Wireless Mesh Networking—The Third Generation

As users demand better and more consistent access to their data, both indoors and outdoors, an emerging new technology—'Third-Generation Wireless Mesh'—offers the mobility, freedom, and power of wireless connectivity, while preserving the performance that's only been available in wired networks. We take a closer look at this technology.

Users today have grown accustomed to wireless networks inside buildings and within their enterprise. This connectivity is often provided by access points based on 802.11b or 802.11g networks. These access points typically are connected physically to the wired Ethernet (Internet or intranet). Users with 802.11b/g equipped devices such as laptops, personal digital assistants (PDAs), and Voice over Internet Protocol (VoIP) phones may connect to the Internet or intranet, wirelessly via these access points.

While this technology works well within a building where wired or fibre Ethernet connections are plentiful and inexpensive, it can be difficult or even

impossible outdoors in a metropolitan environment. This is because the costs and infrastructure requirements of a wired or fibre connection to each access point are prohibitive.

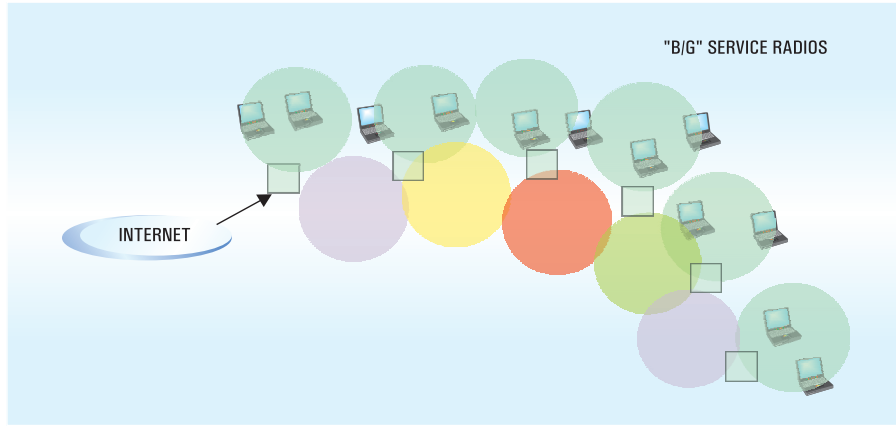
Wireless networks — the early generations

The first solutions for outdoor wireless networking created access points that could not only connect to users, but also could create links from node to node. First developed for military applications, this first-generation product is sometimes called an 'ad hoc' or 'single radio' mesh. This was the first wireless technology to allow some extended distance between wired or fibre connections.

Although a welcome initial step, this technology had its limitations. As a single radio provided both 'service' (connection to individual user devices) and 'backhaul' (links across the mesh to the wired or fibre connection), wireless congestion and contention took place at every node. Users soon discovered that only one or two radio 'hops' were possible between connections to the wired or fibre Ethernet. Support for voice and video applications was also poor because of excessive and varying delays across the network.

In an effort to solve the contention and congestion issue, the second-generation mesh was developed by placing two radios in each node. Often called '1+1' mesh, this technology separated user traffic from backhaul traffic by creating a separate network for each. This was often achieved by combining an 802.11b/g service radio with an 802.11a backhaul radio in each node.

While this offered a significant performance improvement over first-generation mesh, problems remained. With heavy user demand, there was still contention and congestion on the backhaul links, which still shared a single radio channel. This limited the number of radio hops. The performance of voice and video applications also suffered because of the congestion in the backhaul stream.



Separate uplink and downlink backhaul radios

The major problem with preceding generations of wireless technology is that they could not overcome the key limiting factors in outdoor networking: scarce radio capacity (or spectrum) that limited performance; the cost of many wired or fibre connections in the outdoor environment; and the necessity for easy and automated deployment.

Advantage, third generation

Third generation solutions have not only addressed some of the issues plaguing earlier generations of wireless technology, but have also attempted to deliver more value to the users. Some of their features are discussed below.

Third generation solutions begin by adding additional radios to each node. Each of these radios has a specific role to play. To overcome the problems of congestion and contention, one radio is used to create a link to its upstream (nearer the wired source or 'root') node. Another radio creates a link downstream to the next neighbour node. Unlike the 1+1 second-generation solution, these two radios make use of different channels. This increases the bandwidth of the network in two ways.

Third-Generation mesh—higher performance over more hops

Firstly, each node may be sending and receiving simultaneously to its upstream and downstream neighbours. This is unlike the backhaul radio of the second-generation 1+1, which would continually 'turn around' between sending and receiving upstream and downstream. It's even worse for the first-generation single-radio mesh network—the radio must manage users and backhaul on the same radio! Secondly, because each link is managed independently, the available channels may be re-used across the network. This expands the available spectrum, improving network performance by almost 50 times compared to first and second generation solutions.

Distributed intelligence for better performance within a limited spectrum

Another factor limiting the spectrum capacity of wireless mesh networks is the potential for interference from devices outside the network. For ease of deployment, wireless mesh products operate in the unlicensed 802.11a and 802.11b/g bands. Unfortunately, another device may begin transmitting in the same

area without warning.

The most sophisticated third generation wireless mesh products provide for channel agility and flexibility in network topology through the use of optimised software on each node. This software dynamically detects and avoids interference. Each individual node contains the equivalent of a radio spectrum 'robot', monitoring other radio traffic, tracking its neighbour mesh nodes, and adjusting the topology and channel mapping of the network instantaneously, automatically, and without disturbing user sessions. Third generation networks deploy easily and work continuously without operator intervention.

Optimising video and voice over wireless mesh

Third generation multi-radio systems with intelligent and dynamic backhaul software vastly increase the performance of the wireless network for all types of demanding data applications. More importantly, this type of third generation solution delivers low delay (latency) and minimal variation in delay (jitter). This capability allows demanding applications like full-motion surveillance video and voice over IP to operate over the wireless mesh network without the need for more costly wired or fibre connections.

Leading third generation mesh networks automatically create connections between nodes, or topology that provides a good balance between data throughput and minimal delay and jitter. But network managers may also tune the network to optimise for particular traffic types—for example, to provide high quality video in surveillance applications, or higher priority to key applications.

Mobility solutions

Because the distributed software in each node dynamically adjusts to changing conditions, third-generation mesh technology is uniquely suited to mobile applications. Transparent roaming, data, video, and voice services for associated users are maintained even while users and nodes may be in continuous motion at speeds above 240 km/hr (150 m/hr). This capability is enabling new services for commuters, public safety agencies and security forces.

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Blurring the line between wired and wireless

As metropolitan and other outdoor networks mature, third generation products are displacing earlier first and second generation wireless mesh installations. Network operators are discovering that the power of third generation wireless networking technology gives them the opportunity to provide dozens of new applications outdoors, including high-demand data, video and voice offerings. These new deployments not only provide users with seamless and powerful solutions, they further blur the line between wired and wireless capabilities, bringing us one step closer to a truly wireless future. IT

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Applications of third generation wireless mesh

Metropolitan networking

Third generation wireless mesh products are being used to provide data services to users within towns and cities with a minimum of expensive wired connections. Municipal Internet Service Providers are beginning to choose third-generation mesh solutions for their easy installation, high performance and excellent interference avoidance capabilities.

Homeland security/ national defence video surveillance

Protecting borders and high-value locations with high quality real-time video demands low latency and jitter. Third generation wireless mesh technology delivers data, voice, and video in key locations far from the nearest wired Ethernet connection.

Public safety

Third generation capabilities, such as support for voice and video, prioritisation, security and spectrum agility are essential to ensure that lifesaving information is shared instantly and securely.

Transportation

High quality IP video surveillance delivered across many wireless hops is one key requirement, but delivering non-stop data networking to passengers and drivers in rail and highway corridors is also an important emerging application. The unique mobility capabilities of dynamic third generation mesh technology keep commuters and operators connected.

Military

The new military is based on command, control and communications applications built on IP-based voice, video and data networking. Third generation wireless mesh technology provides secure, dynamic solutions with the capacity to incorporate the latest defence technology.

Temporary networks for sporting events and fast-growing facilities

Bringing networks up quickly without the delays and expense of wired infrastructure demands easy installation and high performance over many wireless hops. Third generation wireless mesh solutions offer a unique combination of ease-of-deployment and high performance networking.