A PRIMER ON MESH NETWORK TECHNOLOGY

By Sharon Allan

How does the technology work? Why should utilities consider mesh network technology for their total system solution?

There is a growing consensus in the utility industry today that wireless mesh network technology is the next generation technology that will enable utilities to stay profitable in a changing global energy market. In fact, since the technology came on the market several years ago, a number of utilities have already deployed mesh network metering systems, and many other utilities are now taking a closer look. Even other industries are embracing mesh networks, and vendors such as Nortel, Cisco Systems, and Intel are ramping up their existing systems.

Wireless meter reading technology is not new. Many utilities over the last ten years or more have deployed wireless networks that have allowed them to improve business operations by automating meter reading with walk-by or drive-by radio-based meter reading devices. Original fixed wireless networks consisted of point-to-multipoint and one-way bubble-up (broadcast) networks.

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Today's requirements are for on-demand reads and full two-way capabilities – which is why utilities are taking a closer look at mesh networks. Utilities today are facing challenges that affect how they do business in a changing and uncertain energy market. Deregulation, energy supplies, increasing operational costs, ageing distribution systems, and consumer demands for more services are just some of the drivers that affect how utilities manage their business operations today.

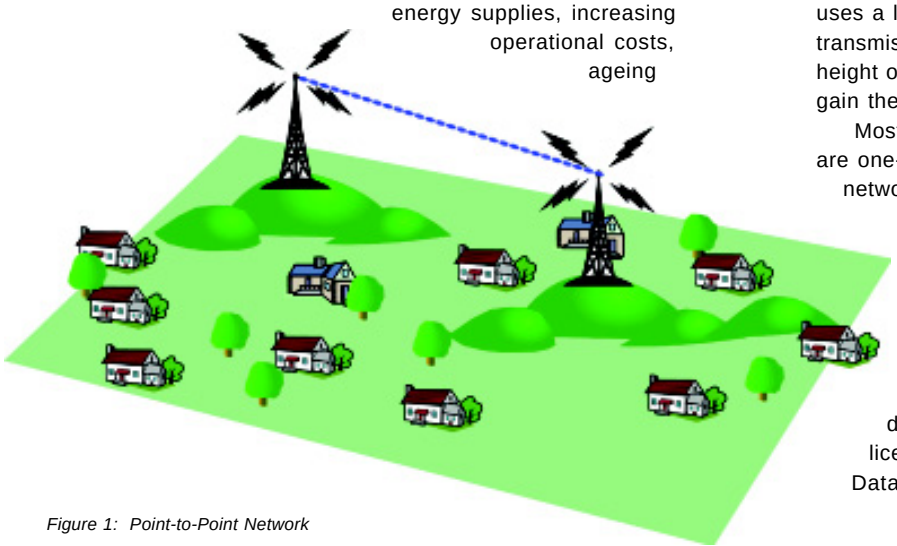

Figure 1: Point-to-Point Network

Are mesh networks the answer? Some utilities think so, because their automatic meter reading (AMR) needs have evolved beyond just streamlining the meter reading process, and mesh networks fit their business case.

AN INTRODUCTION TO WIRELESS NETWORKS

There are several types of wireless network available on the market today, including point-to-point networks, point-to-multipoint networks and mesh networks. All have advantages and disadvantages, and some are more viable for automated meter reading.

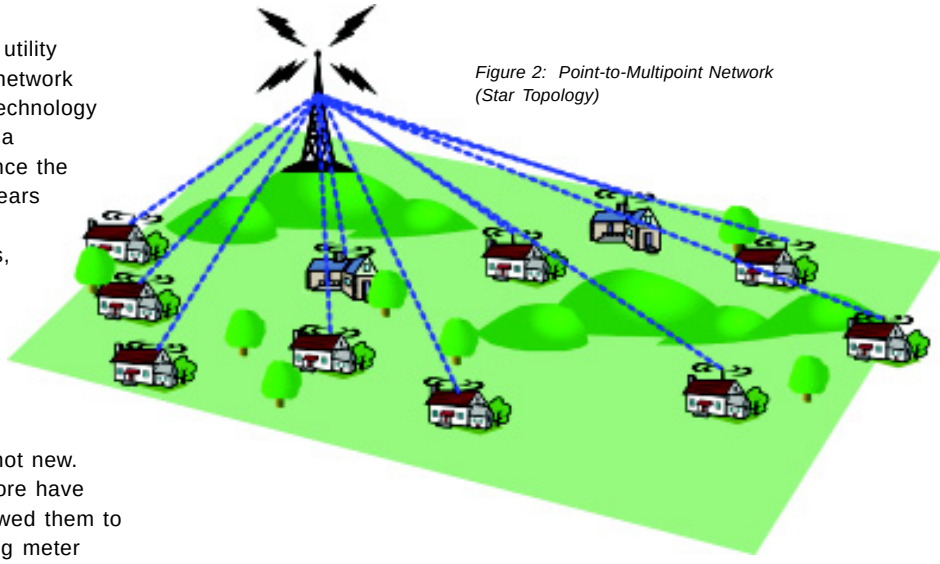

Figure 2: Point-to-Multipoint Network (Star Topology)

Point-to-Point Networks

In a point-to-point network, each endpoint only communicates directly with one other point (see Figure 1). Wireless point-to-point systems are often used in the wireless backbone to connect cell towers to each other. Cellular carriers may connect cell towers with a wireless connection that connects one tower to another, so that only one fibre or wired connection is needed to connect the cell tower back to system enterprise.

Point-to-Multipoint Networks (Star Topology)

Point-to-multipoint networks use a star topology that has either one-way or two-way communications (see Figure 2). These networks use either licenced radio frequency (RF) spectrum or non-licenced spectrum. If the system uses a licenced fixed frequency, the power level of the transmission devices, the quality of the antenna, and the height of the collection point are all important factors to gain the most distance and area coverage possible.

Most unlicenced wireless RF fixed networks in use are one-way single hop configurations where the network nodes communicate to a data collector (often called a concentrator) mounted on a nearby pole or tower. The communication from the utility enterprise server to the concentrator generally uses some form of two-way communication. Many licensed wireless RF public networks use two-way communication from the radio tower to the end device radio in the meter. Examples of public licensed wireless are GSM, CDMA, iDEN, and DataTAC.

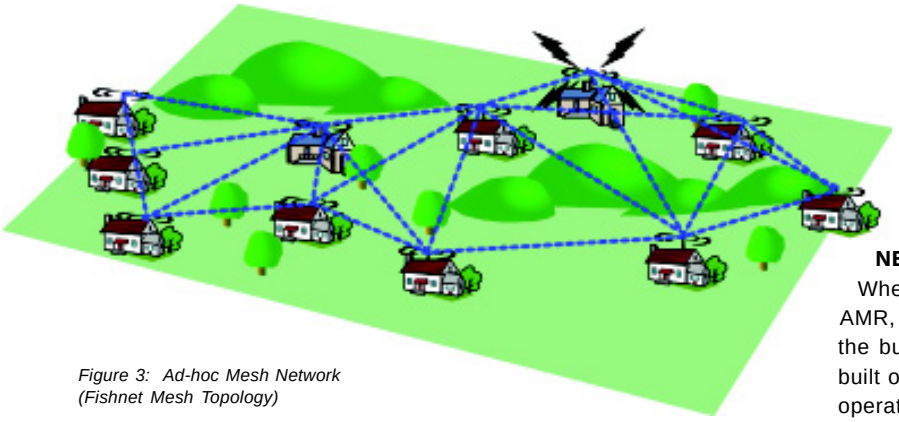

Figure 3: Ad-hoc Mesh Network (Fishnet Mesh Topology)

Mesh Networks

Mesh networks are different to point-to-multipoint RF networks because every node can communicate with another node or multiple other nodes within the network. Properly designed mesh networks are self-healing and self-configuring. When new endpoints are installed, they automatically register themselves within the network without human intervention. Similarly, if communication paths are broken, mesh networks automatically self-heal by redefining new communication routes – again without human intervention. "Mesh networks are also inherently robust, as new routes can be found if any one node goes down. There isn't normally just one point of failure," stated Mike Witteman, Researcher for Intel's Network Architecture Lab, in a ZDNet news article titled "Intel makes a mesh of wireless networks" February 2003.

Ad-hoc Mesh Networks

There are, however, differences in mesh networks. With ad-hoc mesh networks, every node is a repeater and is capable of communicating with other nodes within the network. The communication paths tend to look like a fishnet (see Figure 3). Each node within the network manages its routing path to every other node in the network. For example, if there are 1,000 nodes within the network, each node has a routing table that it uses to address the other 999 nodes. Additionally, to manage the network, each node has routing algorithms used to determine link states and transmission vectors. The nodes use this information to determine the best multiple-hop path to return information to the data collector, based on which node is closer, has the strongest signal strength, or is fewer hops away.

Controlled Mesh Networks

In a controlled mesh network, each node within the network also acts as a repeater, so the communication path between a node and a data collector can cover multiple hops between nodes (see Figure 4). Additionally, nodes in a controlled mesh network are self-registering and self-healing. If a communication path is blocked, the system automatically establishes an optimal communication path through another repeating node and automatically creates a map back to the data collector. The difference in a controlled mesh and an ad-hoc mesh is that the controlled mesh is typically less expensive, since each end node does not need to maintain large routing tables. The algorithms in the endpoints are less complex than in an ad-hoc mesh.

NETWORK RELIABILITY AND COST

When evaluating and selecting a wireless network for AMR, it is important to consider the system's reliability. If the business case for wireless network technology is built only on automated meter reading to lower operational costs, then the reliability of the network is critical. If the percentage of meter reads missed every month is high, the true cost of the network could be much more than anticipated in the original business case. Unreliable systems can generate additional hidden costs, because a meter reader may still need to go into the field to read meters that were missed, or the utility may need to calculate an estimated bill.

"Mesh networks are reliable, scaleable, and are inherently adaptable."

Point-to-Multipoint Networks

Point-to-multipoint networks are generally reliable if there is margin factored into the design. These networks are typically low cost, but they can have some economic pitfalls. If a communication obstacle exists, it is more difficult to obtain the endpoint communication without adding a new collector point.

The reliability of point-to-multipoint networks is determined by the placement of the data collector and the endpoints. The reliability of point-to-multipoint networks is directly dependent on the signal strength and receiver sensitivity of the data collector and the endpoints. With point-to-multipoint networks, the weather, hilly terrain, trees, and tall buildings can block transmission. If the data collector fails, the entire network goes down.

Point-to-multipoint networks require much more planning to deploy. They can be difficult to site, require a bucket truck and crew to install or service, and are more costly to wire for power and communications. Any miscalculation in the planning and implementation stage of these networks could result in additional costs that

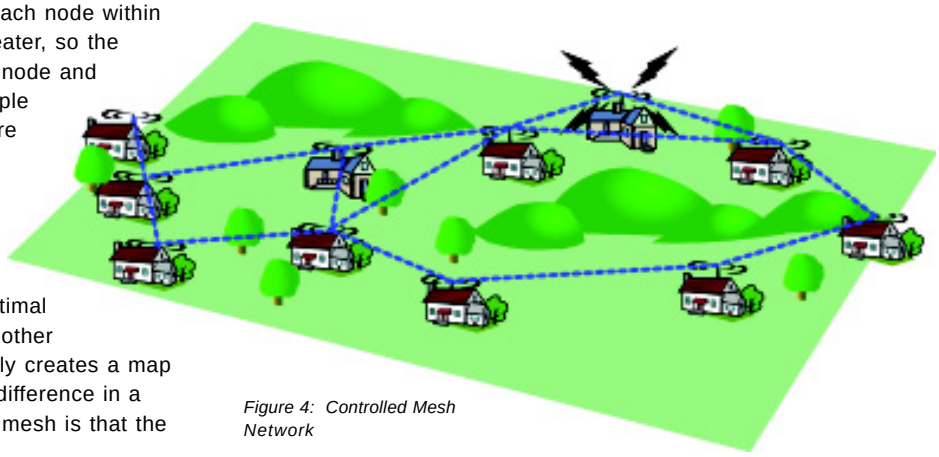

Figure 4: Controlled Mesh Network

Network Topology	Economical	Reliability	Adaptability	Scalability
Point-to-Point	Low	High (depending on design)	Low	None
Point-to-Multipoint	Medium	Medium-High	Low	Medium
Ad-hoc-Mesh	High	High	Medium (may require programme for routing tables)	Medium
Controlled Mesh	High	High	High (self configuring)	High

Table 1: The Suitability of Wireless Networks for AMR

were not anticipated. If the system has poor reliability, it is difficult to correct. A utility could incur additional expenses after committing to a point-to-multipoint network if higher towers are needed, or if more data collectors are needed to make the system more reliable. The planning required and the logistics of deploying this type of network influences the total system cost.

Mesh Networks

Mesh networks are reliable, scaleable, and are inherently adaptable. Consequently, they are economical wireless networks. It is important to understand that there are some subtle differences between ad-hoc mesh networks and controlled mesh networks. Ad-hoc mesh networks use meters that include routing tables and routing algorithms to determine the transmission path back to the data collector. If network traffic is high, the ad-hoc network concept can result in lower bandwidth on the local area network (LAN) for end devices. Nodes in controlled mesh networks scale better and generally the communication is quicker, as multiple nodes are not repeating the same messages, thereby adding unnecessary additional air traffic in the wireless frequency.

"When evaluating a wireless metering system, it is important to look at the total system cost..."

Mesh networks are reliable because of their multi-hop, self-healing, and repeating characteristics. Mesh networks are also more immune to interference because they use low power, short-haul transmission devices that can use multiple paths to route around areas of interference. Albert Lin, American Technology Research Analyst, stated in Forbes magazine (April 7, 2005) that a mesh network is a "far less expensive way to construct a [wireless] network than the traditional way."

Why use Controlled Mesh Networks for AMR?

Controlled mesh networks are dependable, high performance systems, which make them more suitable for AMR than other fixed wireless networks. (See Table 1 for a summary of wireless network characteristics.)

When evaluating a wireless metering system, it is important to look at the total system cost rather than just the per meter cost before making a big investment. Utilities often justify their expenditures by using a business case that is built upon the ability to deploy a certain number of end devices around the data collector. Typically, the greatest cost element in the business case is the recurring monthly cost of the communication path needed to bring data back to the enterprise IT system.

During a system deployment, however, the business case can fall apart if additional data collectors are needed to receive complete wireless coverage for an area. Often more data collectors are needed than were anticipated, because obstacles prevent end devices from being able to communicate with the data collector. The most significant limitation of networks that use star topologies is the single communication path between each end device and the data collector. If the data collector fails, then the entire network it serves is down until the failed data collector is diagnosed, repaired, or replaced.

With controlled mesh networks, systems have true scaleability. System deployments can be installed in specific geographical areas that a utility company targets for AMR and then easily scaled up to a full system installation that covers the majority of its service area. Because of the self-registration and self-healing characteristics of mesh networks, the task of system expansion is simplified by just installing additional meters.

Looking ahead, in the near future it is possible that state public utility commissions will encourage utilities to offer demand response programmes to their customers. While it is still uncertain how future regulations will impact on the electricity utility industry, utility companies that have already deployed mesh networks with two-way communication have found value in those systems. Controlled mesh networks with two-way communication have enabled utilities to offer their customers new services such as remote service connects and disconnects, and daily on-demand meter reads for customers who participate in demand response programmes with critical tier pricing. MI

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ABOUT THE COMPANY: Elster is a leading technology company that supplies enterprise metering information solutions to utilities around the world. Located in Raleigh, NC, Elster Electricity provides a broad range of electro-mechanical and 'SMART' electronic meters for both North American ANSI and international IEC standards. Elster also provides software systems and communication networks to facilitate business process usage of metering data.

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