Wireless Mesh Technology: Netting Applications Across the Board

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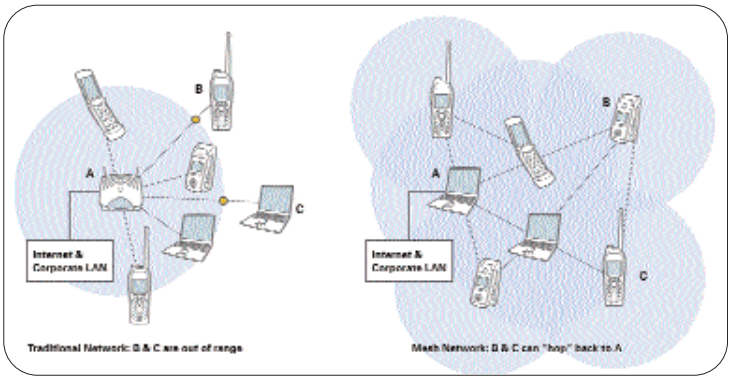
Mesh networking offers a new model of seamless mobility that is already transforming wireless data and voice communications for police work, at the scene of fires, in industrial settings, and anywhere instant, wireless information access can provide both economic, quality of life and safety benefits. From initial military, first-responder and municipal applications, mesh networks are being quickly adopted in several vertical markets such as mining, manufacturing, transportation, and other enterprise or industrial settings.

Mesh networks were originally developed to give soldiers reliable broadband communications anywhere in the battlefield, and the benefits of the current technology flow directly from the military's unique needs. Mesh technology provides troops with instant broadband communications across the battlefield without the need to pre-deploy large towers or antennas. Every soldier's radio powers the network - creating an interconnected web of radios that automatically extends network coverage and robustness as new users join the mesh. The system also increases tactical situational awareness with support for real-time data and video connectivity.

Since police and other first responders have many of the same needs it is not surprising that many of the first non-military mesh networks were deployed to support public safety applications. Forward-thinking city governments quickly expanded the use of mesh networks to other agencies such as public works, code enforcement, and other mobile city workers, eventually making its way to additional various vertical markets seeking similar benefits.



How a mesh network works

Wireless mesh networking leverages the concept of the wired internet where each node acts as a router/repeater for other nodes in the network. These nodes can be fixed pieces of network infrastructure, such as wireless routers (WRs) and intelligent access points (IAPs) and/or can be the mobile users themselves. This results in a decentralized and inexpensive mobile broadband network, since each node need only transmit as far as the next node.

By transmitting data from nearby nodes to peers that are too far away to reach, a mesh network can span large distances, provide high data rates, and eliminate line of sight issues by routing around obstacles, especially over rough or difficult terrain. Mesh networks are also extremely reliable, as each node is connected to several other nodes. If one node drops out of the network, due to hardware failure or any other reason, its neighbors instantly find another route. Additionally, network capacity can be increased by simply introducing more wireless routers and intelligent access points.

Mesh networking is typically implemented in two basic modes: infrastructure and/or client meshing. To gain the maximum benefit that meshing can offer, both modes need to be supported simultaneously and seamlessly in a single network. Infrastructure meshing creates a wireless backhaul mesh among wired access points and wireless routers. This reduces system backhaul costs while helping increase network coverage and reliability. Client meshing, on the other hand, enables wireless peer-to-peer networks to form between and among client devices (i.e., end users) and does not require any network infrastructure to be present. In this case, clients can "hop" through each other to reach other clients in the network.

By overcoming traditional wireless network limitations, mesh networking opens the door to remarkable new wireless capabilities:

• Instant, automatic formation and evolution of wireless networks. The centerpiece of mesh network technology is the ability for nodes to automatically join and leave the network anytime. Networks can be instantly established virtually anywhere, even in places with no fixed infrastructure. In fact, vehicles moving at over 150 mph can automatically join a mesh network, enabling completely new models for mobility.

• Self-forming, self-healing, and self balancing. Mesh networks are inherently more robust than traditional wireless networks. Automatic configuration and routing enables networks to be self-forming and self-healing. The network continues to function even if one or more nodes fail.

• Increased coverage and performance. High data throughput requires a high signal-to-noise ratio. However, signals weaken exponentially as the distance from the transmitter increases - meaning relatively more noise and correspondingly lower performance; whereas in a mesh network, full signal strength is restored with each "hop" in the network. As a result, networks can grow to virtually any size while retaining excellent performance.

• Non-GPS location and asset tracking. GPS can be subject to several types of errors, and is ineffective in mines, inside large structures or in other locations that block the signals from GPS satellites. Motorola's mesh network technology uses sophisticated triangulation and time-of-flight algorithms to determine the location of nodes in the network. That can mean the ability to find a firefighter in a burning building where GPS is unsuccessful.

• Lower infrastructure and operational costs. The self-forming, self-healing capabilities of a mesh technology help reduce the administration, maintenance, and support costs of these types of networks. Additionally, the skill sets required for network administration are typically lower than for cellular and other centralized wireless networks.

• The power needed to maintain a given signal strength increases exponentially with distance from the transmitter. The multi-hopping characteristics of some mesh solutions continually regenerates signals to minimize power while maximizing signal strength. Each node in the mesh network is only required to transmit at 1x power, regardless of the total end-to-end distance of the transmission. This maximizes battery life and enables the use of low-cost, off the shelf radio components.

Mesh networking represents the ultimate evolution of the Internet, taking it into the realm of wireless mobility, which is why mesh networks are increasingly serving a variety of exciting new usage models that will affect almost every aspect of life.

Public Safety

Mesh networks enable public safety officers with high-speed access to mission critical applications (Amber Alerts, mug shot, finger print and criminal history databases) in their vehicle, creating a virtual mobile office. Video features include surveillance of high-crime, high-security areas 24 hours a day, 7 days a week and monitoring police at routine traffic stops for enhanced security. Additionally, Fire and EMS vehicles are mesh-enabled as a reliable way to transfer and receive data - building schematics, HAZMAT information, medical records, etc. - when responding to incidents.

Public Works

Public works/engineering departments are utilizing mesh networks for a variety of applications involved in street, water and sewage management, as well as facility and vehicle maintenance. Through real-time data accessibility and video transfers over the mesh network, public works officials are able to review and monitor the operation of the City SCADA systems on city wells and pump stations. These systems lessen the burden on technicians and operators by automatically collecting and analyzing process data, as well as circumventing physical barriers making communication and transference of voice, data and video possible. Mobile computing is used to monitor and control the wastewater and water production processes so personnel can make changes to the system parameters from their vehicles, saving time and increasing worker efficiency.

Mesh networking in a water treatment facility

Enterprise

Mesh networks are empowering enterprise field workers with access to databases, photographs, product manuals, dispatch information and other high-bandwidth information. Additionally, mesh networks technology provides users with the ability to set up ad hoc applications - such as temporary security camera networks - without the need for pre-deployed infrastructure.

Mobile Wi-Fi and public transit

Mesh technology can put Wi-Fi access points "in motion" for public transit agencies and commercial network access providers. Instead of limiting 802.11 access to stations and stops, mesh technology can extend access into buses and trains themselves - transforming hot spots into "hot routes." The same networks can also carry security video images, driver communications, and other information that helps the transportation system run smoother and safer.

Intelligent Transportation Systems

Departments of transportation rely on intelligent transportation systems that typically require a run of fiber-optic cable to monitoring cameras and other devices - an expensive and inflexible approach that leads to traffic disruptions and rights-of-way issues. Moreover, portable and mobile devices may not be able to attach to the network at all. Mesh networks provide flexible, cost-effective, non-disruptive wide-area connectivity even for devices moving at freeway speeds.

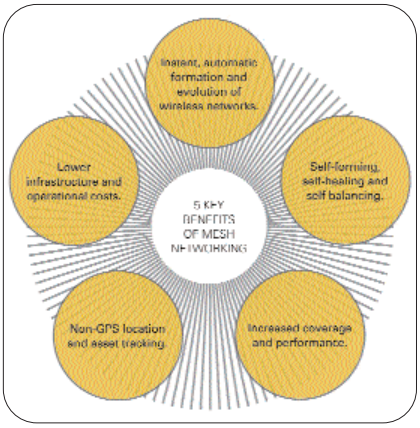
Digital home

As home users build increasingly sophisticated wireless networks to enjoy more kinds of content, at higher resolutions and on more devices throughout their homes, the tradeoff between bandwidth and range/coverage becomes a critical issue. At the same time, consumers prefer not to deal with site surveys and configuration issues - they just want to turn on devices and have them work together automatically. Mesh networks offer an easy way to achieve whole-house multimedia distribution, security monitoring, Internet connectivity, VoIP communications, and more.

Redefining the Capabilities of Wireless Mesh: Industrial Mesh

Generally speaking, when dealing with industrial environments, one must consider the difficult surroundings involved and issues that most radio systems are not equipped to overcome. Thick concrete walls, extensive metal structures and radio frequency, noise generating machinery that create interference and "non-line of sight" obstacles are some of the challenges to be considered. Early attempts to wirelessly enable sensors and controllers with cellular or 802.11 technologies in industrial environments have resulted in mixed outcomes. Smaller scale and light industrial deployments have usually been successful since the physical scope and radio interference in these settings tend to be manageable for traditional wireless technologies. However, large scale and heavy industrial settings have proven far more problematic for wireless solutions, since these environments make many types of wired and wireless networking difficult. Consequently, mesh networking technology has become the popular solution to such problems.

Automatic and ad hoc communications between machines, particularly in industrial settings, will provide new ways of remotely monitoring, measuring, and tracking both fixed and mobile systems. Self-forming, self-healing wireless mesh networks make it simple and cost effective to poll, monitor, adjust and control systems that once required either laborious and expensive manual processes or expensive cabling or wiring. Until recently, these networks were limited to point-to-point, low-bandwidth, fixed position sensors. However, the crossover of high performance (i.e. mobile broadband) meshing technology into the wireless sensor space is opening up a whole new set of applications and capabilities that were beyond the reach of traditional wireless sensor solutions.



It is no wonder that high performance wireless mesh networking is gaining wide spread acceptance in large scale, interference laden industrial facilities. A wireless mesh is different from the typical point-to-point and centralized radio solutions used for networking sensors today. In a mesh network, each node (in this case the sensor itself) can not only send and receive its own information, but can also function as a router/repeater that can relay messages for neighboring nodes. This ability to "hop" signals through neighboring nodes offers several critical benefits needed to achieve a cost-effective and reliable network for even the most challenging settings.

By leveraging the peer-to-peer connectivity between nodes, signals can be routed around obstructions, interference, congestion and node failures automatically. The ability for the nodes themselves to create multi-hop non-line of sight connections simplifies deployment and engineering of the network. Since each node regenerates and strengthens the signal as it hops through its radio, wireless coverage and reliability are greatly enhanced. Finally, meshing enhances the ability of these wireless networks to support end-to-end broadband data rates; so video, imaging, and other bandwidth intensive applications can be wirelessly networked as well.

Resulting from its inherent advantages, many mesh based sensor products are appearing on the market. Some products, particularly those that are being adapted from wide area mobile broadband technology, offer interesting possibilities for process and security use. Unlike battery-powered, low-speed data wireless mesh solutions designed with near-zero power consumption in mind (which leads to short range and low data speeds), higher powered, broadband mesh technologies are aimed at applications where performance, bandwidth and reliability are paramount. With burst data rates of up to 6 Mbps, these more powerful mesh networking systems can enable applications that take remote monitoring and control to their next logical step. At broadband speeds, real-time video monitoring can be implemented to allow facility staff to see remote environmental and equipment conditions without having to physically travel to these locations. Similar remote security monitoring capabilities are also possible. Technicians could leverage the wireless mesh network for connectivity to central inventory, repair manuals and reporting systems from their laptops or PDAs.

Mesh is a revolutionary technology that is changing the way wireless networks are created and used in a wide range of applications. Users of all types are benefiting from mesh networking technology's proven ability to provide the required ease of deployment and high throughput in even the most difficult environments. Its inherent ability to support mobile users, deliver remote video and prioritize real-time data traffic elevates mobile broadband meshes from simple wire or cable replacement to a strategic operational investment. As evidenced by its quick and continual adoption in a wide range of industry settings seeking instant wireless broadband access, mesh networking delivers on the promise of seamless mobility and has quickly established itself as a model that is transforming wireless data and voice communications.

Motorola is known for innovation and leadership in wireless and broadband communications. Inspired by the vision of Seamless Mobility, the people of Motorola are committed to helping users get and stay connected simply and seamlessly to the people, information, and entertainment that you want and need. For more information please visit www.motorola.com or contact Pamela Benke, Marketing Communications Manager for Motorola's Mesh Network Product Group at Pamela.Benke@motorola.com or (407) 562-4032.