MOTOROLA

Mesh Networks

Decentralized, self-forming, self-healing networks that achieve unprecedented coverage, throughput, flexibility and cost efficiency.

Mesh networks technology is helping to enable the 4th generation of wireless mobility by using basic radio frequency (RF) physics in a new way — overcoming inherent limitations to achieve unprecedented coverage, throughput, flexibility and cost-efficiency. Mesh networking offers a new model of seamless mobility that's already transforming wireless data and voice communications for citizens, in police work, at the scene of fires, on the battlefield and in other settings where instant, wireless information access can provide both economic, quality of life, and safety benefits.

Mesh networks provide the required ease of deployment and high throughput in even the most difficult environments. From military and first-responder applications, mesh networks are being quickly adopted in municipal wireless broadband networks. They are also appearing in several vertical markets such as mining, manufacturing, transportation, and other enterprise settings. And increasingly, you'll see mesh networking technology transforming commercial settings, public places and even home networks. Mesh networks are revolutionizing wireless mobility.

Mesh Networking: A Revolution in Anywhere, Anytime Wireless Connectivity

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 powered the network — creating an interconnected web of radios that automatically extended the coverage and robustness of the network as new users joined the mesh. The system was designed to increase tactical situational awareness by adding support for real-time data and video connectivity to individual soldiers and battlefield commanders.

Since police and other first responders have many of the same needs it is not surprising that many of the first non-military mesh network deployments were 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. Mesh networks are also being deployed to create citywide wireless Internet clouds that provide "always on" broadband access for residential and business users.

Motorola has dramatically increased the capabilities of these early military networks to create a robust, flexible, standards-based architecture that enables seamless mobility in government, transportation, industry, and more. Under Motorola's leadership, mesh networking is rapidly taking its place as a major driver of the 4th generation of wireless mobility.

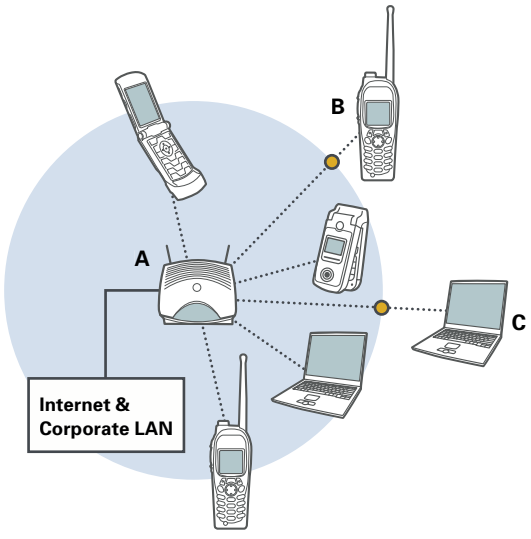
What is mesh networking?

Wireless mesh networking leverages the concept of 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 and/or can be the mobile users themselves (Motorola's mesh technology supports both modes simultaneously).

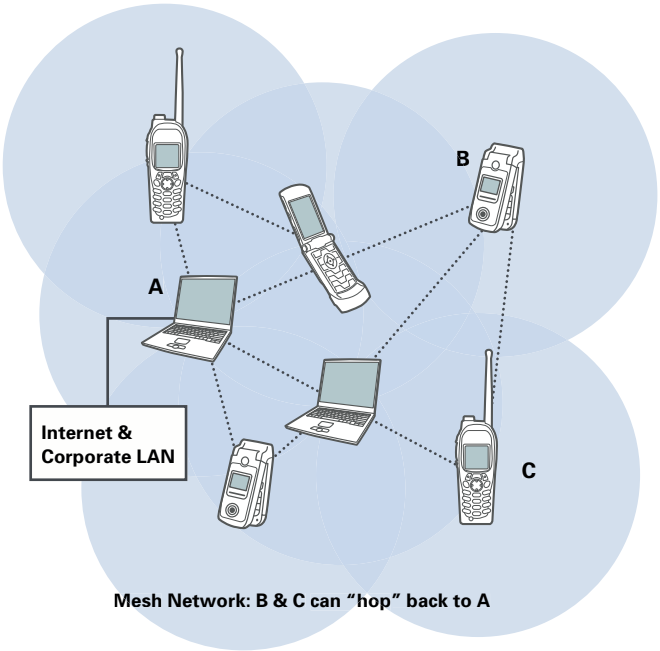
This result is a decentralized and inexpensive mobile broadband network, since each node need only transmit as far as the next node. Nodes act as router/repeaters to transmit data from nearby nodes to peers that are too far away to reach (something Motorola calls Multi-Hoping®), resulting in a network that can span a large distance, provide high data rates, and create non-line-of-sight connections 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. Extra capacity can be installed by simply adding more Access Points.

The principle is similar to the way packets travel around the Internet — data will hop from one device to another until it reaches a given destination. Dynamic routing capabilities included in each wireless device allow this to happen. To implement such dynamic routing capabilities, each device needs to have sophisticated hardware and software that can communicate its routing information to every device it connects with in "real time". Each device then determines what to do with the data it receives — either pass it on to the next device or keep it.

It is important to understand that mesh networking is not a new type of radio or modulation. Instead, it's a new way to network and connect existing and new radio technologies. Mesh networking is more about a type of network architecture than it is about which particular radio technology is used. Radio modulation determines how a specific radio will transmit and receive information over the air, whereas network architecture defines the overall structure, components, and interrelationships of devices in the network. This means, in essence, that mesh-networking technology can be applied to practically any radio scheme, effectively allowing the best radio to fit the desired application.



Traditional Network: B & C are out of range



Mesh Network: B & C can "hop" back to A

New Wireless Capabilities

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. Signals are routed optimally, even as the network grows and evolves. 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. Reliable networking can be established anywhere, almost instantly — without relying on fixed infrastructure.

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. But in a mesh network, each node acts as a router/repeater, restoring full signal strength 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 is a boon for organizations that need a precise way to locate people and things in motion. But GPS can be subject to several types of errors, and it doesn't work at all 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 fight algorithms to determine the location of nodes and users in the network. That can mean the ability to find a firefighter in a burning building, a place where GPS typically can't reach.

Lower infrastructure and operational costs. Mesh networks typically require less backhaul than a traditional wireless network, sometimes as much as 90% less, which can greatly reduce deployment and operating expenses. Because mesh networks are self-forming and self-healing, administration and maintenance costs are reduced as well. Network administration skill sets can be lower than what is typically required for cellular and other centralized wireless networks. And since the network is self healing, the need for 24 hour on-call maintenance support is greatly reduced.

Transforming the Wireless Architecture

In previous generations of wireless, RF physics have always placed strict limits on network capabilities. For example, in a typical client/access-point wireless network, RF signal attenuation can impose unacceptable tradeoffs between power, distance and throughput; disrupt data streams as users cross roaming boundaries; and even lead to dropped connections when physical barriers get in the way. All of these limitations result from the way signal strength drops exponentially as a function of distance between the sender and receiver.

Simply put, mesh networking makes any radio system perform better. This statement is not based on marketing hype, but rather RF physics. Meshing solves one of the biggest issues encountered by wireless broadband systems: the Range vs. Data Rate Dilemma.

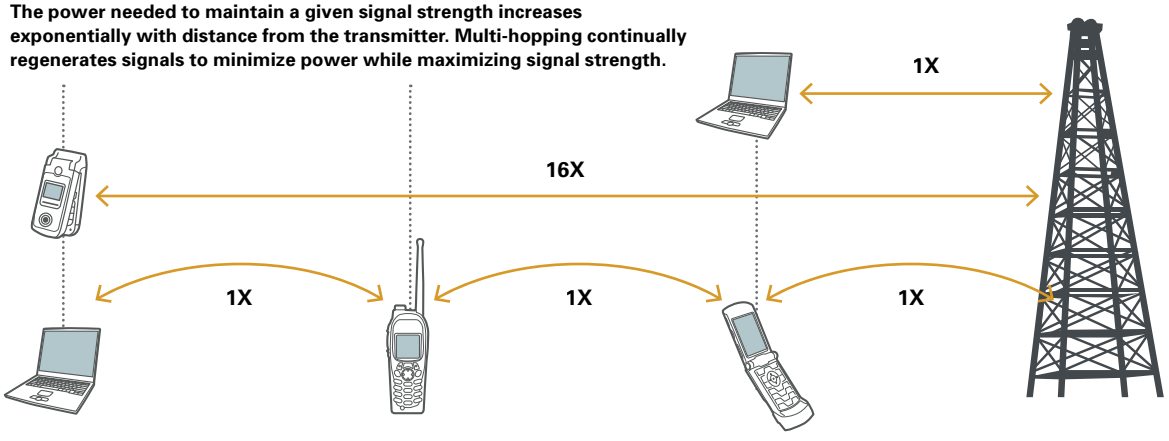
The physics of broadband wireless communications stipulates that trade-offs between data rate and radio range for any given transmitter power output have to be made. That is, for a specified transmit power, the data rate available (i.e. throughput) will decrease as range from the transmitter increases. This is true for any radio modulation or protocol. Once a radio reaches the maximum allowed power level, it must start dropping data rates to increase transmit distance.

In the diagram below we show that for a given data rate, the power required to send data from a transmitter to a receiver over one unit of distant is 1X of power. However, to send that same data rate to a user that is three times that distance away doesn't take 3 times the power; it takes 16 times the power! Meshing changes this equation by breaking up long distances into several short hops. The result is that by using hopping and a mesh architecture we can send that same data rate over the same distance, but only require a total of 3 times the power not 16. Also worth noting is the fact that each node in the mesh is only required to transmit at 1X power — regardless of the total end-to-end distance of the transmission. This extends battery life and enables the use of low-cost, off the shelf radio components

Transmit power is typically limited by regulation or available battery power on the end users device. This is why cellular (centralized) networks offer high data rates close to the cell or access point, but much lower rates as you move even a short distance away. The same physics explains why the downlink data rates (from the high power cell to the mobile user) are much higher that the uplink (from the low power mobile user to the cell) in cellular systems.

Meshing, on the other hand, offers both long end-to-end range and high data rates by hopping through a series of intermediate nodes. Since the distances between each node (i.e. hop) is relatively short compared to the distance between the end transmitter and receiver, each hop can be completed at much higher data rates than is possible with a direct end-to-end connection. However, hopping creates an end-to-end connection that supports high downlink and uplink data rates over very long distances. In other words, meshing lets you have both higher data rates and longer range by making radio physics work for you, not against you. This phenomenon can used to enhance any personal area (Bluetooth, UWB), local area (WiFi) and wide area (WiMax, Cellular) radio technologies.

The power needed to maintain a given signal strength increases exponentially with distance from the transmitter. Multi-hopping continually regenerates signals to minimize power while maximizing signal strength.



Learn more about mesh networks

Mesh networking is a revolutionary technology that is transforming the way wireless networks are created and used in a wide range of applications — from industry, government, transportation and public safety to mobile WiFi, the digital home and beyond.

Motorola is a leader in mesh technology and standards. Look to Motorola for the mesh networking innovations that will transform the way people work, travel, learn and communicate in a new world of seamless mobility.

Learn more about how mesh networking is transforming the wireless landscape, enabling a new era of seamless mobility. For more information, visit: www.motorola.com/mesh.

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