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Wireless TCO: The Value of an Overlay Network

Symbol Technologies wireless strategy blends portability, mobility and virtualization to deliver value

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This document was authored by:

- Kevin Tolly, President/CEO The Tolly Group
- Charles Bruno, Executive Editor The Tolly Group

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Executive Summary

A new wave of wireless LANs (WLANs) is infiltrating enterprise networks. These new WLAN technologies represent a thin approach to access point technology, where a large portion of the intelligence and processing load is redirected from the access point (AP) to the wireless switch — with an eye toward lower total cost-of-ownership, reduced complexity which leads to management /administrative cost savings and greater centralized control over wireless services.

Symbol Technologies, Inc. commissioned The Tolly Group to measure the performance of Symbol's WS 5000 Wireless Switch architecture and its "thin" approach to access point technology. Tolly Group engineers measured the performance of the WS 5000 against a traditional "fat" AP approach from Cisco Systems, Inc.

Tolly Group engineers found that the Symbol "thin" Access Port (Symbol's variant of an access point) and Symbol's WS 5000 Wireless Switch, together deliver superior throughput for users that roam across an enterprise network – meaning Symbol's wireless solution afford users greater mobility than the "fat" AP Cisco approach tested.

Engineers also discovered that handheld PDAs connected to the Symbol Access Ports benefit from 2.5 times greater battery life than when they are connected to the Cisco APs. This is due to the way that the Symbol Access Ports interact with the wireless clients. Ultimately, this translates into productivity gains since mobile users get more life out of the equipment for extended periods of time.

Moreover, Symbol's innovations, like virtual APs, translate into reduced management complexity and vastly simplified configuration of "virtualized" services – meaning administrators spend less time configuring networks and more time on other tasks.

This report also chronicles Symbol's leadership in wireless standards development and its dedication to evolving wireless services. Further, a brief cost-of-ownership discussion examines the areas in which Symbol's wireless solution can contribute to a lower total cost-of-ownership.

Creating the Enterprise Fit

As wireless LANs (WLANs) have rocketed into the consciousness of enterprise managers in the past year or so, many organizations have been quick to deploy the technology to satiate user demands for portability and mobility within the enterprise.

In many ways, the deployment of WLANs parallels the deployment of the first PC LANs. Back then, almost a quarter century ago, departments and business units flocked to Novell NetWare LANs, IBM's Token Ring Network and ARCnet as an economical way to realize productivity gains rapidly. In the process, business units performed an end-run around the IT department, and it wasn't long before network managers had to begin reining in those maverick LAN purchases to implement some standards and ensure that any deployed LANs met corporate objectives and integrated seamlessly with the enterprise network.

Those LAN implementations became isolated islands, cut off from corporate network infrastructures. The resulting effort to integrate them into the mainstream corporate network often negated any gains reaped by the initial move to LAN infrastructures.

Fast-forward to today's WLAN explosion. Increasingly, users want to enjoy the benefits of mobility across the enterprise with their laptops and business-critical applications in tow. While enterprise network managers are tasked with meeting those needs, they must do so with the knowledge that the infrastructure they install must be capable of fitting into the enterprise network with ease, while also providing an enterprise-class wireless LAN service.

Yet, as discussed below, there is a vast difference that exists between some older-generation traditional WLANs and more modern WLAN architectures that were designed to snap into an enterprise network and complement existing network services.

Symbol Technologies, Inc. commissioned The Tolly Group to examine Symbol's WS 5000 Wireless Switch architecture and its efficient approach to access point technology. The goal was to investigate the performance of the WS 5000 Wireless Switch and its distributed design pertaining to access point intelligence. Tolly Group engineers measured the performance of the WS 5000 against a Cisco Systems, Inc. Aironet 1220 Access Point. The Cisco Aironet 1220 represents a traditional "fat" approach to AP design.

The goal of the project was to determine the effectiveness of Symbol's 'overlay' WLAN approach. So-called overlay networks enable companies to leverage the investment in their wired networks by integrating wireless alongside the existing infrastructure. The wireless network components then can make use of critical services on the installed wired network, such as security and Quality of Service (QoS). By contrast, some WLAN

infrastructures force the removal of existing gear and network policies may not mesh fully with existing wired infrastructures.

To validate Symbol's performance claims, The Tolly Group's test team benchmarked Symbol's wireless switch system comprising of the WS 5000 Wireless Switch and the 802.11b AP100 Access Port (connected using CAT5/6 Power over Ethernet cable) against the "fat" access point, Cisco's Aironet AP1220. The test team built a microcosm of a WLAN infrastructure and devised a series of tests for both wireless solutions under identical test conditions using industry-standard test tools. The WLAN configurations needed for Symbol's wireless solution were performed in the wireless switch — with the Access Ports being plug-and-play devices, whereas a traditional access point like the Cisco AP1220 was individually configured.

NetIQ's Chariot traffic generation test suite was used to evaluate the performance of the systems under test. Chariot emulated application traffic between Endpoint 1, which was a wireless device in the WLAN and Endpoint 2 that was a wired device on the server side. The Chariot traffic stream was appropriately configured to produce the required measurements. The metrics measured using Chariot were TCP throughput while roaming, raw TCP throughput and latency.

Thin vs. Fat AP Approach

Traditional WLANs utilize an architecture based upon distributed intelligence located in various access points (APs). This is commonly known as the "fat" AP approach. Wireless devices, such as Centrino laptops and wireless PDAs, communicate with the APs, which, in turn, channel data via wired connections back to an Ethernet switch.

With this fat approach, APs combine radio technology and wireless software to maintain session state with mobile clients. For security, users may introduce a third-party VPN gateway or a firewall.

Now, the latest generation of WLAN products employs a different design. Access points are slimmed down; these devices basically house the radio components while session management has been transferred to a wireless switch that manages all connections wirelessly, or alternatively via wired Ethernet/Fast Ethernet. The wireless switch, in turn, connects to an existing Ethernet switch fabric, which provides connectivity into the wired infrastructure.

One of the benefits of this approach is that APs can be configured as a group and a policy applied from a central switch. Ultimately, this translates into a lower total cost-of-ownership.

Symbol's 'Thin' Strategy

Symbol's wireless architecture is based on a Central Intelligence Packet Switched infrastructure model which includes two critical hardware components: the Wireless Switch for media independent, switch-based wireless networking, and Access Ports for wireless client communication access.

Figure 1. Symbol Access Ports

Symbol supports the thin AP approach, choosing to name its wireless end devices 'Access Ports' instead of access points. Symbol's AP100 Access Ports support either 802.11b, or a dual-radio hybrid supporting 802.11b and 802.11a. The company says an Access Port including a full virtual LAN 802.11g capability will follow in the summer of 2004.

Symbol's Access Ports contain only the wireless LAN radio antenna, and Ethernet port supporting power over Ethernet. All RF configuration is centralized at the switch. This translates into a lower-cost AP deployment cost. Network World newspaper reported in an April article ("WLAN vendors take stand in Virtual Showdown," Network World 04/12/04) that Symbol's Access Ports are at least 30% less costly than APs offered by Airespace, Aruba Networks, Trapeze Networks and others.

With this design, users can deploy new technologies without impacting existing wireless LAN installations. Power can be distributed to Access Ports over Ethernet cabling using PoE, eliminating the AC power requirements of traditional APs.

From a security standpoint, the AP100s provide advanced physical security; if someone attempts to tamper or to replace the Access Port, the device fires off a network alert to LAN administrators. The other security advantage is that any Access Port removed does not contain the security information such as addresses of servers, hashes of passwords and other security information typically stored within a traditional fat access point.

Symbol's wireless architecture revolves around more than just slimmed-down Access Ports. The focal point is the company's WS 5000 Wireless Switch.

View of a Smart Switch

The WS 5000 Wireless Switch centralizes control and management of the wireless functions. Until recently, much of the control and intelligence now resident in the WS 5000 was distributed into traditional APs, forcing them to be configured, managed and upgraded on an individual basis.

Figure 2. Symbol WS 5000

At the hardware level, the WS 5000 Wireless Switch does not contain the Ethernet ports typically found on an Ethernet switch, but instead utilizes wireless Access Ports. The Access Ports perform the same function as Ethernet ports in bridging traffic, but bridge wireless traffic instead of wired traffic. Wireless traffic in the 802.11 frame format from a wireless device is tunneled back to the Wireless Switch with an Ethernet (IEEE 802.3) frame header wrapped around the original 802.11 frame header and contents.

The WS 5000 is based on a Linux-based real-time operating system, allowing functions to be added via software, rather than requiring more costly hardware upgrades. The benefit of the centralized intelligence is that it enables IT managers to define a single set of security, policy management, QoS and network access rules at the switch level, instead of at each AP.

The WS 5000 Wireless Switch bridges wireless traffic to the wired Ethernet network along with additional upper layer services such as management and security. Sharing the same higher-layer services as Ethernet switches enables the WS 5000 Wireless Switch to provide extensive wired LAN support, fully integrating wireless traffic into the enterprise network.

System Management functions are available via an XML-based graphical user interface accessed via standard Java-based browsers, or via a command line interface (using telnet over the switch's serial port). Using this GUI, the Wireless Switch System can be completely controlled, regardless of the number of switches and Access Ports added.

The WS 5000 supports load balancing (moving users from a congested Access Port to one with more available capacity), pre-emptive roaming and clear-channel detection for improved bandwidth utilization, enabling users to roam across different APs.

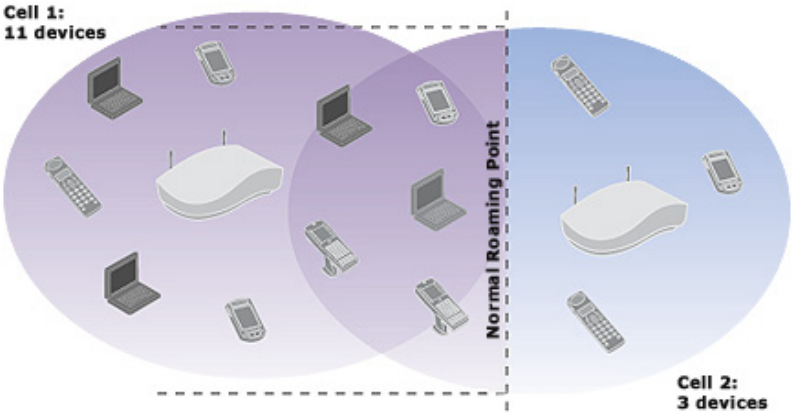
The mobility angle is key here. A variety of features targeted at enabling mobile devices – wireless laptops and application-specific devices – are included within the WS 5000 specification.

Portability and Mobility

In wireless networks, it is easy for new users to become confused over mobility versus portability issues that are central to the success of their wireless services.

Portability relates to the use of laptops and other devices without them being hard-wired into the network. Mobility applies to using those same devices while moving throughout the enterprise.

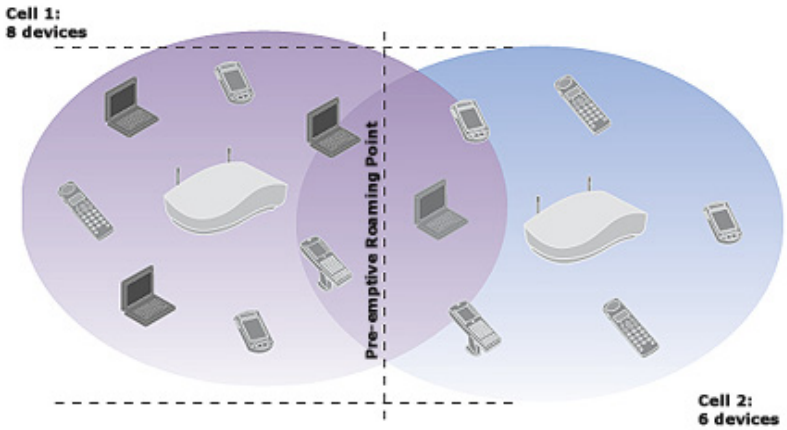
Figure 3. Traditional Roaming



Today's core networking protocols were not designed with mobility in mind. TCP/IP, for example, assumes that once a connection is established, the device in question will remain at the same network address for the life of that connection. It assumes a hard-wired connection. However, if a mobile device is attached to a network that is segmented, and the device moves from one area into another that is serviced by a different subnet, the device needs to acquire a new IP address to function properly on the new network segment. Transport and application end points are then lost and users may be forced to log in again, re-authenticate, restart their applications, and recreate lost data.

In most 802.11 networks, users log onto the network and associate and authenticate with a nearby AP. As users roam within the AP range, signal quality of the laptop or other client device will change, eventually degrading to a point where the connection may be dropped. Then the client goes off and looks for another AP to connect with and authenticate. This type of 'distressed' roaming however can wreak havoc on latency-sensitive applications, especially if the connection is dropped.

Figure 4. Symbol's pre-emptive roaming with load balancing



Symbol, however, puts special hooks into its Access Ports and client software to prevent this type of roaming. Symbol supports 'application persistence' or 'pre-emptive roaming.' Here, the client device actively decides to roam to another Access Port.

Basically, driver software planted in the mobile client monitors signal strengths and looks for signal degradation. Symbol client software also examines beaconing information broadcast across the network to decide which neighboring Access Port has the optimal conditions to re-associate with to load balance among Access Ports.

Mobility can affect the performance and even the ability to run some applications, such as latency-sensitive voice or real-time applications. Such applications may run just fine in test bed LANs, but once deployed in a real-world wireless network performance may suffer as users become mobile. Throughput of some applications, for instance, may be 3 Mbps when all users are stationary in a test bed, but drop precipitously to well under 1 Mbps once users begin to roam.

Figure 5. Impact of Roaming on TCP Throughput During File Upload

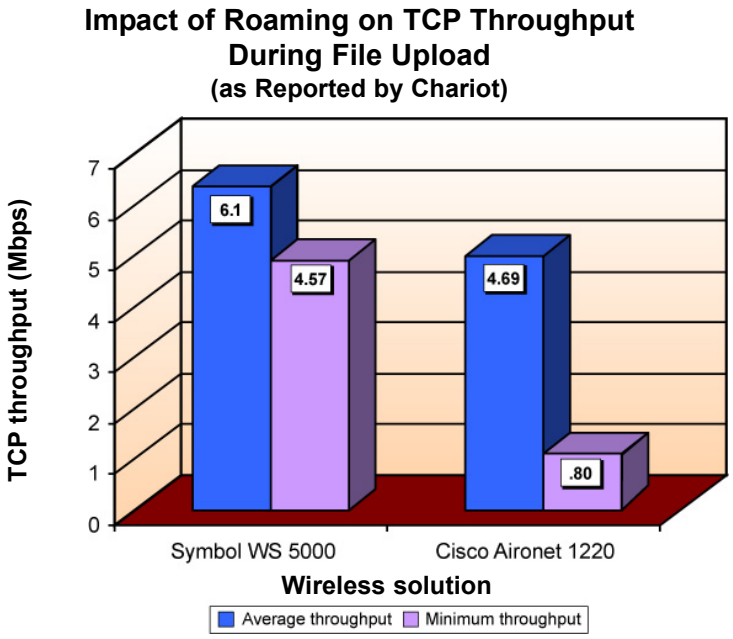
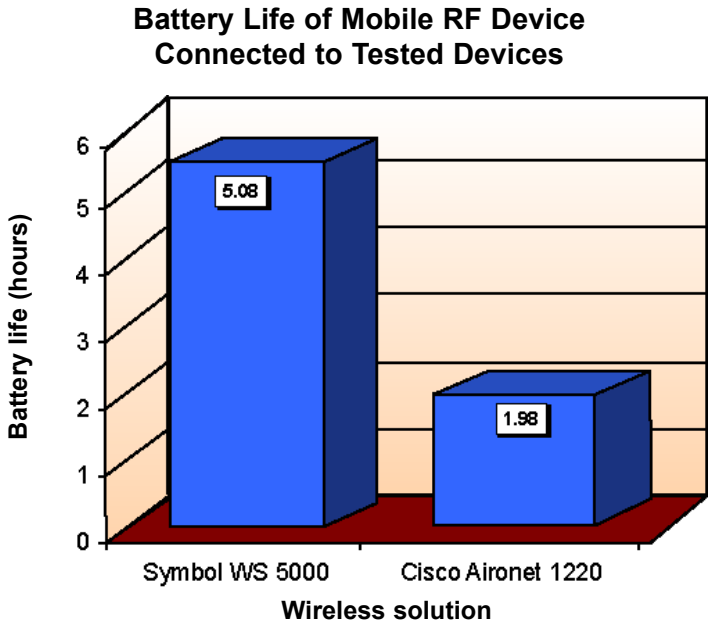


Figure 6. Battery Life of Mobile RF Device Connected to Tested Devices



The Tolly Group measured the impact of roaming on performance in WLANs for the Symbol WS 5000/Access Port pairs and also on traditional Cisco Systems switch/AP pairs.

The effect of roaming is visible as dips in the throughput plot generated by the Chariot test tool. Chariot-generated plots in this test showed that both the systems had throughput of above 6 Mbps when the client was stationary.

Throughput degraded at the point where the client (users) moved around within the building. The worst degradation was much less at 4.57 Mbps for the wireless switch system-based WLANs compared to that of 0.8 Mbps in the Cisco AP1220-based WLANs. Applications suffered a 23% drop in performance on the Symbol WS 5000 versus and 83% performance hit on the Cisco access points. Full test results are available in Tolly Group document #204100.

With regards to roaming, maintaining data rate or wireless throughput is very important for smooth running of many applications. As tests bear out, the Symbol WS 5000 delivers ample bandwidth and application persistence to users who roam from one AP to another, while the Cisco APs sizable drop in application throughput would result in serious application interruptions as users roam from one AP to another. Symbol's pre-emptive roaming delivers latency-free mobility to the enterprise.

Battery Life

Another factor that comes into play with mobility is battery life. In order for handheld PCs and laptops to roam freely and effectively, they cannot practically connect to AC power and thus rely on extended-life batteries.

Tolly Group engineers measured the battery life of a Pocket PC handheld device connected wirelessly to a Symbol Wireless Switch System 5000 and the battery life of the same handheld PDA when connected to a Cisco Systems Aironet 1220 Access Point.

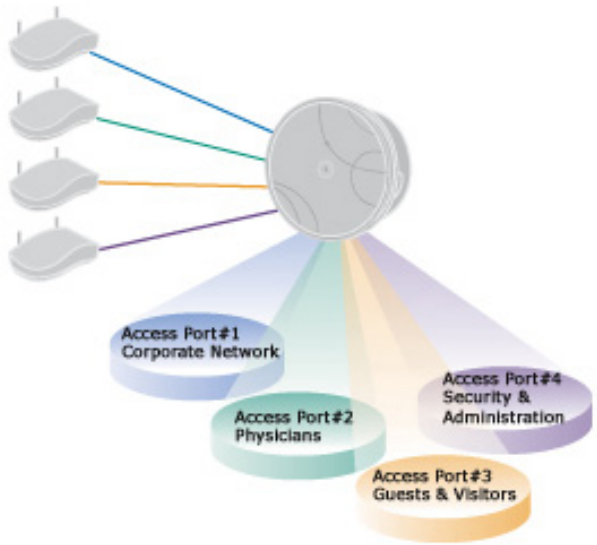
Engineers found that the Symbol WS 5000 Wireless switch prolonged the battery life of the Pocket PC by

2.5 times versus the Cisco Aironet 1220. Symbol's WS 5000 system enabled longer battery life for wireless devices by reducing the amount of time the handheld wireless device needed to go from idle mode to active mode. The pocket PC-based handheld demonstrated a battery life of just over five hours with the WS 5000-based WLAN versus just under two hours when attached to the Cisco Aironet 1220.

This significant enhancement of battery life observed for a handheld PC attached to the Symbol WS 5000 Wireless Switch demonstrates that the Symbol switch mitigates the impact of background traffic on mobile devices so they do not have to change from their standby modes as often. Ultimately, this translates into a productivity gain since mobile users can use their equipment for extended periods of time.

While we're on the subject of battery life, WLAN network interface cards (NICs) have an impact on the battery life of a mobile device. To conserve battery life, WLAN radio cards turn off periodically to save battery when they are not in use. Unfortunately, this can have the same effect as roaming out of coverage — application sessions may be dropped, causing a loss in user productivity and increased user dissatisfaction with the wireless solution. Symbol's WS 5000 incorporates a clever "Proxy ARP" implementation to keep connections to servers across the network alive while a WLAN radio is dozing to save even more battery power.

Figure 7. Virtual AP – One Access Port Supports Four Virtual LANs



Virtual AP

Another important facet of Symbol's wireless architecture is its support of the virtual AP.

Symbol is a pioneer of true 'wireless VLANs' (or 'Virtual AP') – the ability to split the wireless media into distinct broadcast domains, much like VLANs on the wired side. Non-Symbol products will segment the network up to the wired interface only (via VLANs), losing any benefits of this segmentation on the wireless side. Symbol extends these VLANs into the wireless media as well, preserving VLAN segmentation and consequently delivering better wireless network throughput and increased battery life of mobile devices.

Each WS 5000 Wireless Switch supports multiple wireless VLANs. A wireless VLAN is the extension of a wired VLAN over the air and is created by establishing independent WLANs; each WLAN can have different policies for bandwidth allocation, network access, security mechanisms and/or packet prioritization. As a result, the WS 5000 Wireless Switch provides

Figure 8. 802.11b Multi-BSS Performance

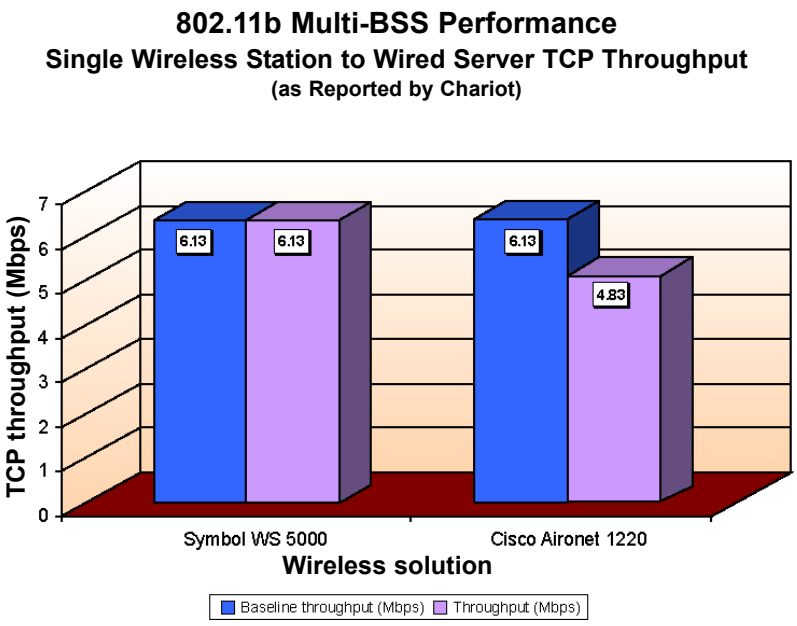
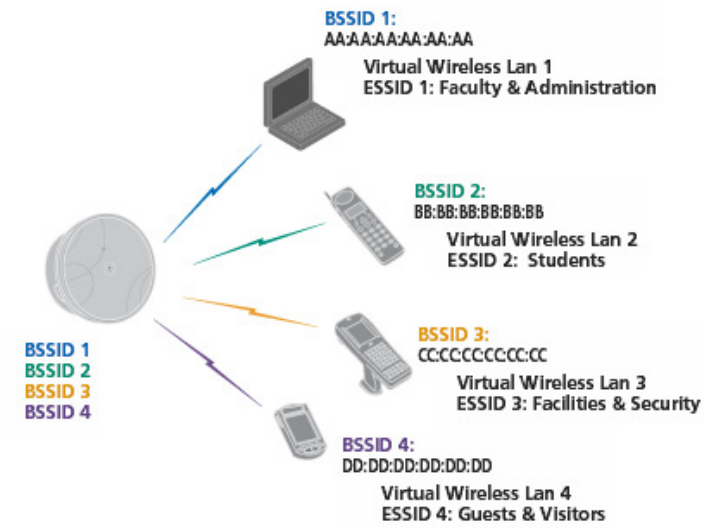


Figure 9. Access port VLAN Architecture: Multiple BSSID VLAN



the flexibility to support the varying demands of different applications.

This is accomplished because each Symbol Access Port supports up to four BSSIDs (essentially independent network IDs), versus traditional APs that support just one.

Instead of individually configuring every Ethernet switch port that will be plugged into an access point for trunked VLANs (to support multiple WLANs), network administrators only need to configure the Ethernet switch ports that will go to the WS 5000 Wireless Switch. The mapping of VLANs to the appropriate WLANs, or ESSIDs, can then be performed in the WS 5000 Wireless Switch.

Moreover, since the Symbol Access Ports provide a BSSID for each WLAN, data traffic from one VLAN/WLAN does not bleed into another like in traditional APs, and, consequently, does not cause performance degradation. The capability to assign multiple SSIDs with uniquely allocated BSSIDs means that network staffers can minimize the impact of broadcast traffic on the network, which saves valuable bandwidth by eliminating chatter. The Virtual AP also significantly improves the battery life of the client devices used for the testing, as client devices were not required to "wake" from their standby modes as often as they would otherwise be requested to do by regular broadcast traffic.

In The Tolly Group examination, engineers measured the TCP throughput associated with supporting multiple BSSIDs. This test illustrated the advantages of having the ability to assign multiple BSSIDs while implementing virtual WLANs.

The support for multiple BSSIDs with corresponding beacons results in proper client association to the suitable access point. A baseline test performed with a single BSSID showed the same level of performance for both the Symbol and the Cisco systems under test. But with multiple applications enabled through the virtual WLANs and multiple BSSIDs enabled in the WS 5000, the Symbol offering delivered 27% greater throughput compared to the Cisco Aironet AP1220 which assigns a single BSSID to all virtual WLANs.

QoS Support

The QoS architecture available in the WS 5000 wireless switch was illustrated by configuring the switch to provide two virtual WLANs with bandwidth allocated based on a 10:90 split. A test was run with traffic being sent between two clients in WLAN1 that had 10% bandwidth allocation at the start of the test and then a second stream from WLAN2 with higher bandwidth allocation after a delay of 30 seconds.

The result demonstrated service classification being provided by the switch correctly, with the second stream being afforded higher bandwidth allocation taking over the traffic from WLAN1. The capability to segregate traffic and to throttle bandwidth is essential to enable Hotspot or guest access successfully within an enterprise. Bandwidth allocation combines with Ethernet, IP and wireless packet tagging mechanisms to provide the capability to implement end-to-end Quality of Service for mission-critical applications.

IEEE Leadership

While Symbol Technologies has been a pioneer for wireless technologies, the company also has been a standardization leader in the wireless community and continues to lead standards efforts.

Prior to wireless LAN standards, the company's SpectrumOne was among the first commercially successful wireless product lines in 1989. Later, Symbol was a founding member in 1993 of the IEEE 802.11 committee, which to this day oversees development of wireless LAN standards. And now, Symbol also started and serves on the Board of Directors for the Wi-Fi Alliance.

More importantly, Symbol is at the center of a number of wireless LAN standardization efforts.

Symbol is a significant player in the 802.11i committee, submitting key proposals for the addition of authentication and encryption to the standard.

Wireless VoIP First:

Symbol was the first to develop an 802.11 VoIP-over-WLAN phone, with enterprise-class QoS for voice in 1997.

Symbol products are centerpieces of the Wi-Fi and WPA test bed. They are the "gold standard," against which other products are tested for wireless security before certification is granted.

Symbol recognized the need early on for Fast Roaming/Fast Handoff in wireless LANs due to the impact of security (re-authentication delay) and QoS (dropped calls). Symbol consequently proposed the Fast Roaming/Fast Handoff Study Group to the IEEE in 2003. A Symbol expert now chairs this group.

The 802.15 committee on Bluetooth/802.11 coexistence was formed by Symbol in 2000.

Symbol originated the proposal in 1996 for International Roaming, otherwise known as 802.11d.

In addition to IEEE and Wi-Fi activities, Symbol is actively engaged in a number of other standards-based endeavors in the areas of security, telemetry and VoIP.

Symbol is a leader in the development of wireless VPNs based in Wireless Transport Layer Security (WTLS), an IETF standard with origins in the cellular telephone industry. WTLS VPNs operate in wireless environments where intermittent connections, slow connections and roaming are normal and frequent occurrences.

Cost-of-Ownership Benefits

A TCO can be defined as an accounting of all the costs associated with procuring, deploying, and owning an IT system.

The purpose of this section is not to provide a comprehensive TCO cost analysis, but instead to identify the primary technology benefits of Symbol's WS 5000 and accompanying Access Ports and explain how they contribute to a lower TCO.

That said, there are a number of functional areas examined by The Tolly Group during testing that have a direct positive impact on TCO.

The functionality of a traditional access point is centralized in Symbol's Wireless Switch along with additional features that cannot be attained on a distributed model, resulting in a low-cost Access Port at the edge. By using the Wireless Switch to manage Access Ports, the Symbol Wireless System is able to realize a number of benefits that reduce the total cost-of-ownership of a WLAN:

Ease of Configuration: The WS 5000 Wireless Switch serves as a central point of management for the WLAN, so network administrators only need to perform configurations at the Wireless Switch-level instead of at each traditional Access Point. For example, to configure multiple Access Ports, network administrators simply have to configure an Access Port Policy in the Wireless Switch that can then be applied to the specified Access Ports with a few mouse clicks on the GUI. The upshot is that there is a quantifiable savings gleaned from eliminating AP-by-AP configuration by network technicians.

Automatic Firmware Updates: As Access Ports are plugged into the network, the Wireless Switch automatically pushes the latest version of firmware out. Keeping track of which access point supports what version of firmware represents a high cost to many enterprises.

"Plug-and-Play" for Ease of Installation: Installing an Access Port is a matter of "plug-and-play" because once an Ethernet cable is plugged into the device, it can be automatically adopted by the Wireless Switch and configured with the correct settings. Enterprises can realize immediate cost savings from this capability by eliminating the need for skilled technicians during the installation phase. Staging costs for setting up WLAN access points prior to installation in the ceiling often are overlooked when adding up the cost of installing a WLAN, Symbol removes these costs completely.

Simpler VLAN Port Configuration: Instead of individually configuring every Ethernet switch port that will be plugged into an Access Point for trunked VLANs, network administrators only need to configure the Ethernet switch

ports that will go to the Wireless Switch. The Wireless Switch then handles any mapping of VLANs to the appropriate WLANs, or ESSIDs.

Ease of Migration: The Wireless Switch is radio-independent, so as new technologies emerge and are adopted as standards, such as 802.11g, migrating is facilitated by just adding new Access Ports or replacing the low-cost Access Ports with new upgrades.

End-to-End QoS: Support for IEEE 802.1Q, 802.1p and ToS/DiffServ in the Wireless Switch ensures that traffic flowing from routers all the way to the mobile client and vice versa is prioritized appropriately. QoS on a network is only as effective as the weakest link, but with the Wireless Switch, a network administrator can be assured that QoS features are being implemented on the wired and wireless portions of the network for optimal network performance.

Moreover, the WS 5000 supports eight QoS traffic queues, meaning prioritized traffic from other devices in the enterprise network can be mapped, appropriately, to their respective queues and guaranteed the bandwidth defined by the traffic type's class of service. In effect, this means strategic applications are guaranteed to run unimpeded, even when the network is congested.

Price Points: From a price perspective, an April 2004 Network World newspaper article shows that Symbol Technologies offers the most cost-efficient pricing for both APs (Access Ports, in Symbol's case) and WLAN switches versus four other competitors.

Symbol's price of $390 per dual-radio Access Port is 28% less than the nearest competitor, Aruba Networks, which sells its APs for $500 each. According to the Network World article ("WLAN vendors take stand in Virtual Showdown," Network World 04/12/04), both Aruba Networks and Airespace sell APs for $550 each and Extreme Networks offers a dual-radio AP for $800.

On the WLAN switch front, Symbol offers the least expensive of the free-standing WLAN switches, at $7,500 for the WS 5000 – or 43% less than Airespace's 4102 at $13,125. An Aruba 5000 was priced at $20,000 and a Trapeze MX-400 costs $22,000. The Network World article did note that Extreme Networks sells a WLAN blade for its switching line that costs $3,000, though an Alpine switch to house the device costs about $7,000.

Considering upfront pricing and the technology benefits that ripple through to contribute to TCO savings, Symbol's WS 5000 Wireless Switch and its thin Access Port technology makes for a competitive WLAN offering that should not be overlooked.

# # #

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THE TOLLY GROUP

The Tolly Group, Inc.
3701 FAU Blvd. Suite 100
Boca Raton, FL 33431
Phone: 561.391.5610
Fax: 561.391.5810
http://www.tolly.com
info@tolly.com