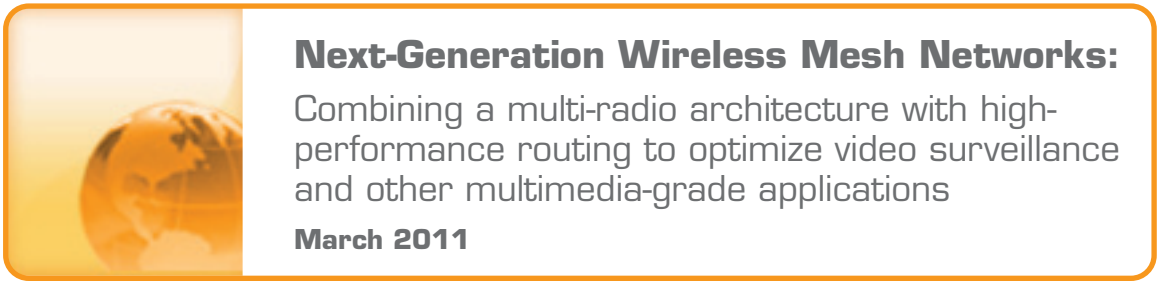
White Paper |



Next-Generation Wireless Mesh Networks:

Combining a multi-radio architecture with high-performance routing to optimize video surveillance and other multimedia-grade applications

March 2011

ARUBA® networks

Table of Contents

Introduction

Wireless mesh networks are fast becoming the preferred way to deliver voice, video and data in outdoor environments.

A wireless mesh can deliver the same network capacity, reliability and security that were once reserved for wired networks – but with the flexibility of wireless. With today's state-of-the-art solutions, municipalities, public safety agencies, port authorities, and industrial organizations can rely on mesh networks to provide essential connectivity to their workers and constituents.

Easily provide connectivity outdoors

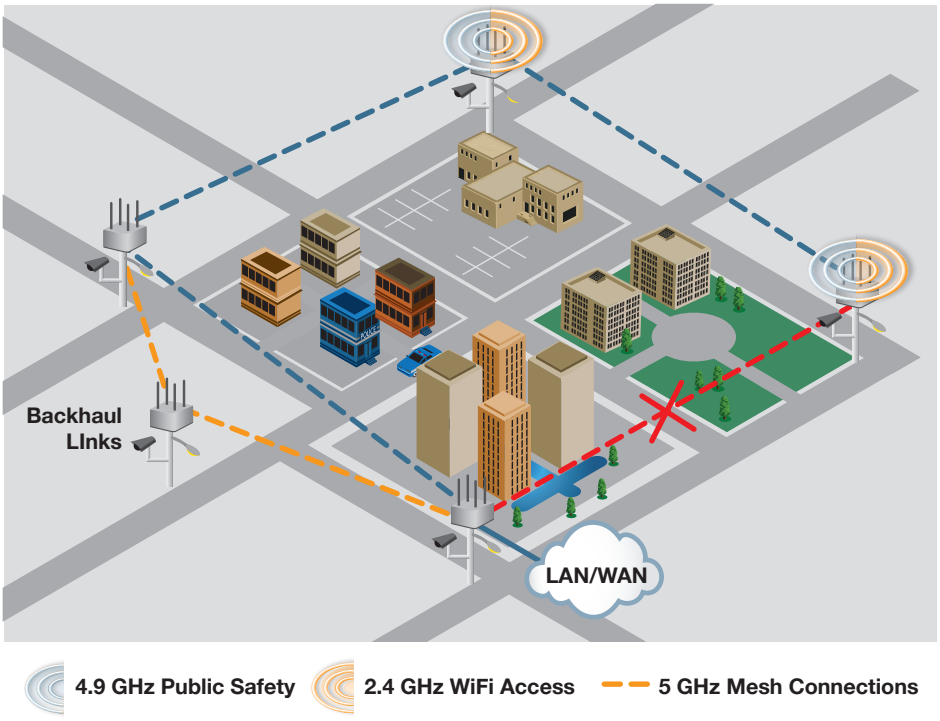
A mesh is a multi-path, multi-hop wireless local area network (WLAN) and wide area network (WAN) that is ideal for outdoor deployment. With a mesh, reliable networking can be established almost anywhere — without the cost and disruption of running cabling or fiber.

With a powerful multiservice mesh platform, organizations can combine formerly separate voice, video and data networks onto a single network.

As a result, the converged network is simpler to manage and operate, while the organization retains control over the delivery of multiple services. In addition, fewer devices are required, so the network is less expensive to purchase and maintain.

A mesh is resilient and low maintenance. A modern mesh network automatically discovers the best route through the network and operates smoothly even if a mesh link goes down or a node fails.

Because the network is self-forming and self-healing, administration and maintenance costs are lower. In addition, a wireless mesh overcomes the line-of-sight issues that may occur when a space is crowded with buildings or industrial equipment.



With a mesh, reliable networking can be established almost anywhere. Automatic configuration and routing enables the mesh to be self-forming and self-healing, which reduces operational costs.

Ideal for municipalities, public safety and industrial operations

Mesh networks have many applications in municipal, public safety and industrial organizations.

- **Municipalities** – Cities can deploy a large-scale mesh network to keep their workers and first-responders productive, no matter where they are in the community. A single infrastructure that supports many different municipal applications and departments ultimately reduces networking costs and simplifies operations.

  With pervasive Wi-Fi, court officers, building inspectors, transit workers, social services workers, and other city employees can perform their duties effectively while in the field. Wi-Fi hot zones also support business development and are a convenience for the general public.

  Cities can install telemetry and smart grid services using mesh networks to support automated traffic control, smart utility meters, and smart parking meters. Mesh networks also support sensors used for earthquake, tsunami and gas detection, among others.

- **Public safety** – Public safety agencies can rapidly and efficiently deploy resilient, high-capacity wireless mesh networks almost anywhere to improve situational awareness and support emergency communications.

  Capable of serving as a temporary or permanent network, the wireless mesh lets police, fire and other first responders connect video surveillance cameras for remote monitoring and provide secure Wi-Fi access to centralized databases and applications.

- **Industrial organizations** – Wireless mesh networks are ideal to connect industrial operations and sites such as oil and gas fields, mining and construction areas, which are difficult to network because of their geography. With pervasive Wi-Fi, field workers communicate easily and have access to key applications.

Mesh enabled IP video surveillance and access control also protect the organization's field operations and crew. For instance, mobile video surveillance allows cameras to follow crews to ensure that maintenance operations are performed and physical security is maintained.

In addition, industrial organizations can use mesh networks to locate and track high-value equipment and people, which improves efficiency and reduces theft.

Meeting today's requirements for mesh networks

A multiservice mesh platform allows industrial organizations and municipalities to meet the needs of multiple user groups and applications with a single infrastructure. Eliminating dedicated networks different uses lowers capital expenses and creates operational efficiencies. With a multiservice mesh, organization can rapidly deploy wireless connectivity that is integrated with existing networks.

- ✔ An 802.11n multi-radio, multi-frequency system to deliver high capacity for IP cameras, CCTV monitoring, smartphones, tablets and other Wi-Fi clients
- ✔ Intelligent, Layer 3 routing to meet network reliability and scalable capacity requirements
- ✔ Smart RF management that is integrated with Layer 3 routing to form the optimal mesh topology automatically and handle changes seamlessly
- ✔ Video-specific optimizations, traffic management and quality of service (QoS) to support video, voice and other latency-sensitive traffic
- ✔ Session persistence to support high-speed roaming of Wi-Fi devices
- ✔ Flexible deployment options with software-configurable radios for client, access and backhaul modes and frequencies
- ✔ Strong security to protect both client devices and the mesh
- ✔ Tools for planning, installation and management of the mesh to simplify operations and ensure a low total cost of ownership

Aruba's high-performance multiservice mesh solution

Aruba Networks brings unprecedented levels of scale, capacity and reliability to mesh networks. The Aruba AirMesh multiservice mesh platform is optimized for high-quality video, voice and data communications over long distances.

It supports a broad variety of Wi-Fi and Ethernet clients, including video surveillance cameras, smartphones, laptops, Wi-Fi tags, IP phones and smart meters. AirMesh routers run the MeshOS operating system, which delivers a set of consistent services across the mesh.

The AirMesh multiservice solution delivers:

- **Intelligent multi-radio design** – With dual and quad 802.11n Multiple Input Multiple Output (MIMO) radios, AirMesh routers deliver massive capacity and sustained throughput over multiple hops while mitigating RF interference.
- **Adaptive Wireless Routing™** (AWR) – AWR is a patented routing protocol designed for wireless networks that provides RF-aware, Layer 3 network intelligence and fast convergence that optimizes the traffic flow in a mesh network.
- **Active Video Transport™** (AVT) – AVT is a patented technology that optimizes and prioritizes video traffic. AVT significantly improves video quality by reducing packet loss and jitter. AirMesh delivers video at 30 frames per second.
- **MobileMatrix™** – This Aruba capability enables reliable roaming between mesh routers in less than 50 milliseconds so that users' application sessions are maintained even if they are moving at high speeds.
- **Strong end-to-end security** – Aruba provides multiple layers of security for both Wi-Fi clients as well as the mesh itself.
- **Planning and management tools** – Aruba provides a full suite of tools for planning, deploying and managing wireless mesh networks that keep operational expenses low.

Massive capacity with a multi-radio architecture

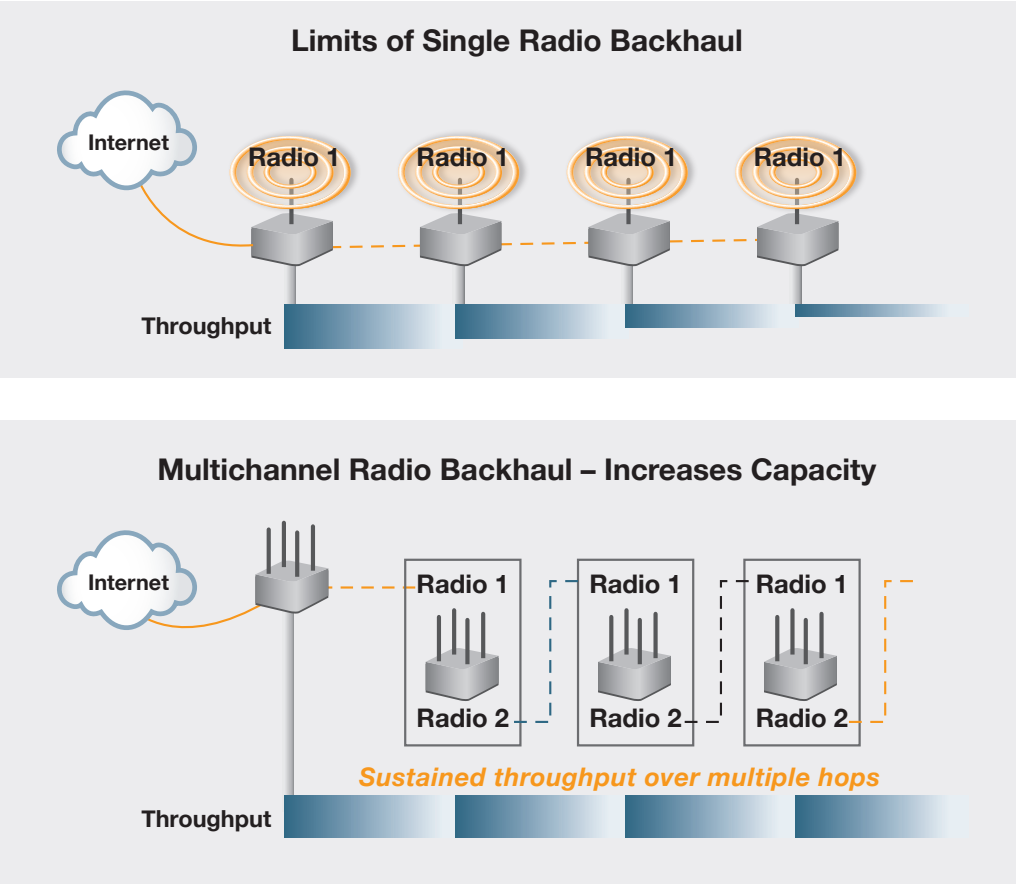
Aruba's multi-radio, multi-frequency architecture is a giant step forward in high-capacity mesh networks.

MIMO is essential to deliver superior wireless coverage for smartphones, laptops and other mobile devices that have a lower transmission power because of their smaller size and battery life. MIMO also enables faster download capabilities with reduced interference, which makes it able to deliver high-quality video across the mesh.

In a MIMO architecture, each 802.11n radio has multiple transmit antennas and paths. Using multiple antennas to transmit increases the effectiveness, because different Wi-Fi devices hear different signals more strongly in different parts of the coverage area, and they will use the best available signal for communications. The result is more uniform coverage and higher data rates.

Unlike the legacy 802.11a/b/g technology, MIMO radio works especially well in a campus or city where buildings and moving people can cause high levels of RF reflection. RF reflections can cause transmissions to take different paths before arriving at their destination, which is known as multipath. MIMO leverages multiple paths between transmitters and receivers to improve network performance.

Another way AirMesh delivers high performance is that the access network is separate from the backhaul network. Each mesh router has multiple radios dedicated to backhaul. With dual-radio systems, the backhaul is a shared network. With AirMesh, the backhaul network is comprised of multiple point-to-point wireless links, with each link operating on a different channel.



This diagram compares a single-radio backhaul network with a multi-radio backhaul network. The Aruba AirMesh multi-radio backhaul network employs multiple point-to-point wireless links, with each link operating on a different channel.

Aruba mesh routers support dual and quad radios with omni-directional or directional antennas. Each 802.11n radio can transmit at up to 300 Mbps in client, access or backhaul mode.

Each Aruba mesh radio can operate in multiple frequency bands – the unlicensed 2.4-GHz band, the 5-GHz band or the licensed 4.9-GHz U.S. public safety band. This allows organizations to deploy AirMesh routers using the frequencies, channels and maximum power allowed in each country.

Aruba's enhancements deliver industry-leading performance and scalability. Aruba delivers significantly higher throughput with sustained performance across multiple hops, as compared to multi-radio mesh nodes that rely only on Layer 2 switching.

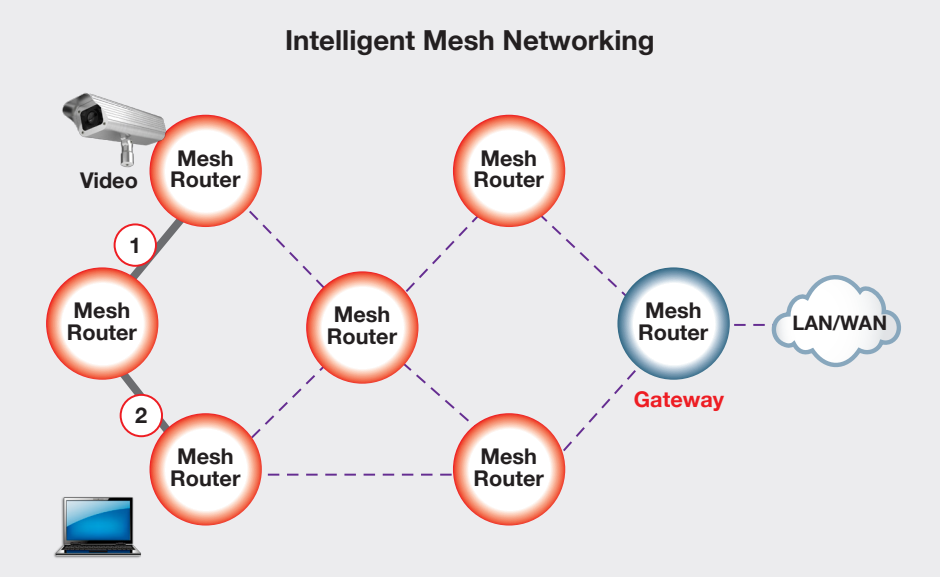
Scalable capacity with Layer 3 routing intelligence

Aruba's patented AWR overcomes the limitations imposed by Layer 2 networks to make the mesh more intelligent, scalable and resilient. AWR is a distance-vector routing protocol (DVRP) that is purpose-built for both mobile and fixed wireless mesh networks.

Some mesh products use Layer 3 routing in their architecture, but those routing protocols, such as open shortest-path first (OSPF), were designed for wired networks. OSPF can easily flood the entire network when handling the rapidly changing conditions that are typical for a wireless network. Such frequent network-wide flooding causes serious performance, scalability, stability and convergence problems.

In contrast, AWR is designed to minimize the unnecessary control traffic related to rapid and transient changes on a wireless network. AWR has lower overhead than other Layer 3 routing protocols, which leaves more bandwidth for user applications.

AirMesh's dynamic, adaptive routing also improves network reliability. AWR maintains multiple routes to each destination, and each router keeps track of connectivity to its neighbors and the devices connected to the mesh via Ethernet or Wi-Fi. Traffic is instantly rerouted around congestion or link failures.



A mesh operating at Layer 3 provides intelligence that allows for optimal performance, scalability and reliability. All traffic does not need to flow through a single gateway, as with a Layer 2 mesh. And Layer 2 services can be delivered over the Layer 3 infrastructure.

AWR maximizes user throughput by taking into consideration the quality of the radio link. Link failures are rare in wired networks, but wireless mesh networks are susceptible to sources of RF interference that can cause a link to degrade or fail. AWR calculates a quality metric to assess the link's data rate, received signal strength indication (RSSI), and external interference.

This allows AWR to make packet-forwarding decisions based on both the link-state quality and routing parameters, which eliminates bottlenecks and single points of failure. The result is superior resiliency and throughput.

AirMesh balances the overall traffic load on the mesh to optimize traffic flow, even in the presence of high levels of RF interference. Balancing the traffic load among gateways to the Internet and other external networks adds to the reliability and scalability.

Although Aruba's mesh architecture relies on AWR at the core, IT doesn't need to understand the inner workings of the routing protocol. Aruba's Virtual Private LAN over Mesh (VPLM) technology provides a native Layer 2 VLAN interface while retaining the Layer 3 routing functionalities underneath.

As a result, IT may treat the mesh network like a managed Layer 2 switch with full virtual LAN (VLAN) functionality, which greatly simplifies the integration with any VLAN service on the wired network. Customers can deploy additional Layer 3 services that run parallel to other Layer 2 services, or choose to disable VPLM and run the whole mesh network as a pure Layer-3 service.

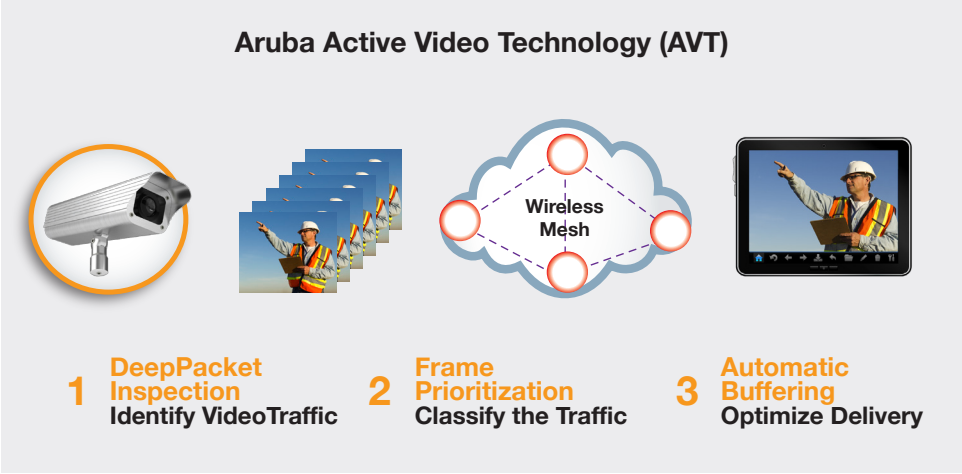
High-definition video over the mesh

The use of video surveillance is growing exponentially as businesses and citizens want greater protection from a perceived increase in crime and terrorism. Real-time video surveillance has quickly become a preferred way to deter crime, improve incident response time and provide evidence. In fact, the video surveillance market is expected to be a $37 billion market by 2015 – a 20% CAGR[1].

But delivering high-quality IP video over a wireless mesh network has been difficult. Problems with network latency, packet loss and jitter often result in pixilated images that are difficult to see clearly – and that are not suitable for evidence.

AirMesh is optimized to deliver high-definition video. AirMesh uses AVT to ensure a real-time, broadcast-quality video at up to 30 frames per second.

AVT is implemented in every AirMesh router so that the video optimization is enforced across the entire mesh. To deliver HD-quality video, AVT makes intelligent tradeoffs between latency and the common impairments to video quality.



Active Video Transport uses a three-step process to optimize video across the mesh. All AirMesh routers implement AVT, so high-definition video can be delivered end-to-end.

[1] *"Global Video Surveillance Market, Applications and Management Services Forecasts (2010-2015)," Research and Markets, January 2011*

Multiple technologies, including deep packet inspection, MAC protocol optimization, in-network retransmission protocol, and adaptive video jitter removal, are used in a three-step process.

IP multicasting allows an AirMesh network to support applications such as IP video. Multicasting is essential for video surveillance applications that require monitoring and recording at multiple locations, as well as for IPTV applications that broadcast video to multiple viewers.

Traffic management and quality of service

In addition to AVT, AirMesh supports industry-standard methods for enforcing QoS. With QoS, organizations can deliver a high quality user experience, while controlling applications' access to the bandwidth, so they can meet their service levels. AirMesh supports end-to-end bandwidth control so that multiple services can reserve their bandwidth and deliver the appropriate service level.

Aruba supports differentiated services (DiffServ), IEEE 802.11e and IEEE 802.1Q VLANs to provide traffic management and QoS.

- DiffServ is the preferred way to control and enforce QoS in a routed network. With DiffServ, organizations can minimize latency and guarantee bandwidth for specific applications. Time-sensitive applications, such as voice, video and transactions, can be assured priority access to the bandwidth. Less time-critical applications, such as email and file transfer, are allocated bandwidth on a best-effort basis.
- 802.11e defines QoS enhancements specifically for Layer 2 WLANs. Aruba also supports the Wi-Fi Alliance's specifications Wi-Fi Multimedia (WMM) and Wireless Multimedia Extensions (WME), which allocate separate queues for voice, video, best-effort and background traffic flows.
- 802.1Q VLANs can be used to segment traffic at Layer 2. Using VLANs is particularly important for Wi-Fi clients that do not support 802.11e. With Aruba, a VLAN ID can be associated with a WLAN service set identifier (SSID), which extends VLAN QoS priorities to users and applications assigned to different SSIDs.

High-speed outdoor roaming

Fast roaming is critical for video and voice. Aruba's innovative MobileMatrix technology facilitates fast roaming across IP subnets with session persistence at speeds up to 60 miles an hour.

First responders in squad cars, fire trucks, ambulances and other vehicles can maintain continuous connections to voice, video and other essential applications. They can view live video from an incident scene while en route for improved situational awareness.

MobileMatrix builds on AWR routing to support fast, seamless roaming with minimal overhead. Clients roam from one mesh router to another in less than 50 milliseconds while maintaining their session and IP address.

Aruba's fast roaming technology works with ordinary Wi-Fi clients. Unlike Mobile IP, MobileMatrix does not require any special software or hardware on the client or in the network, which greatly simplifies deployment and operations.

Strong end-to-end security

AirMesh provides strong multi-layer security for Wi-Fi clients as well as the mesh infrastructure itself, including authentication, encryption and network segmentation.

All Wi-Fi clients must authenticate with an AirMesh router before being allowed access to the wireless. Aruba supports IEEE 802.1X authentication, which is based on the extensible authentication protocol (EAP). Aruba also supports digital certificates, EAP-transport layer security (TLS) and EAP-tunneled transport layer security (TTLS).

Communications between Wi-Fi clients and Aruba routers are protected and encrypted with Wi-Fi Protected Access (WPA and WPA-2), which uses the temporal key integrity protocol (TKIP). Aruba also supports the advanced encryption standard (AES) to encrypt both mesh nodes and backhaul traffic.

AirMesh supports network access control (NAC), IPsec virtual private networks (VPNs), and network address translation (NAT).

Organizations can use access control lists (ACLs) to filter and control traffic on the Aruba mesh based on a user's source IP or MAC address and the application's destination address. Additional filtering at the MAC level can be performed to ensure that only devices with valid MAC addresses gain access to the network.

VLANs can be used to isolate traffic from different users or applications and to provide an additional layer of security. An SSID can be associated with a VLAN ID, and each VLAN can have its own security policy for access control, authentication and encryption.

For enterprise VPN services, organizations can provide secure remote connectivity for Windows laptops with Aruba's Virtual Internet Access (VIA) agent. VIA automatically scans network connections and creates a secure connection back to the corporate network. Unlike traditional VPN software, VIA provides a zero-touch experience for the user and attacks.

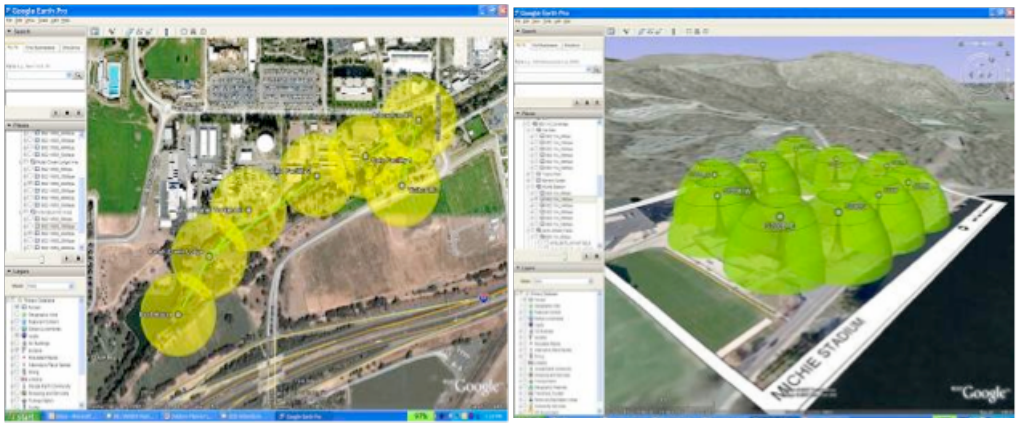
Organizations can deliver secure Wi-Fi access through a customized web portal with Aruba Amigopod. With Amigopod software, organizations can provide time- and policy-based network access while simplifying the task of managing large numbers of users. Users may be welcomed with personalized messages or targeted offers. Amigopod also provides reporting to track user demographics, usage, movement and even the success of promotions.

Planning, deploying and managing the mesh

Organizations can ease mesh deployment and operations with Aruba's suite of visualization tools, including Aruba RF Outdoor Planner, MeshConfig and AirWave.

- **Planning** – Aruba's Outdoor RF Planner makes it easy for solution providers to design the mesh to meet customers' requirements. Outdoor RF Planner also provides ongoing visibility into network performance. The Aruba tool is purpose-built for outdoor applications.

  Outdoor RF Planner automatically calculates bandwidth, distances, link budget, gain and coverage for the mesh network. It uses real-world data to show geographical and rendered RF from antenna polar pattern data. Completed plans with 3D mapping make it easier to visualize the network.



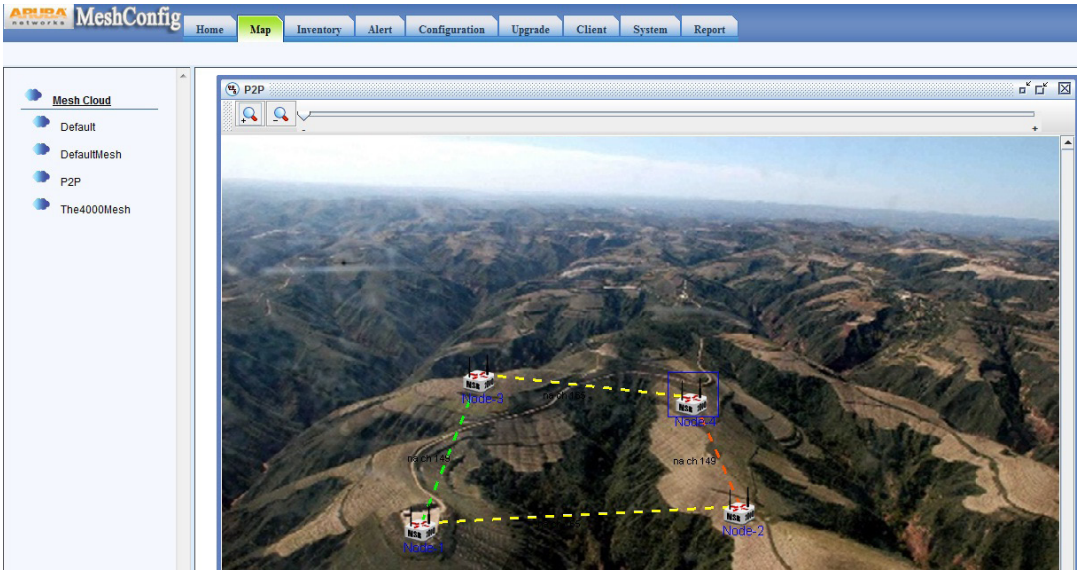
With Aruba's RF Outdoor Planner, organizations can design the mesh network and gain visibility into ongoing performance.

- **Managing smaller meshes with MeshConfig** – Designed for the rapid deployment and management of small mesh networks, the browser-based MeshConfig tool is ideal for topology, inventory and fault management. MeshConfig also lets network administrators upload topography, Google Earth and other digital background maps to view and monitor mesh deployments across geographical areas.

  It automatically initializes wireless mesh routers. IP addresses for each wireless mesh router are automatically assigned and the mesh topology is discovered and displayed in an intuitive graphical window.

  MeshConfig builds the network inventory and identifies wireless mesh router properties, including router names, IP addresses, image versions, status and alarm conditions. Network-wide settings can be configured within MeshConfig and be propagated to all mesh routers in the network.

  Network administrators can use MeshConfig graphical views to centrally manage and monitor mesh routers, which reduces configuration and troubleshooting time. Administrators can view the real-time performance statistics for each link and enable or disable mesh links and define preferred links.



The browser-based MeshConfig tool lets users upload topography, Google Earth and other digital background maps to view and monitor mesh deployments across geographical areas.

- **Managing large-scale mesh networks with AirWave** — Operators can use AirWave from Aruba to manage large-scale mesh networks and support mobile users who connect via the wireless LAN or wired Ethernet ports. IT can use AirWave for remote monitoring and visibility, user and device monitoring, and RF visualization and location tracking. With AirWave, IT can improve service quality and make better decisions about the network.

  With AirWave, IT has a single place to go for everything they need to diagnose and resolve user problems. IT can find any user device on the network and see real-time monitoring views as well as historical information. AirWave RF visualization and location tracking enable IT to see what's really going on in the network to correctly diagnose a problem.

  AirWave automates routine tasks, such as configuration management and software updates, which saves IT time and reduces the risk of error. Changes can be scheduled to minimize disruptions.

  The real-time alerts and historical trend reporting provided by AirWave allow IT to make better decisions with visibility into trends. Detailed user tracking and session history can also be used to verify that security policies are being enforced properly.

A portfolio of products to suit your needs

Aruba offers a family of mesh solutions to fit a variety of business requirements. The AirMesh portfolio includes both outdoor and indoor routers for mesh and point-to-point connections.

Aruba provides the most flexible deployment options for outdoor networks, including Wi-Fi, point-to-point, point-to-multipoint and mesh connections. The combination of a multi-radio architecture and Layer 3 routing are the foundation of the flexibility.

Customers can count on round-the-clock access to Aruba's network engineering expertise. Aruba delivers world-class customer support and services that ensure products operate optimally and deliver services to the highest standards possible.

The Aruba AirMesh portfolio fits a variety of indoor and outdoor applications and can be deployed as Wi-Fi, point-to-point, point-to-multipoint and mesh.

Aruba AirMesh	MSR4000	MSR2000	MST200	MSR1200
Use	Outdoor mesh router	Outdoor mesh router	Point-to-Point connections	Indoor mesh router 802.11n, dual radio
802.11n Radios	Quad radio	Dual radio	Single radio with integrated antenna	Dual radio
Radio Capacity	300 Mbps	300 Mbps	300 Mbps	300 Mbps
Band	Software configurable for 2.4-, 5- or 4.9 GHz	Software configurable for 2.4-, 5- or 4.9 GHz	5-GHz	2.4 or 5 GHz
Support Access and Backhaul	Yes	Yes	Yes	Yes
Throughput per Router	1 Gbps	1 Gbps	1 Gbps	1 Gbps
Advanced Features	• Layer 3, intelligent routing • Video at 30 frames per second • Fast roaming < 50 milliseconds	• Layer 3, intelligent routing • Video at 30 frames per second • Fast roaming < 50 milliseconds	• Layer 3, intelligent routing • Video at 30 frames per second • Fast roaming < 50 milliseconds	• Layer 3, intelligent routing • Video at 30 frames per second • Fast roaming < 50 milliseconds

Rely on a world-class provider for your outdoor mesh

Aruba's multiservice platform delivers the high capacity and most resilient mesh network to meet today's requirements for industrial organizations, public-safety agencies and municipalities. Workers have ready access to voice, video and data applications, whether walking around or traveling in vehicles.

AirMesh can be deployed in places with no fixed infrastructure, and the solution's flexible deployment options allow the network to adapt to changing business conditions and requirements. A full suite of planning, design and management tools help keep operational costs low.

Unprecedented scalability and flexibility is why Aruba wireless mesh networks are used in some of the largest industrial, transportation, logistics, public safety, municipal and educational applications.

About Aruba Networks

Aruba is the global leader in distributed enterprise networks. Its award-winning portfolio of campus, branch/teleworker, and mobile solutions simplify operations and secure access to all corporate applications and services – regardless of the user's device, location, or network. This dramatically improves productivity and lowers capital and operational costs.

Listed on the NASDAQ and Russell 2000® Index, Aruba is based in Sunnyvale, California, and has operations throughout the Americas, Europe, Middle East, and Asia Pacific regions. To learn more, visit Aruba at www.arubanetworks.com. For real-time news updates follow Aruba on Twitter, Facebook, or the Green Island News Blog.

1344 Crossman Ave. Sunnyvale, CA 94089-1113
Tel. 408.227.4500 | Fax. 408.227.4550 | 1-866-55-ARUBA
info@arubanetworks.com | http://www.arubanetworks.com

WP_Wireless Mesh_110319