THE TOLLY GROUP

No. 204131 June 2004

Intel Corp.

Intel® IXP425/IXP422/IXP420 Network Processors

Performance Analysis of 802.11 Broadband Routers and Access Points

1989 - 2004 15 Years TOLLY

Test Summary

Premise: *The market for small office/home office (SOHO) and small/medium business (SMB) is inundated with a range of broadband wireless gateway products at highly competitive prices. Theses devices are equipped with features that utilize the advantages of present-day wireless technology and state-of-the art network processor capabilities. It is important for consumers to know the performance characteristics of these SOHO routers/access points in order to better understand these products' value proposition and to aid in making informed purchasing decisions.*

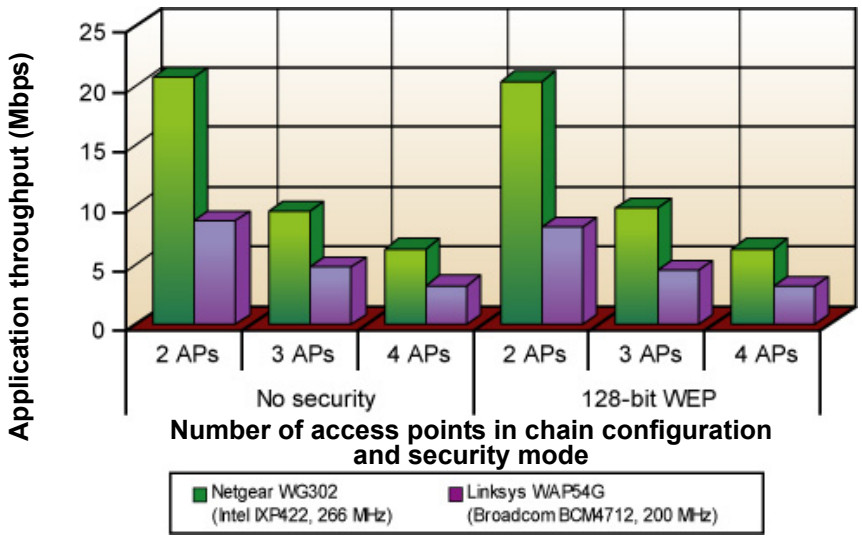
Intel Corp. commissioned The Tolly Group to benchmark the performance of several commercially available 802.11 wireless gateways (wireless broadband routers and access points) that utilize the Intel® IXP425, IXP422 and the IXP420 network processors, and compare the performance of those devices against other, generally available products based upon alternative chipsets.

Tolly Group engineers used the industry-accepted IxChariot's "throughput.scr" script to determine the aggregate application throughput of the devices under test. Tests

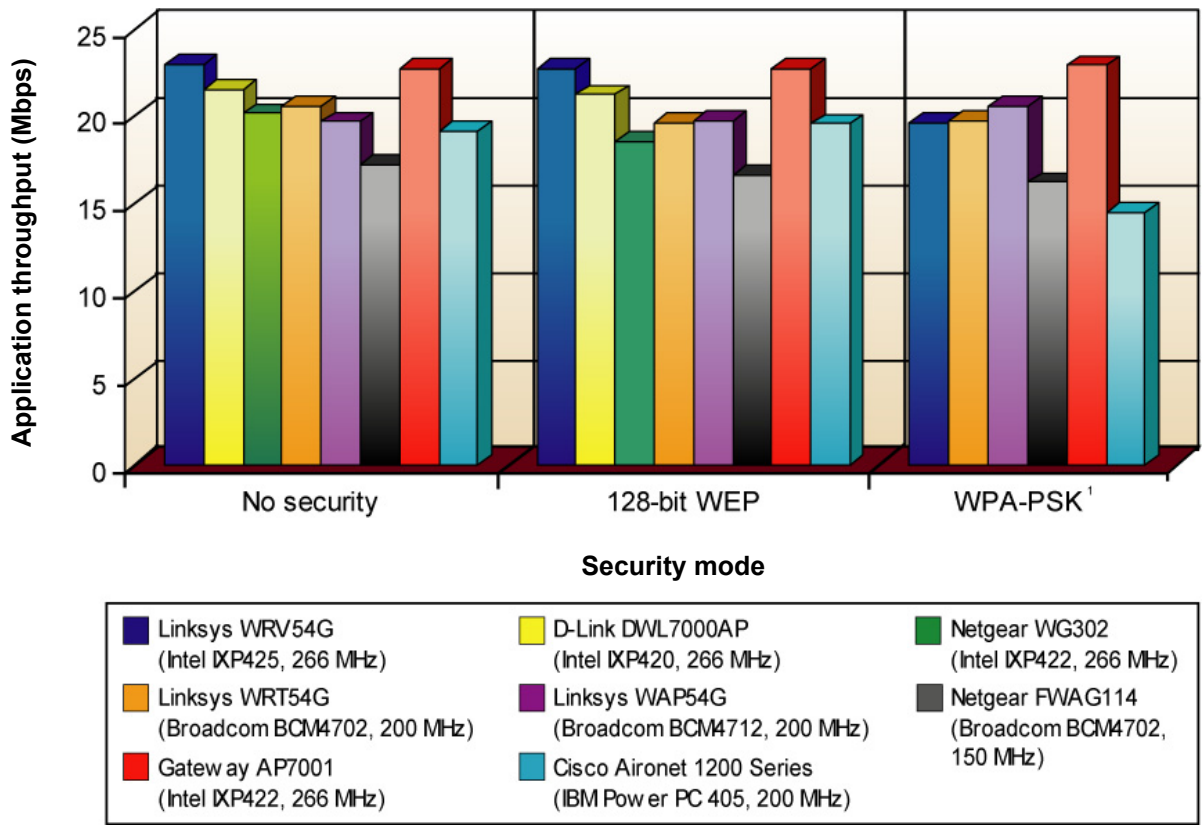
Test Highlights

- Intel IXP42X network processor-based products outperformed other, non-Intel devices in almost every scenario, consistently demonstrating the highest throughput
- Intel IXP425 network processor-based Netgear WG302 outperformed the Broadcom BCM4702-based Linksys WAP54G by 50% or more in Wireless Distribution System tests with two to four APs
- Intel IXP425 network processor-based Linksys WRV54G and IXP422-based Gateway AP7001 demonstrated the best 802.11g WLAN-LAN performance recording 19.6 Mbps to 23 Mbps of application throughput
- IXP425-based Linksys WRV54G delivered 23 Mbps of throughput in both the No Security and 128-bit 802.11g WLAN-WAN WEP tests outperforming the Broadcom BCM4702-based Linksys WRT54G
- IXP425-based Linksys WRV54G outperformed the BCM4702-based Linksys WRT54G by 14% to 18% in 802.11g WAN-WLAN tests

802.11g Bidirectional WDS Application Throughput (Mbps)
as Reported by IxChariot 4.3



Source: The Tolly Group, May 2004 *Figure 1*



[1] The D-Link DWL7000AP and the Netgear WG302 were not tested for WPA-PSK because they did not support the feature at the time of testing.

Source: The Tolly Group, May 2004

Figure 2

were performed using the standard script provided by IxChariot version 4.3, "throughput.scr" with 1-MB file size under identical test conditions with the clients running IxChariot Performance Endpoint version 4.5. Tests were conducted with three network topologies: WLAN-to-LAN, WLAN-to-WAN and Wireless Distribution System (WDS). Most tests utilized real-world bidirectional traffic.

Engineers measured application throughput for devices supporting 802.11g and 802.11b wireless standards. Extensive testing was conducted during May 2004.

The test scenarios are indicative of those encountered by wireless laptop PC users using the Internet with a connection to a broadband wireless router connected to a wired infrastructure. Moreover, test scenarios also show how wired PCs connected to the router are not limited by the performance of the router when utilizing the Internet.

Test results show that the wireless gateways based upon the Intel IXP425, IXP422 and IXP420 either outperform competitive products in every scenario, or provide performance on par with the other devices.

Results

Wireless Distribution System Throughput

Engineers measured the bidirectional application throughput in a configuration supporting the Wireless Distribution System (WDS), a common architecture in campus networks. WDS allows packets to pass from one wireless access point to another, just as if they were ports on a wired Ethernet switch; in effect, this provides a way to extend the wired network using wireless access points.

In a test of 802.11g devices supporting bidirectional traffic with no encryption and 128-bit WEP encryption, the NetGear WG302, based upon the Intel IXP422 network processor, clearly outperformed the Linksys WAP54G by 50% or more in every test. (See Figure 1.) Tests show the overall throughput degrades exponentially when adding a new AP into the daisy-chain configuration; this applies to both devices under test.

802.11g WLAN-LAN Throughput

In this bidirectional WLAN-LAN test, engineers measured the 802.11g application throughput of eight devices representing a mix of broadband routers and access points.

Overall, the products generally delivered throughput between 16 Mbps to 23 Mbps in three security modes – No Security, 128-bit WEP and WPA-PSK. (See Figure 2.) The Linksys WRV54G and the Gateway AP7001 (which utilize the Intel IXP425 and IXP422 respectively) demonstrated the best performance, recording up to 23 Mbps of application throughput. The WRV54G delivered consistent throughput around 23 Mbps in both the No Security and 128-bit WEP tests, to about 20 Mbps during the WPA-PSK test. The Gateway AP7001 delivered consistent throughput, about 22.7 Mbps for both the No Security and 128-bit WEP tests, and a slightly higher 22.9 Mbps during the WPA-PSK test.

The other tested devices demonstrated a level of throughput of 18.5 Mbps to 21.5 Mbps (except for the Netgear FWAG114 which recorded the lowest performance) in the No Security and 128-bit WEP modes. The IBM Power PC 405-based Cisco 1200 performance in the WPA-PSK degraded by about 25% — the biggest performance degradation among the devices tested.

D-Link's DWL7000AP and Netgear's WG302 did not support WPA-PSK security mode at the time of testing; hence, no results are shown for these devices.

802.11b WLAN-LAN Throughput

In this bidirectional WLAN-LAN test, engineers measured the 802.11b application throughput of eight devices representing a mix of broadband routers and access points.

All devices tested delivered throughput in the range of 5.2 Mbps to 6.5 Mbps. The Intel® IXP42X network processor-based products, once again, performed slightly better than or equal to devices based upon other processors. (See Figure 3.) The Gateway AP7001 consistently stood out as the "overall" best performer. The tests indicate that the Intel® IXP42X network processors can achieve industry-leading performance with appropriate implementation.

802.11g WLAN-WAN Throughput

The WLAN-WAN test was designed to measure the

Intel Corp.

IXP425/IXP422/ IXP420 Network Processors

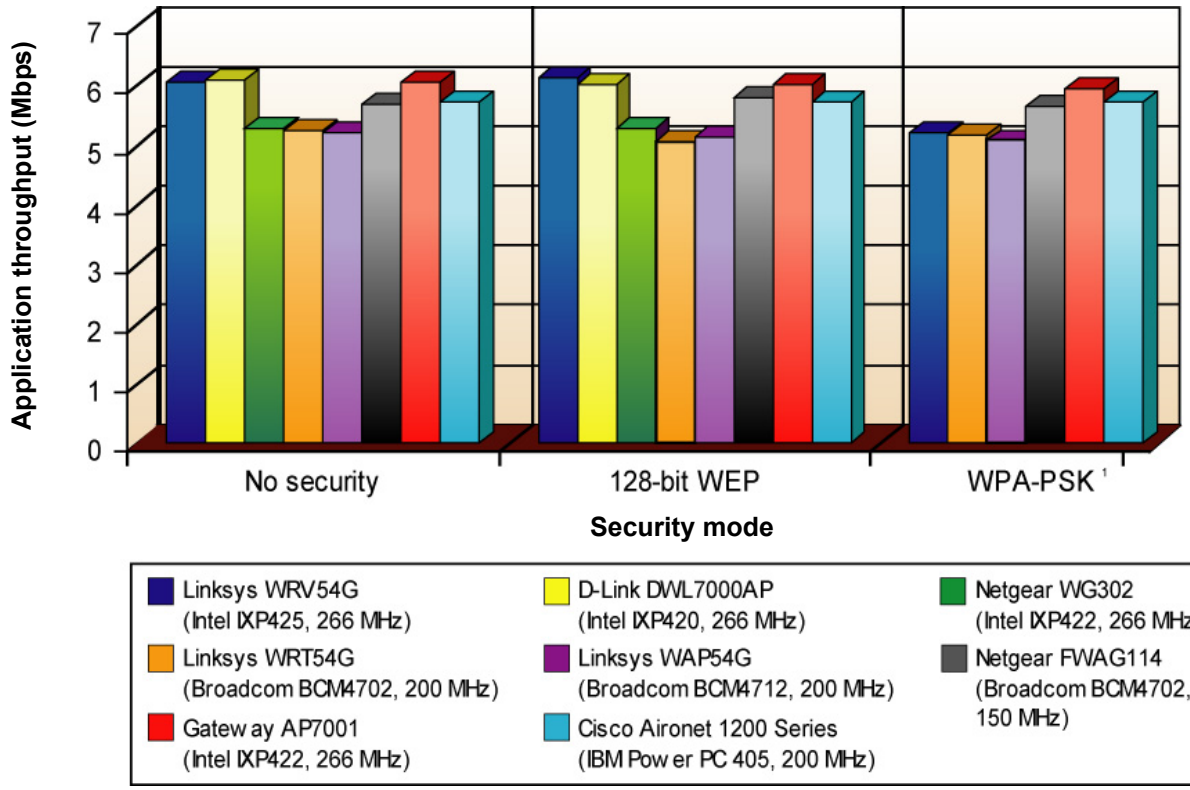
Performance Analysis of 802.11 Broadband Routers and Access Points

Intel Corp.
IXP425 Network Processor
Product Specifications*

- Member of the IXP42X network processor product line for enterprise, small-to-medium enterprise (SME), residential and other networking applications
- Intel XScale® core at up to 533 MHz provides headroom for customer-defined applications
- Integrated hardware acceleration of popular cryptography algorithms (SHA-1, MD5, DES, 3DES, AES) for secure applications
- DSP software library on the Intel XScale core supports two to four voice channels and reduces system cost
- Two high-speed serial (HSS) ports for VoIP SLIC/CODEC or T1/E1
- Two integrated 10/100 Base-T Ethernet MACs with Media Independent Interface (MII) for design flexibility and cost-effective wire-speed performance
- UTOPIA 2 interface with multiple ADSL/G.SHDSL or VDSL support
- 33/66-MHz PCI v2.2 host and option interface for glueless connection of up to four devices
- SDRAM controller supports from 8 to 256 Mbytes of SDRAM memory
- Low system power consumption (1.0 - 1.5 Watt typical)
- USB version 1.1 device controller
- Two high-speed UARTS support up to 921 Kbaud each
- 16 GPIO pins
- 16-bit configurable expansion bus
- Commercial (0° to 70° C) and extended temperature (-40° to +85° C) versions

For more information contact your Intel sales representative:
URL:
http://intel.com/design/network/products/npfamily/ixp425.htm

**Vendor-supplied information not verified by The Tolly Group*



[1] The D-Link DWL7000AP and the Netgear WG302 were not tested for WPA-PSK because they did not support the feature at the time of testing.

Source: The Tolly Group, May 2004

Figure 3

throughput performance of the broadband routers in typical home networking environments where regular home or SOHO users mostly access Internet via their broadband routers. In this test of broadband routers, the Linksys WRV54G, with its Intel IXP425 network processor, consistently outperformed the Broadcom BCM4702-based Linksys WRT54G and Netgear FWAG114 products by as much as 10%. The Linksys WRV54G delivered 23 Mbps of throughput in both the No Security and 128-bit WEP tests, versus 20.6 and 20.8 Mbps for the Linksys WRT54G. In the WPA-PSK test, both Linksys products delivered just over 19 Mbps of throughput with the Linksys WRV54G demonstrating a slight advantage. (See Figure 4.)

802.11g WAN-WLAN Throughput

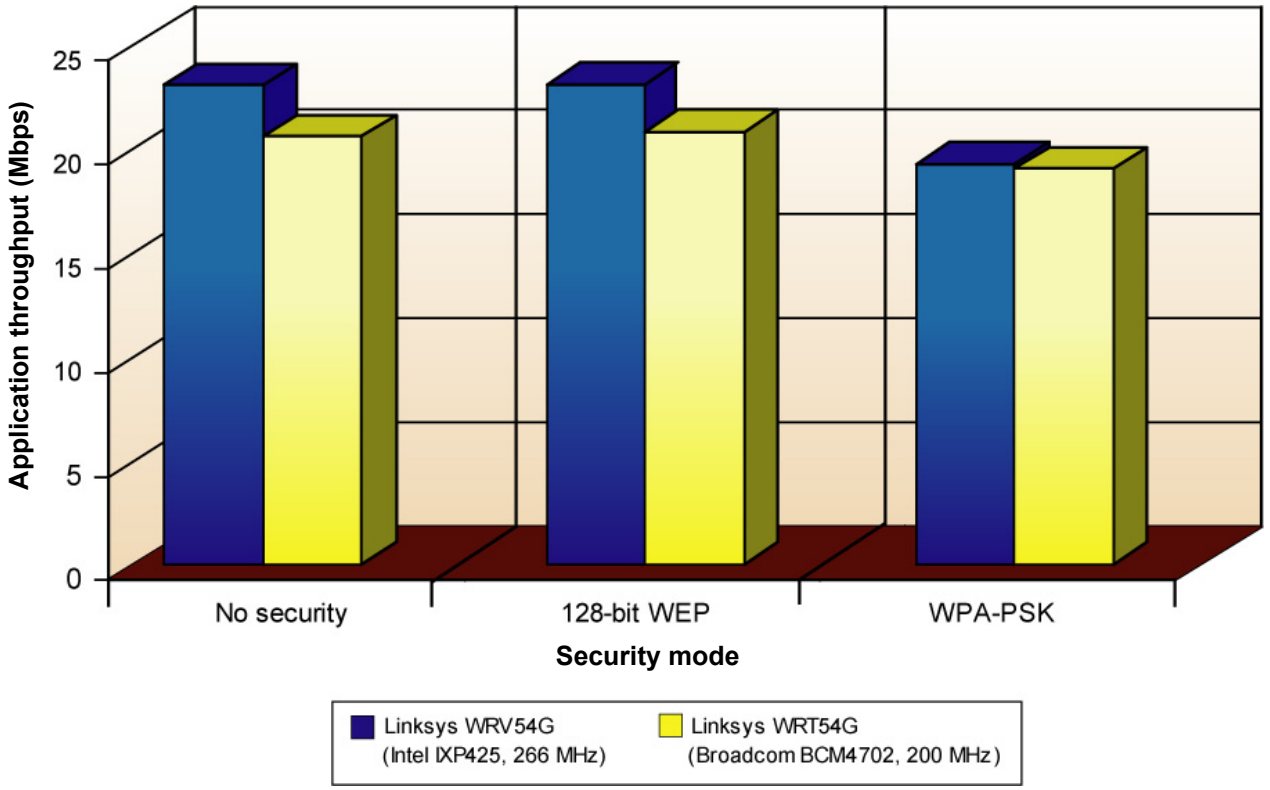
The WAN-WLAN test measured the throughput performance of broadband routers in typical home networking environments where regular home or SOHO users typically access the Internet via broadband router connections.

The Intel IXP425-based Linksys WRV54G outperformed the Broadcom BCM4702-based Linksys WRT54G by 14% to 18% in downstream traffic tests, regardless of the type of security used. (See Figure 5.)

Analysis

TCP throughput is a measure of how fast data moves between the clients using the TCP protocol. Under identical test conditions with no influence from any environmental variables, among other components (WLAN chipset and associated driver) the network processor has the greatest possibility of influencing the throughput performance of the wireless gateways. This assumption was confirmed in the WDS configuration test.

In the WDS configuration test, the Netgear WG302 delivered more than twice the performance of the Linksys WAP54G — 20.7 Mbps versus 8.7 Mbps



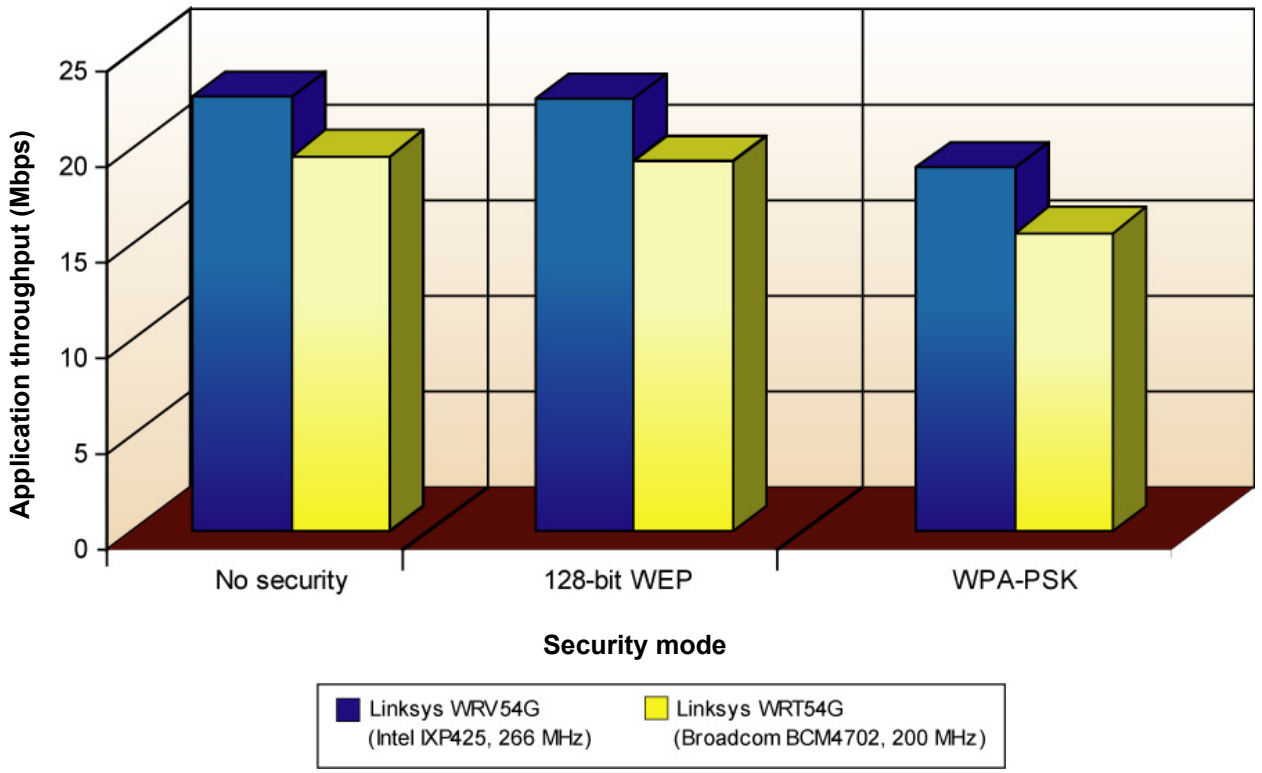
Source: The Tolly Group, May 2004

Figure 4

respectively. That performance delta was observed in every WDS test (as the numbers of APs increased), in both the No Security scenario and the 128-bit WEP-enabled scenarios. In fact, the Intel-based Netgear WG302 broadband router delivered twice as much throughput as the Linksys unit. Moreover, tests show that as the number of APs increase in a WDS configuration, throughput drops exponentially. It is normal for performance to degrade as the number of AP "hops" increase, but at least with the Intel-based devices, users get almost as much throughput with 128-bit WEP enabled and four APs daisy-chained in a row as when the WAP54G supported two APs.

In the bidirectional 802.11g WLAN-to-WAN throughput test, the Linksys WRV54G with the Intel IXP425 network processor was able to transfer more encrypted and unencrypted data at rates of 23 and 23.1 Mbps in the No Security and 128-bit WEP tests, respectively. In the WPA-PSK security scenario, the Gateway AP7001 delivered from 10% to 37% greater performance. Likewise, the Intel IXP425-based Linksys WRV54G broadband router was in the upper echelon of performance, as well. In the WPA-PSK test, the WRV54G delivered slightly greater performance than the WRT54G, though both delivered over 19 Mbps of throughput. Because WPA is a highly processor-intensive encryption technique, network processors have the potential to facilitate higher performance.

In 802.11b WLAN-LAN tests, the Intel IXP42X network processor-based products once again delivered the highest throughput. In summary, Intel IXP425-based products consistently demonstrated the highest throughput in tests of wireless application performance.



Source: The Tolly Group, May 2004

Figure 5

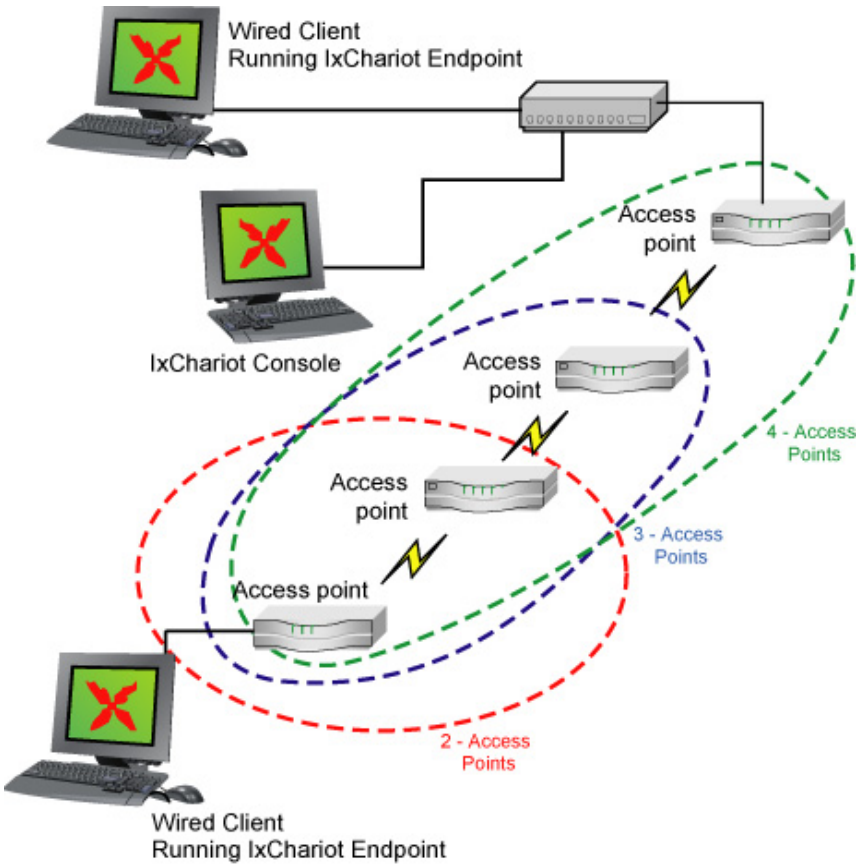
Test Configuration and Methodology

For performance tests, The Tolly Group tested a 266-MHz Intel IXP425-based Linksys WRV54G broadband router. Other broadband routers tested were: Linksys WRT54G (using a Broadcom 200-MHz BCM4702 chipset) and a Netgear FWAG114 (using a 150-MHz Broadcom BCM4702 chipset). On the access point side, The Tolly Group tested a 266-MHz Intel IXP420-based D-Link DWL 7000AP access point, a Netgear WG302 based upon a 266-MHz Intel IXP422 and a Gateway AP7001 using the same Intel IXP422 network processor. Other access points tested were: Cisco Aironet 1200 Series (using a 200-MHz IBM Power PC 405) and a 200-MHz Broadcom 4712-based Linksys WAP54G. During all tests, firewall functionality in the devices under test was disabled.

All tests were conducted under identical test conditions with no other radio interference. The firmware and device driver software for each device tested was updated to the latest version available from the manufacturer Web site prior to the testing. The wired connections in the bidirectional traffic tests were set at 100 Mbps, full duplex.

The wireless tests were conducted in the infrastructure mode with devices set at full rate. For most testing phases, the routers and access points were configured in mixed wireless mode (802.11g and 802.11b); SSID broadcast enabled, wireless channel 1, 6, 11 and power output mode set to the default. However, in WDS mode, each access point was configured to a certain wireless network mode, either 802.11g or 802.11b, depending on the type of testing. The power output mode for WDS was configured to the level lowest possible to avoid signal interference between the devices. The WEP key was created with 26 HEX digits

Wireless Distribution System Test Bed



Source: The Tolly Group, May 2004

Figure 6

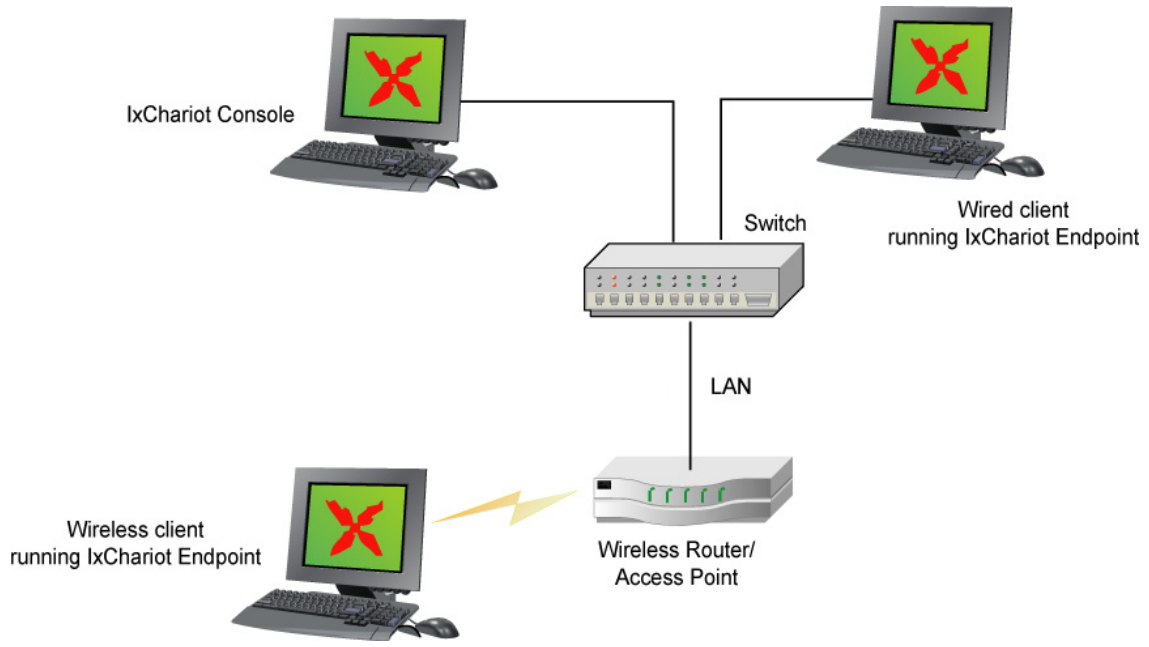
and the WPA-PSK key was created with 10 HEX digits. The same keys were used in all tests. Firewalls and filters were disabled for all devices tested. The wireless clients were placed within 10 feet of each other and the DUT in all tests. All test variables such as wireless settings, encryption keys and test-run options were held constant for all tests.

For the WDS test, one laptop was wired to the LAN port of the first access point and a second computer was wired to the LAN port of the last access point. Both computers had Ixia's Performance Endpoint software agent running, and one additional laptop served as the IxChariot console that managed the performance testing. (See Figure 6.)

The bidirectional WLAN-LAN test was conducted with one laptop connected wirelessly to the WLAN side of the DUT and a second computer wired to the LAN side of the router/access point. Both computers had Ixia's Performance Endpoint software agent running, and one additional laptop served as the IxChariot console that managed the performance testing. (See Figure 7.)

On the bidirectional WLAN-WAN side, the test was conducted with one laptop connected wireless to the WLAN side of the DUT and a second computer wired to the WAN side of the router/access point. Both computers had Ixia's Performance Endpoint software agent running, and one additional laptop served as the IxChariot console that managed the performance testing.

WLAN-LAN Test Bed



Source: The Tolly Group, May 2004

Figure 7

The Tolly Group gratefully acknowledges the providers of test equipment used in this project.

Vendor	Product	Web address
Ixia	IxChariot Ver 4.3	http://www.ixiacom.com
Ixia	IxChariot Endpoint Ver 4.5	http://www.ixiacom.com

PERFORMANCE VERIFIED By IXIA

Tolly Group Services

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TOLLY FAIR TESTING CHARTER

For info on the Fair Testing Charter, visit: http://www.tolly.com/Corporate/FTC.aspx

Project Profile

Sponsor: Intel Corp.
Document number: 204131
Product class: Network processor for wireless gateways
Broadband routers under test:

- Linksys WRV54G Ver 2.25.2 (Intel® IXP425, 266 MHz)
- Linksys WRT54G Ver 2.02.2 (Broadcom BCM4702, 200 MHz)
- Netgear FWAG114 Ver 1.0.21 (Broadcom BCM4702, 150 MHz)

Access Points under test:

- D-Link DWL 7000AP Ver 1.00 (Intel® IXP420, 266 MHz)
- Cisco Aironet 1200 Series Ver 12.2.13-JA3 (IBM Power PC 405, 200 MHz)
- Gateway AP7001 Ver 1.04 (Intel® IXP422, 266 MHz)
- Linksys WAP54G Ver 1.09.1 (Broadcom BCM4712, 200 MHz)
- Netgear WG302 Ver. 1.0.5 (Intel® IXP422, 266 MHz)

Testing window: May 2004
Software status: Generally available

For more information on this document, or other services offered by The Tolly Group, visit our World Wide Web site at http://www.tolly.com, send E-mail to sales@tolly.com, call (561) 391-5610.

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