BelAir NETWORKS

White Paper

Enterprise Wi-Fi on a Mesh Architecture

More Broadband, Less Infrastructure, Dramatically Less Cost

The widespread availability of Wi-Fi enabled devices has driven Wi-Fi network growth from an in-home solution to a citywide phenomenon. Apple's high-profile introduction of their dual-mode (Wi-Fi and cellular) iPhone™ continues to fuel this growth while the advent of WiMAX-enabled devices and associated licensed networks promises to complement it.

In the enterprise, the Wi-Fi phenomenon offers a number of benefits, including:

- improvements in employee productivity driven by the ability to work effectively from multiple locations
- savings on cellular charges by taking advantage of VoIP-based voice services (in addition to the iPhone™, 2007 sees new dual-mode devices and functionality from Nokia, Motorola, Samsung and RIM's Blackberry®)
- effectively addressing the communications needs of enterprise guests and visitors

But Wi-Fi networks can deliver more than just a handy Internet connection for nomadic users around the enterprise. Dolphin Stadium is using Wi-Fi to network the world's large Point-of-Sale (POS) system, while providing broadband connectivity for media, vendors and staff throughout the venue. The Westin Kierland Resort and Spa in Scottsdale is using it to enhance the guest experience with single sign-on connectivity, indoors and outside, provided by an outdoor network. And the Lincoln Center is using it to encourage visitors to arrive earlier and stick around after performances.

Traditional Wi-Fi access points are not geared to cost-effectively providing the type of secure, seamless broadband networking experience that many enterprise customers are now demanding. For example, both Dolphin Stadium and the Westin considered traditional access point implementations before opting for a mesh architecture. Each implementation would have required more than 100 Wi-Fi access points. Using BelAir's patented switched mesh architecture, ubiquitous broadband coverage was achieved in days with only 5 and 12 wireless mesh nodes, respectively.

By opting for a "switched" mesh architecture, enterprises avoid the issues associated with traditional Wi-Fi access point implementations including:

1. high number of access points required to achieve acceptable coverage
2. time and labor costs associated with both wiring and installation of access points
3. lack of resiliency inherent in the single point of failure architecture and the APs inability to withstand environmental challenges such as extreme heat and cold, dust and vibrations

Switched mesh is not the only mesh option available for enterprise coverage. Shared mesh, often referred to as first generation mesh, can also address enterprise coverage, albeit without Quality of Service (QoS) or traffic prioritization functionality, and with higher latency and less bandwidth available to users.

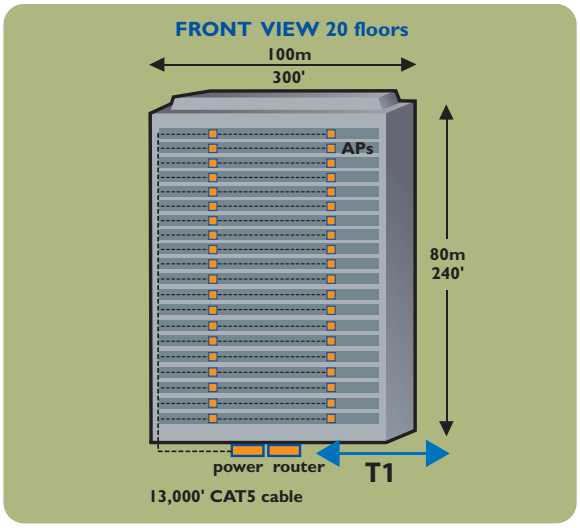
BelAir Networks manufacturers the industry's most comprehensive portfolio of wireless mesh nodes featuring both shared and switched architectures. This whitepaper will focus on enterprise implementations of the company's patented switched architecture and looks at the drivers behind the choice of that architecture including:

- Reduction in both the capital and the ongoing operating expenditures associated with deployments
- Increased capacity and a broader range of services supported
- Scalability that protects the network investment

Switched Mesh Saves Money

A switched mesh architecture can be deployed to provide ubiquitous outdoor coverage but it can also provide excellent inside coverage from nodes deployed outdoors. In fact, actual BelAir deployments have been proven to deliver coverage from the "outside-in" to 36 floors. These nodes can be mounted on buildings, poles, cables, towers, and rooftops to deliver up to ten times more capacity and five times more range compared to traditional shared mesh architectures. They also avoid the disruption of running cabling throughout the premises and installing dozens of obtrusive access points all over the buildings. In fact, deploying BelAir wireless mesh rather than traditional Wi-Fi access points typically results in capital expenditure (CAPEX) savings of more than 60%, as shown in Figure 1.

Traditional



– 57 indoor access points, cabling, router, power inserters, new construction

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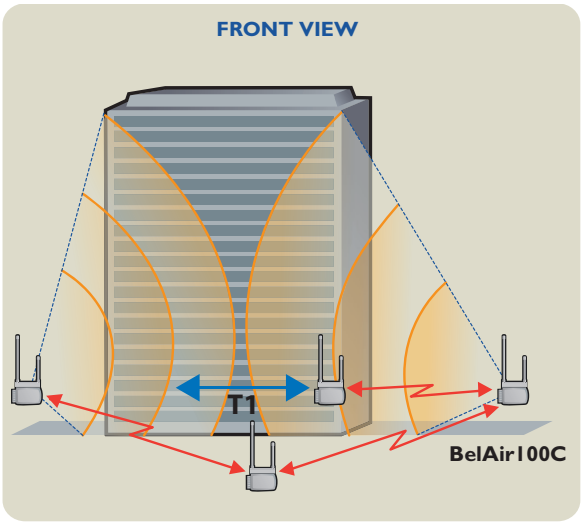

– 4 outdoor BelAir100C Wireless Mesh Nodes

Cost comparison	**Traditional**	**BelAir Netwoks**	**Savings**
Capital expenditure (installed)	$41,000	$13,200	67%
Cost per room	$102	$33	67%
Coverage	Indoor only	Indoor and outdoor	

Figure 1. Outside-in coverage: CAPEX and OPEX savings

With fewer, more accessible nodes to manage and maintain, the ongoing costs of maintenance are also reduced. End-to-end network management enables the whole system to be managed, monitored and maintained remotely.

With less equipment required, the associated wiring and labor are greatly reduced. In fact, with a switched mesh architecture, most enterprises can be effectively covered, inside and out with a single wireline egress. Second or subsequent egress connections can be added for resiliency or capacity injection, without adding more nodes. Of course, the additional benefit of less nodes, less labor, and less wiring is that the deployment is much faster, generally completed in days rather than the weeks associated with traditional AP deployments.

Switched Mesh Delivers True Broadband and High-Quality Services

While Wi-Fi is essentially an access technology, the concept of mesh is really about backhaul or how the Wi-Fi nodes are interconnected. Traditional access points require a wireline connection on a 1:1 ratio, while mesh nodes interconnect with each other reducing the number of required wireline egress points and eliminating costly LAN cable runs. Because each node in a mesh connects to more than one other node, there is inherent resiliency in the wireless mesh. But all wireless mesh nodes and networks are

not created equal. Wireless mesh nodes are generally characterized by the number of radios employed (single, dual, or multi), while mesh architectures are differentiated by how the nodes interconnect in the backhaul (switched vs. shared).

A switched mesh architecture is comprised of wireless mesh nodes with a separate access and more than one backhaul radio providing backhaul links to neighboring nodes in the mesh. In the switched architecture, all of the available bandwidth of each separate radio channel is dedicated to the link to the neighboring node. The total available bandwidth is the sum of the bandwidth of each of the links. Each link is on a separate channel, ensuring that forwarded traffic does not use any bandwidth from any other link in the mesh. As a result, as shown in Figure 2, a switched mesh is capable of much higher capacities and transmission rates than a shared mesh. Switched mesh architectures are typically comprised of multi-radio wireless mesh nodes.

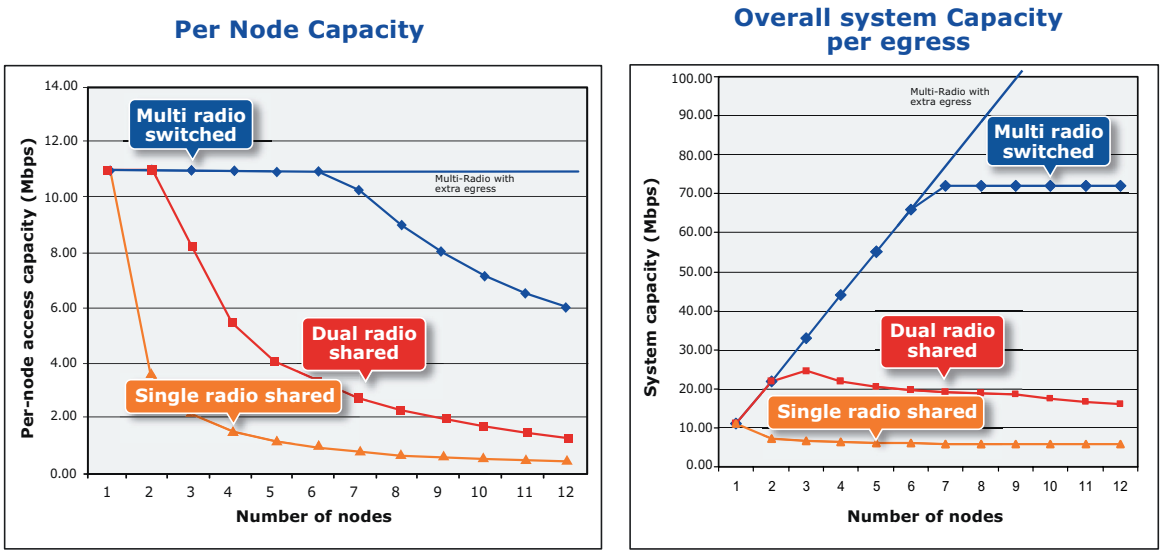

Figure 2. Comparison of single and dual radio nodes in a shared architecture and multi radio nodes in a switched architecture that only BelAir can deliver

In a shared mesh architecture, a single radio in each node communicates via mesh backhaul links to all the neighboring nodes in the mesh. Here the total available bandwidth of the radio channel is 'shared' between all the neighboring nodes in the mesh. The capacity of the channel is further consumed by traffic being forwarded from one node to the next – reducing the end to end traffic that can be passed. Because bandwidth is shared among all nodes in the mesh, and because every link in the mesh uses additional capacity, this type of network offers much lower end to end transmission rates than a switched mesh and degrades in capacity as nodes are added to the mesh. Shared mesh architectures will employ single or dual radio nodes. In a single radio mesh node, access and mesh backhaul are collapsed onto a single radio so the available bandwidth is shared between both the backhaul links and client access, further reducing the end to end traffic available. A dual radio shared mesh node uses separate access and mesh backhaul radios. Only the mesh backhaul radio is shared. The availability of dual radio nodes at single radio price points has rendered single radio nodes virtually obsolete except where already deployed in existing networks or at the edge of a network comprised of multi and dual radio nodes.

While the user experience in shared mesh networks is often characterized as 'wireless dialup' (i.e. unpredictable and slow end user experiences often makes shared meshes "feel like" a dial-up modem connection), a switched architecture delivers a true broadband experience to users. In fact, of 41 wireless networks independently tested in the second half of 2006, the network using BelAir Networks switched mesh architecture was rated as #1 in performance with the testers stating that service, in excess of 5 Mbps in both directions, was "better than my home broadband." By comparison, the Cingular network in Philadelphia, using HSDPA technology, delivered 666 kbps download and 111 kbps upload throughput averaged across all of the testing locations.

But service delivery is not just about bandwidth. As shown in Figure 3, the choice of switched or shared architecture (referred to as 'mesh modes' in the figure) also impacts service delivery. While single radio shared mesh networks may be acceptable for basic data services, higher speed Internet services and multimedia demand at least a dual radio network. To enable support for high-quality video transmissions and carrier-grade VoIP services, which are sensitive to delay and jitter, a multi radio switched mesh architecture featuring Quality of Service (QoS) and traffic prioritization features as well as very low latency, is required.

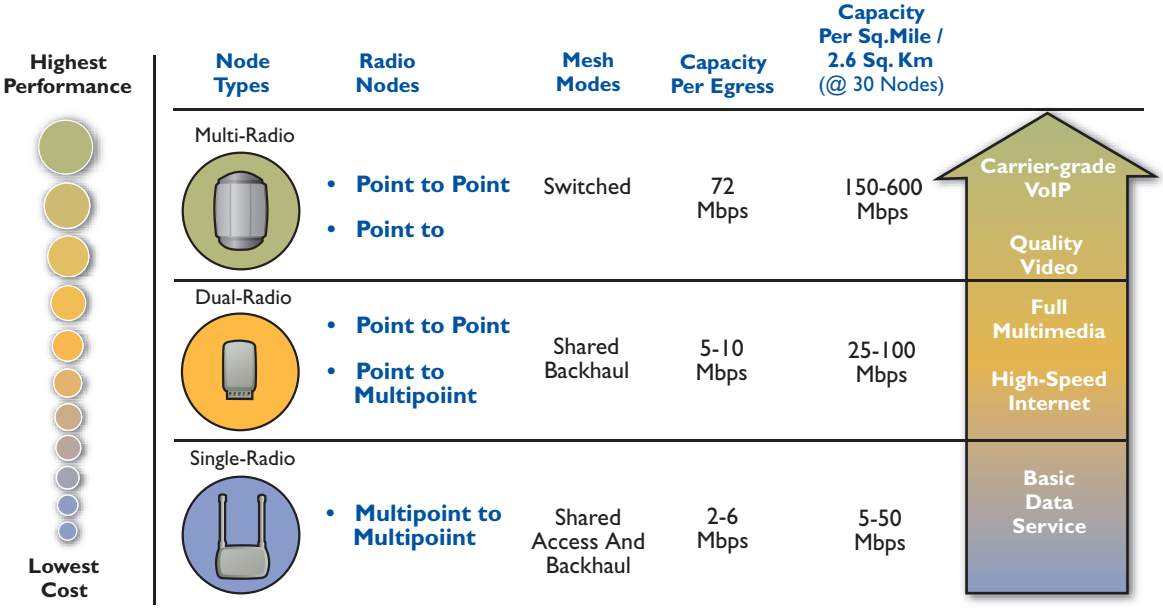

Figure 3. Performance, capacity, and service comparison of single and dual radio nodes in a shared architecture and multi radio nodes in a switched architecture

Switched Mesh is Future Proof

If you expect the capacity and QoS requirements on your network to increase over time (it's hard to imagine a scenario in which they wouldn't), you'll need to consider the impact that choice of architecture can have on how you expand the capacity of your network in the future. The decision as to whether to go with traditional APs vs. shared mesh vs. switched mesh drives different expansion options.

With traditional APs, you would wire another AP in the area where more capacity is required, effectively providing overlapping coverage. While a shared mesh environment does not necessitate the same 1:1 ratio of wireless node to wireline egress, adding a node to an existing network may actually have the counter-intuitive result of decreasing available bandwidth to users because of the contention in the network (this effect can be seen in Figure 2). So, you actually have to add another node and a wired egress in the specific area where more capacity is required. This can create deployment challenges when wired egress is not available in areas where capacity is needed.

In BelAir's switched mesh architecture, however, capacity can be directed to the nodes covering the areas where more capacity is required. So adding capacity to any part of the network is as simple as adding a wired egress anywhere in the network. You don't need to add another node and you have flexibility over where you secure the additional wired egress.

Another concern for many cities and enterprises deploying wireless networks is how the allocation of other frequencies will impact their network. If you choose the AP or shared mesh approach, you are limited to the wireless frequency in which the radios are operating. To support another frequency, you deploy another network. With BelAir's modular, multi-radio approach you can run more than one wireless network at different frequencies over one wireless mesh. For example, BelAir's multi radio nodes already support Wi-Fi, WiMAX, and 4.9GHz Public Safety spectrum on the same mesh.

Who's Switching to Switched Mesh?

How do you know if your enterprise would benefit from a switched mesh architecture? Generally, if you're looking for Wi-Fi coverage inside one or more multi-story buildings as well as outside the building(s), switched mesh is your best option. Of course, if you're also looking to save money, reduce wiring and labor costs, and get up and running quickly supporting a full range of services, users and applications now and in the future, switched mesh looks even better.

Leading cities around the world, such as Minneapolis, City of London, and Toronto are using this same switched mesh architecture to Wi-Fi enable public works employees, public safety personnel, residents and visitors.

Hotels and resorts are also realizing the benefits of a switched mesh architecture. The Westin Resort and Spa in Scottsdale, Arizona researched their Wi-Fi options from the perspective of three IT priorities:

- User satisfaction
- Reliability
- Cost-efficiency

After receiving a quote for more than a hundred APs that would have taken weeks to install, required additional wiring throughout the facility and incurred high labor costs, Jeff Lartigue, IT Director, went with BelAir Networks instead and deployed twelve nodes in a few days to provide seamless coverage both indoors and outside. As Jeff explains, users "really appreciate the simplicity of logging in once and having

uninterrupted service wherever they go in the resort. The network is reliable, resulting in fewer support calls, and incredibly cost-efficient, requiring fewer nodes, and less wiring, labor, and installation time than competing solutions."

Of course, when you're in a customer-facing enterprise like hospitality, it also helps that the BelAir Networks architecture involves no disruption to business, guests or ambiance during installation.

Lincoln Center's objectives were similar with regard to user satisfaction and reliability. They naturally wanted world-class Wi-Fi for the world's leading performing arts center. In their case, though, cost-effectiveness wasn't a key driver since the BelAir Networks equipment was donated by Nokia, as Lincoln Center President Reynold Levy explained: "We're extremely grateful to Nokia for providing this 21st century communications technology to all who use the Internet as an integral part of their lives while enjoying the facilities at Lincoln Center."

For Dolphin Stadium, cost-effectiveness, reliability, security and future-proof technology were priorities in their choice of the BelAir switched mesh architecture. As Tery Howard, Director of Information Technology, Miami Dolphins, Ltd. and Dolphin Stadium confirms: "We looked at competing solutions, but BelAir offered best-in-class performance. It would have required more than 100 traditional Wi-Fi access points to provide the coverage we're getting with five BelAir nodes. And, with BelAir, we can support multiple applications in a secure networking environment." In addition to supporting the stadium's POS system, media and vendors, the network can also link the stadium's video surveillance cameras and network its enterprise VoIP solution.

Property developers building new neighborhoods use BelAir Networks switched mesh architecture to provide broadband coverage that supports the communications needs of site personnel and the connectivity requirements of sitewide video security systems deployed to reduce shrinkage. As homes are built and marketed, the ubiquitous Wi-Fi coverage provides a competitive value-add to differentiate the neighborhood.

Property management firms handling residential multiple dwelling units (MDUs) and commercial multiple business units (MBUs) are achieving huge savings by providing broadband connectivity to tenants using BelAir's outside-in approach.

And, of course, college and university campuses are leveraging the switched mesh architecture to address the networking requirements of students and faculty and provide a future proof broadband 'test bed' for innovative new services developed in their own research facilities.

The Shift to Switched Mesh

Along with the exponential growth in Wi-Fi usage an obvious evolution has taken place in Wi-Fi networking. In order to scale the functionality and capacity of Wi-Fi networks to address increasingly demanding users, the concept of disparate hotspots has evolved to more comprehensive, ubiquitous hotzones, covering enterprise campuses and entire cities.

As these demanding users look to Wi-Fi to address a growing list of voice, video and data applications, whether for enterprise networking, public works, public safety or public access, a switched mesh architecture delivering high bandwidth along with QoS and traffic prioritization features and the economics of outside-in coverage, becomes the logical option.

For more information on single, dual and multi-radio wireless mesh networks, visit www.belairnetworks.com.

About BelAir Networks

BelAir Networks is the first company to offer scalable, wide-area Wi-Fi solutions with the highest quality for data, voice and video. BelAir's wireless networking solutions are built on the only multi-service architecture for wide-area wireless broadband deployments of Wi-Fi, WiMAX, and 3G Cellular networks. Built specifically for outdoor deployments, BelAir Networks patent pending solution delivers the lowest cost per user and deploys in days, blending into the physical infrastructure of downtown business districts, hotels and resorts, and college campuses. Founded in 2001, BelAir Networks is a privately held company headquartered in Kanata, Ontario.

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