



Lab Testing Summary Report

June 2013

Report 130605

Product Category:

Integrated Services Router

Vendor Tested:



Products Tested:

Cisco 4451-X ISR



Key findings and conclusions:

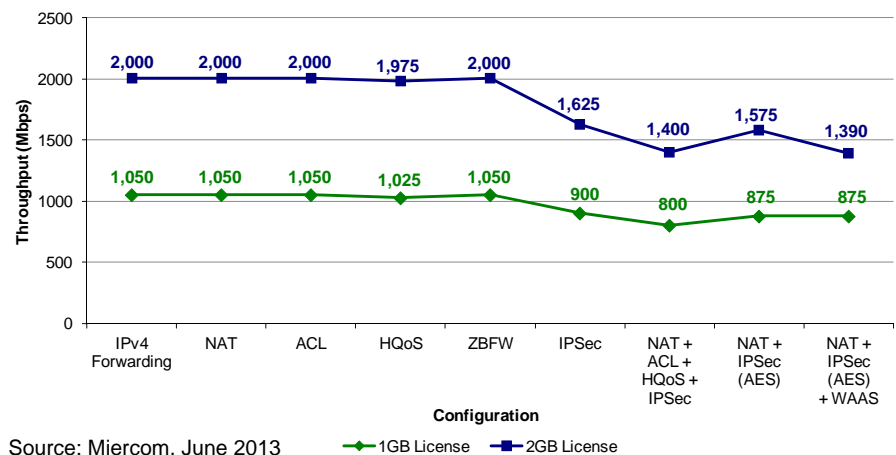
- Cisco 4451-X ISR branch office router, with advanced features enabled, demonstrated 1 GB and 2 GB capacity as advertised
- Excellent performance of 980 Mbps to 1 Gbps with Cisco Application Visibility and Control (AVC) service enabled
- Enabling Cisco Wide Area Application Services (WAAS) provide over 97% time reduction in application responsiveness
- Native WAAS performance shows sustained throughput of 150 Mbps with 2,500 optimized connections

Cisco engaged Miercom to evaluate the capabilities and performance of the latest Cisco Integrated Services Router (ISR) for branch offices, Cisco 4451-X ISR, to deliver bandwidth needed for collaboration and LAN-like application delivery via the WAN from a corporate data center or cloud. While testing the 4451-X ISR, performance was observed to determine if activating available features and services affected throughput.

The functionality of the integrated features included routing, security and QoS. Specifically, the features were IPv4 Forwarding, NAT, ACL, IPSec, Zone-Based Firewall (ZBFW) and Hierarchical Quality of Service (HQoS).

In addition, the Application Visibility and Control (AVC) feature, enabled via the Application Experience (AX) software license, provides application-level classification, monitoring and traffic control. With AVC, network administrators are able to improve business-critical application

Figure 1: Cisco 4451-X ISR Branch Office Router Performance Test



Source: Miercom, June 2013

The 4451-X ISR for both 1 GB and 2 GB licenses held line rate throughput with individual features enabled: IPv4 Forwarding, NAT, ACL, HQoS and ZBFW.

performance, facilitate network capacity management and planning, and reduce operating expenses.

Finally, Miercom tested Cisco WAAS, an integrated, cloud-ready WAN optimization and application acceleration service that is running the full-featured software natively on the Cisco 4451-X ISR. The number of optimized connections supported can be increased by adding the Cisco UCS E-Series server blade.

Router Throughput Tests

A series of five tests were conducted. The first utilized RFC 2544 standard baseline tests and involved enabling individual features, combinations of features and combinations of features and services. The tests calculated the frames per second (fps) that can be transmitted without error using IMIX.

The test bed for the first test included the Spirent TestCenter generating bi-directional traffic through a Cisco 4451-X ISR and a Cisco ASR 1002-X Aggregation Services Router typically deployed at a corporate data center.

There were two scenarios in this test, which simulated the experience of a network administrator receiving a new router. The first was that the router had only default options, no factory-installed configuration or software feature sets. The necessary feature sets were installed and activated manually or online using Cisco

Table 1: Throughput with Features and Solutions

Feature and Solution(s)	1 GB License (Mbps)	2 GB License (Mbps)
IPv4 Forwarding	1,050	2,000
NAT	1,050	2,000
ACL	1,050	2,000
HQoS	1,025	1,975
ZBFW	1,050	2,000
IPSec	900	1,625
NAT + ACL + HQoS + IPSec	800	1,400
NAT + IPSec (AES)	875	1,575
NAT + IPSec (AES) + WAAS	875	1,390
NAT + IPSec (AES) + AVC	348	610
NAT + IPSec (AES) + WAAS + AVC	325	610

Throughput in Mbps for 1G and 2G licenses with various features and solutions configured. Some IPSec test configurations used the AES.

License Manager. The other scenario assumed that the router was ordered with typical branch office features installed, such as NAT, ACL and HQoS, and pre-loaded with a customer-specified configuration using the Cisco Integrated Customization Service (CICS).

The ISR 4451-X was tested based on a typical branch configuration of the router. First, the following features were enabled one at a time; IPv4 Forwarding, NAT, ACL, HQoS, ZBFW and IPSec. Next, combinations of features were tested. Lastly, combinations of features and the Cisco solutions, AVC and WAAS, available with the ISR 4451-X were tested. See [Figure 1](#) on [page 1](#).

Testing was done using the Cisco 4451-X ISR with both a 2 Gbps license and a 1 Gbps license. The Cisco 4451-X ISR uses a dedicated, multi-core data plane processor to deliver stable, hardware accelerated throughput with services.

With HQoS enabled, traffic shaping was carried out. Miercom considers the Cisco 4451-X ISR to have maintained maximum throughput with HQoS enabled for both 1 GB and 2 GB configurations.

Throughput decreased when IPSec was enabled, to 900 Mbps for the 1 GB license and 1.625 Mbps for the 2 GB license.

Throughput remained stable when WAAS was tested with NAT and IPSec with Advanced Encryption Standard (AES) enabled. Throughput declined in both combinations of features and solutions that included AVC. See [Table 1](#) for more information on throughput.

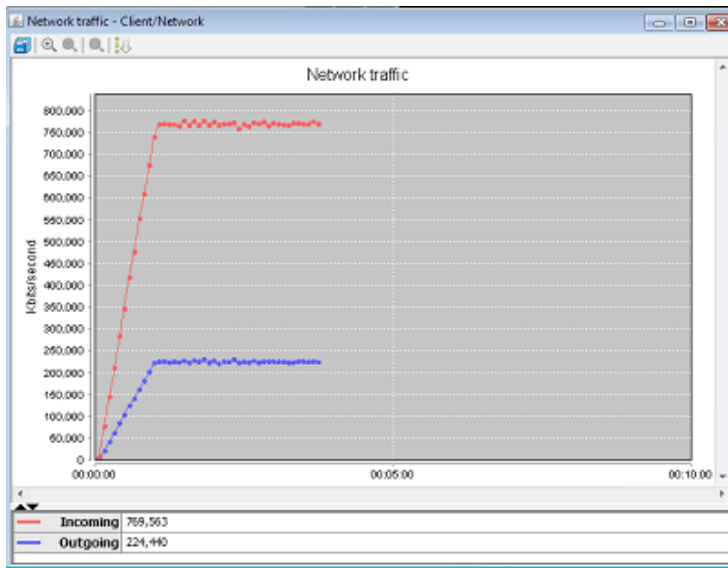
Application Visibility and Control Throughput

The objective of this test was to show the maximum throughput of the Cisco 4451-X ISR with AVC configured and activated.

A suite of Cisco solutions that is integrated with Cisco ASR 1000 Series Aggregation Services Routers and Cisco ISR for branch offices, AVC uses stateful, deep-packet inspection to identify, analyze and optimize more than 1,000 applications on the network, including Citrix, YouTube and Netflix. The availability of AVC on the router eliminates the need for adding probes into the network.

Network congestion can be reduced by controlling unwanted traffic. Enhanced application

Figure 2: Cisco 4451-X ISR AVC Throughput



Graphical results from the Spirent TestCenter of the Cisco 4451-X ISR throughput performance, which maintained a consistent 980 Mbps to 1 Gbps throughput with AVC configured and activated.

Source: Miercom, June 2013

performance can improve the experience and productivity of users.

A network administrator can quickly and easily activate AVC on Cisco ISRs in the network.

In the test, the Cisco 4451-X ISR maintained consistent 980 Mbps to 1 Gbps throughput with AVC configured and activated. See [Figure 2](#).

WAN Optimization

WAAS Easy Configuration The objective of this test was to show the ease and speed of deploying WAAS natively on the ISR 4451-X. The process was completed in 7 minutes with 3 simple steps.

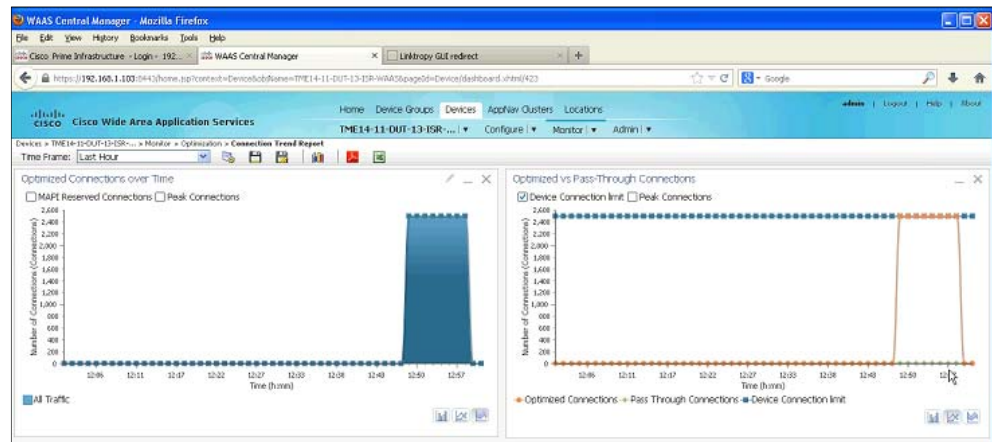
The following were selected in order: the WAAS image, the IP address of this instance of WAAS and the desired WAN interface.

The ISR 4451-X provided a configuration summary that can be modified before activation. The summary includes the IP address of the WAAS central manager, provided by DNS. After activation begins, the user can walk away. In this test, approximately 7 minutes was needed to get WAAS up and running, optimizing traffic. See screenshot in [Figure 4](#) on [page 4](#) for the WAAS Configuration Summary.

WAAS Maximum Connections The objective of the test was to sustain the maximum number of

The Cisco 4451-X ISR router could sustain the stated 2,500 connections without loss or dropped connection. The test results depicted here shows that the number of connections was increased in real time to 2,525 exceeding the stated maximum.

Figure 3: Cisco 4451-X ISR WAAS Maximum Connections



Source: Miercom, June 2013

Figure 4: Cisco 4451-X ISR EZConfig Tool

The 4451-X ISR has a configuration tool that allows for quick deployment of WAAS. The summary setup includes the IP address of the WAAS central manager, provided by DNS.

```
Enter additional WAN interface (blank to finish) []:
*****
** Configuration Summary: **
*****

a) WAAS Image and Profile Size:
bootFlash:/ISR4451X-WAAS-5.2.0-b9.ova (942100480) bytes
ISR-WAAS-750

b) Router IP/mask:
Using ip unnumbered from interface GigabitEthernet0/0/0

WAAS Service IP:
2.8.1.37

c) WAAS Central Manager:
2.8.90.100

d) Router WAN Interfaces:
GigabitEthernet0/0/0

Choose one of the letter from 'a-d' to edit, 'v' to view config script, 's' to apply config [s]:
The configuration will be applied and the status of the WAAS service will be displayed after deployment
.
.
.
WAAS service activated!
Note:Please issue "copy running-config startup-config" command to save changes!
```

Source: Miercom, June 2013

connections over time. In this test, we used HTTP connections, which can be short-lived. Therefore, the test was carried out by requesting 200 MB files from a Spirent Avalanche traffic generator to establish longer-lived HTTP connections and sustain them over time.

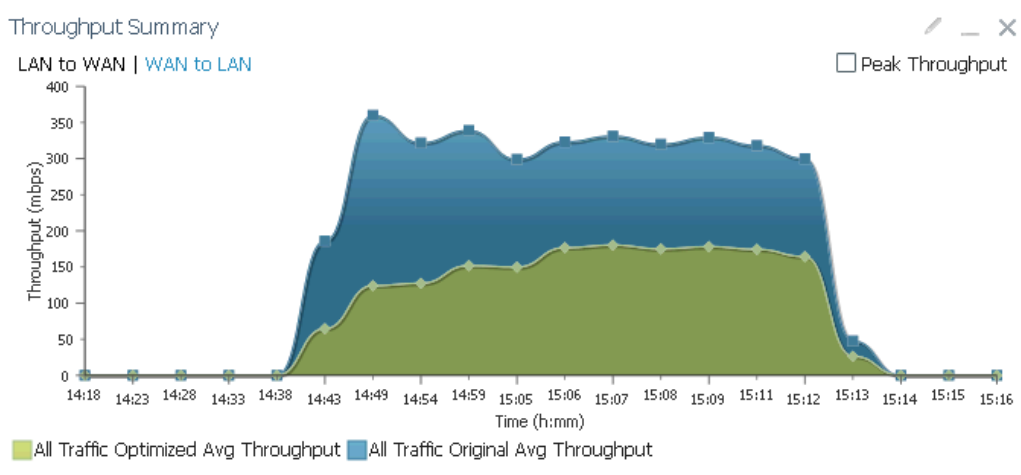
At the start of the test, there was one active connection. It took the Avalanche 100 seconds to ramp up to the maximum of 2,525 connections, as shown in Figure 3 on page 3. The maximum sustained capacity of the Cisco 4451-X ISR is 2,500 optimized connections. If the number of connections exceeds 2,500, there is no blocking, as the excess connections will go into pass-

through. Note that when the Cisco USC E-Series blade server is added, up to 6,000 optimized connections are supported.

As the Avalanche ramped up, it was possible to view the number of connections increasing in real time in the CLI of the 4451-X ISR. (The GUI of the Cisco WAAS Central Manager polls and then updates the number of connections every five minutes.)

Both types of traffic, original and optimized, were visible on the WAAS Central Manager. Original traffic was compressed by more than 99 percent, reducing throughput of up to 650 Mbps to an

Figure 5: Cisco 4451-X ISR WAAS Bandwidth Optimization

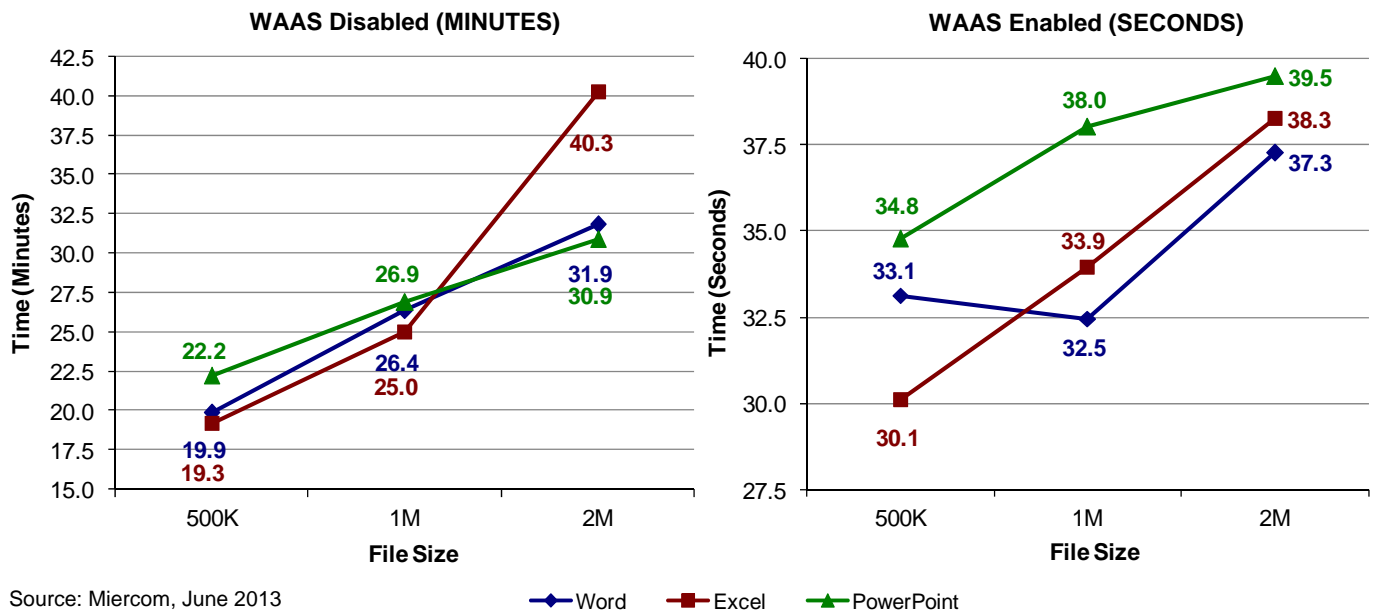


Source: Cisco, June 2013

Cisco 4451-X ISR demonstrated a reduction in bandwidth utilization with WAAS employed. LAN traffic is hovering around 325 Mbps (from Client to WAAS, unoptimized) and WAN traffic is around 175 Mbps (optimized traffic to the WAN).

The WAN throughput is over the advertised 150 Mbps optimized traffic.

Figure 6: Cisco 4451-X ISR WAAS Performance - Before and After Feature Enabled



The 4451-X ISR router dramatically improves MS Office response times over a congested WAN connection. Application functions that took tens of minutes before took only seconds after WAAS was enabled. This test was for all document types listed above and shows the reduction in time for opening, changing/saving, and then closing. The reduction in time between WAAS disabled and WAAS enabled was 97%.

extremely low level as shown in Figure 5 on page 4. Compression can increase to more than 400% without affecting any of the Layer 3 traffic.

Improving Application Experience with WAAS

The objective of this test was to measure and compare the time in seconds to perform three common actions in Word, PowerPoint and Excel files, with and without WAAS. First, the file was opened, a simple change was made and the file was saved. Lastly, the file was closed. The test simulated the experience of a user in a branch office accessing information from a corporate data center. File sizes ranged from 50KB to 2 MB. The total load was 11.3 MB. See charts in Figure 6 for more details on this test.

With WAAS disabled, it took tens of minutes to complete each step. With WAAS enabled, each step was completed in seconds.

For example, values were recorded using Cisco Wide Area File Services Benchmark (WAFS) for a 105.5KB Word file. With WAAS disabled, it took 340.81 seconds to open, 519.91 seconds to make the change and save, and 88.89 seconds to close. The total, 949.61 seconds, is nearly 16 minutes.

With WAAS enabled, the figures were 12.56 seconds to open, 16.52 seconds to make the change and save, and 2.67 seconds to close. The

total was just under 32 seconds. There was a 10-second delay built in before each document was saved, regardless of WAN optimization conditions. See Table 2.

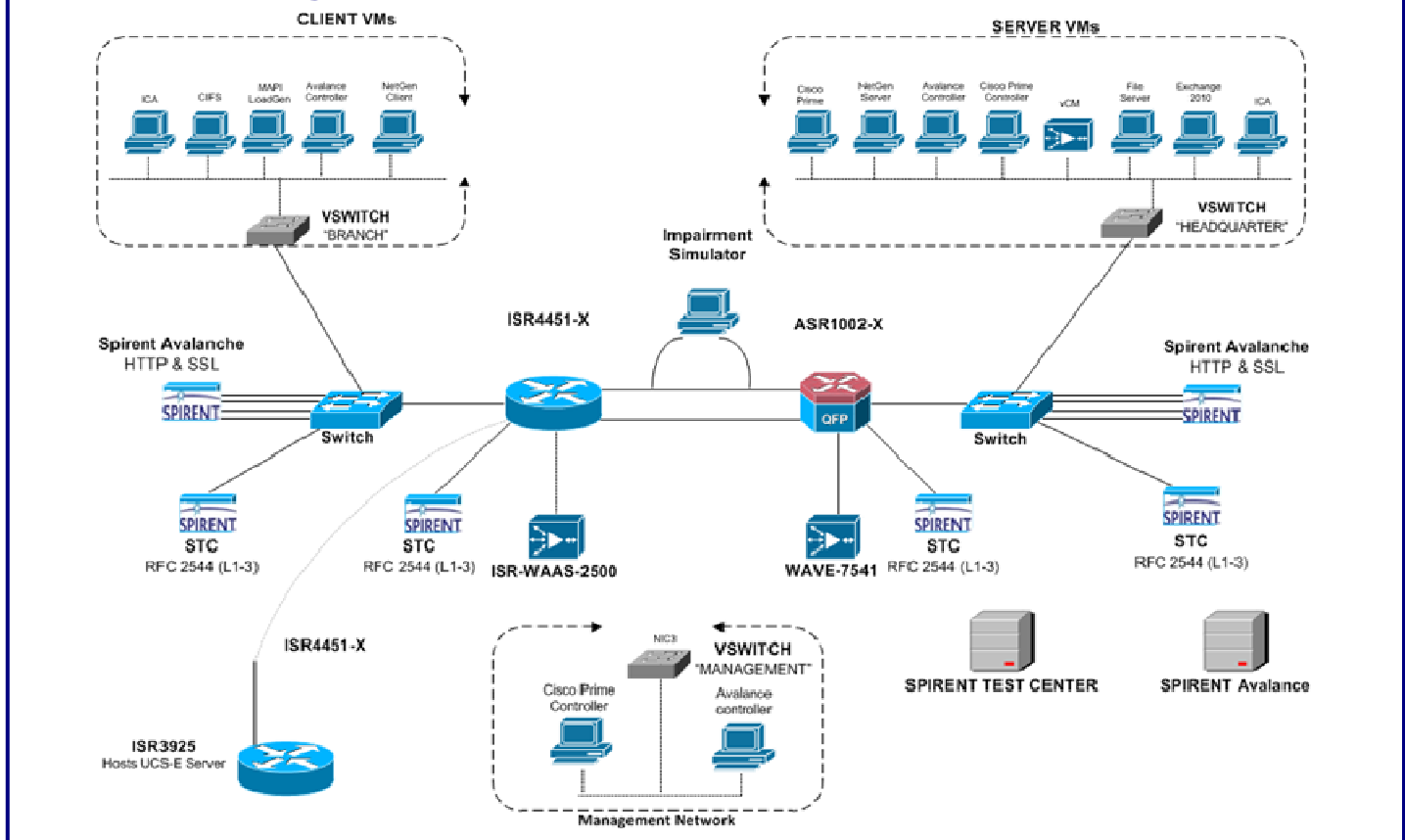
The results of this test show that with WAAS enabled on the Cisco 4451-X ISR, application performance to users in a branch office via the WAN can resemble LAN-like response time, enhancing end-user experience and productivity.

Table 2: File Actions with WAAS Disabled and Enabled, 100KB Word File

File actions	WAAS disabled (seconds)	WAAS enabled (seconds)
Open file	340.81	12.56
Make change and save file	519.91	16.52
Close file	88.89	2.67
Total	949.61	31.75

Time differences observed with common actions performed on a file with WAAS disabled and enabled. Note, the time reduction with WAAS enabled.

Test Bed Diagram



How We Did It

The Cisco 4451-X ISR for branch offices, running IOS-XE 3.10, was evaluated using Spirent TestCenter, Spirent Avalanche 3100A (v3.71), Aposuite Linktropy 5500 and Cisco NetFlow v9 for data collection.

In the RFC 2544 testing, traffic was generated by the Spirent TestCenter. Traffic consisted of IMIX packets, with built-in features and services enabled. All testing used a combination of a Cisco 4451-X ISR and a “branch” switch linked with an ASR 1002-X and a “headquarters” switch. A Spirent traffic generator was used to create bi-directional traffic.

WAAS ease of activation, maximum connections sustained and application performance to the branch office with the service enabled and disabled was evaluated. The WAAS tests also used the Aposuite Linktropy 5500 for WAN emulation. The Aposuite, as an impairment simulator, was configured to provide 200 Mbps of bandwidth with a constant delay of 100 milliseconds round-trip and packet loss of 0.1%.

Traffic generated by the Spirent Avalanche was sent to the Cisco 4451-X ISR, then subsequently sent using Flexible Netflow (FnF) to a Netflow collector for analysis and compilation of results.

The AVC configuration included Network Based Application Recognition version 2 (NBAR2) and three types of traffic monitoring – conversation, URL and application. NBAR2 carries out deep-packet inspection for application optimization. It identifies and analyzes more than 1,000 applications running on the network, including Citrix, YouTube and Netflix.

The tests in this report are intended to be reproducible for customers who wish to recreate them with the appropriate test and measurement equipment. Current or prospective customers interested in repeating these results may contact reviews@miercom.com for details on the configurations applied to the Device Under Test and test tools used in this evaluation. Miercom recommends customers conduct their own needs analysis study and test specifically for the expected environment for product deployment before making a product selection.

Miercom Performance Verified

Based on a performance review during testing, the Cisco 4451-X ISR has earned the Performance Verified award.

The 4451-X ISR provides a powerful single-box solution for a branch offices with stable, hardware accelerated maximum throughput of 2Gbps and full functionality including routing, security and QoS.

The 4451-X ISR has separate data, control and service processors to deliver a broad set of Layer 2-7 services natively on the router without any tradeoffs in performance, security and management.

The Cisco solutions available with the Cisco 4451-X ISR, AVC and WAAS, enhance the productivity and overall end-user experience in a branch office by facilitating access to centralized information on the network via a WAN connection.



4451-X ISR
Branch Office Router



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