even more critical if one wishes to develop a system where one takeout point may service several adjacent structures, such as in a subdivision or office park. Meter locations, thermostats, and load controllers are frequently located closer to the ground or in the center of the structure, limiting the ability to reach out to the nearest cell tower.

Likewise, in cases where wireline infrastructure will be used, it will usually make sense to place the takeout point in proximity to the DSL/T1 router.

Digi's Drop-in Networking architecture for AMI/AMR:



In the first diagram, the gateway is located to provide effective communications to the various endpoint devices and to the uplink network. A ZigBee wall router is placed to provide additional coverage where needed.



In the second diagram, the network in the first diagram is extended to encompass additional end-point devices located some distance away.

Depending on the preferred method of deployment, external or embedded solutions are available. External adapters can connect to a device's native serial port or to an analog or digital output from the device, or a module can be integrated into the device. These options are available in the same form factors regardless of the type of RF communication chosen.

Summary

In an effort to define technologically viable and cost-effective AMI solutions, the utility industry has inherently defined points of commonality between competing networking topologies. Each AMI provider strives to design unique and often proprietary solutions aimed at optimizing the cost and level of services the utilities can provide to their customers – but have identified commonality in two key areas:

1. Virtually all AMI architectures being deployed present opportunities to introduce open, industry standard communications to other devices inside a building. This approach enables manufacturers of thermostats, sensors, load control devices, and other technologies to quickly support SmartGrid initiatives.

2. In addition, most AMI solutions provide neighborhood concentrators that ultimately connect to a public WAN. This connection can be achieved using Ethernet, cellular or similar technologies.

Digi's Drop-in Networking technologies are designed to address the needs of these two points of convergence.

Digi's XBee® solutions provide embedded radios that can be utilized by device manufacturers to provide standard 2.4 GHz ZigBee or 802.15.4 communications, or to design connectivity solutions based on proprietary 900 MHz radios. Digi also provides off-the-shelf adapters housing any of these radios that can be used to wirelessly enable existing electronic devices, as well as a family of gateways that provide cellular, Wi-Fi or Ethernet uplink. These gateways allow utility providers and metering companies to leverage public network availability rigth down to the home or neighborhood.

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