

## Cisco Wide Area Application Services: Optimizing Third-Generation Wireless Networks

### What You Will Learn

As wireless networks become faster and more reliable, they provide a viable alternative to traditional wired WAN solutions, functioning either as primary access links or as backup links to wired services. Third-generation (3G) wireless solutions tend to be relatively low-cost and high-speed and are often available in areas where acquiring wired service may be difficult or impossible. However, 3G wireless is not without its shortcomings, which include relatively high latency, asymmetric bandwidth limits, and packet loss. This document demonstrates how to address some of these limitations through the use of Cisco® Wide Area Application Services (WAAS).

This document is based on a series of tests performed to gauge the performance characteristics of a 3G wireless connection before and after optimization using Cisco WAAS. Each test uses real-world data and real applications to demonstrate the improvement in overall user experience when the link is being optimized and accelerated. In all cases, substantial performance gains are experienced when Cisco WAAS is deployed over a 3G wireless link.

### Cisco WAAS Overview

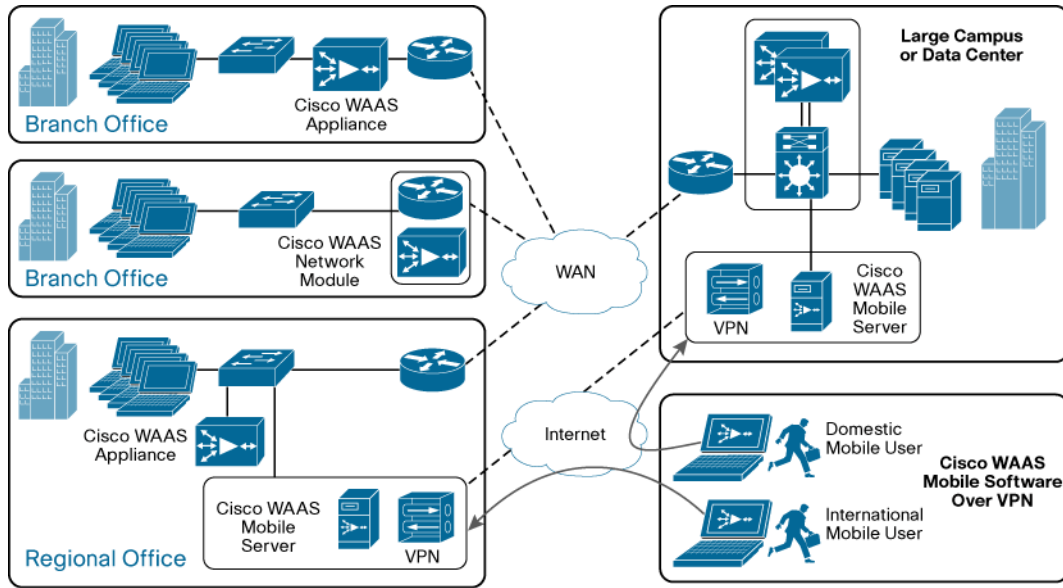
Cisco WAAS is an industry-leading, easy-to-use solution that couples application acceleration technologies with WAN optimization techniques to solve the application delivery dilemma, facilitating consolidation of distributed servers and storage, improving performance of already centralized services, and maintaining performance levels for services that are being centralized.

Cisco WAAS enables organizations to accomplish these primary IT objectives:

- Centralize applications and storage in the data center while maintaining LAN-like application performance
- Improve throughput and delivery of applications and application data to the enterprise edge to maintain or improve user productivity and efficiency
- More efficiently utilize existing WAN connections to mitigate the need for costly WAN bandwidth upgrades
- Enable locally hosted IT services while reducing overall floor space consumed by branch-office devices

Figure 1 shows a typical customer deployment using Cisco WAAS.

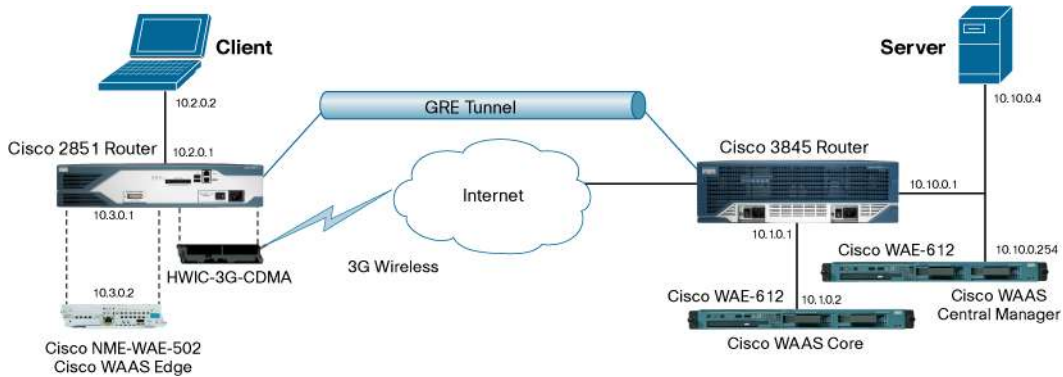
**Figure 1.** Cisco WAAS Deployment Architecture



**Test Topology**

The simplified network topology used for testing, shown in Figure 2, is based on a remote-site-to-core-site methodology. The remote site, on the left side of the figure, is made up of a Cisco 2851 Integrated Services Router that contains two modules: a network module (Cisco NME-502) running Cisco WAAS Software, and a 3G high-speed WAN interface card (HWIC), which provides wireless connectivity to the Internet. The router and its associated modules enable both wireless connectivity and WAN optimization to exist within a single chassis, reducing the overall connectivity footprint. A Microsoft Windows XP client is the final component of the remote site and will be the point from which all measurements are taken.

**Figure 2.** Network Test Topology



On the right side of the figure is the core site to which the remote site will be connecting. A Cisco 3845 Integrated Services Router provides Internet connectivity, though instead of modules, the core site uses a standalone Cisco WAAS appliance, a Cisco WAE-612 Wide Area Application Engine. A second Cisco WAE-612 running as a central manager provides management for both the core Cisco WAE and the Cisco NME at the remote site. Finally, a Microsoft Windows 2003 Server provides Common Internet File System (CIFS) file services, Microsoft Active Directory, FTP, HTTP, Domain Name System (DNS), and Network Time Protocol (NTP).

Connectivity between the two sites is simplified in the figure. The remote site has no physical connections outbound and relies on the HWIC to provide connectivity to the service provider's 3G wireless network. The service provider terminates the wireless component at a gateway and then routes traffic through the Internet to the WAN interface on the core site's router. Because the remote and core sites use private addressing, a generic routing encapsulation (GRE) tunnel is established between the two routers to encapsulate the traffic going across the Internet.

Traffic flows from the client to the remote router, which is running Web Cache Communication Protocol Version 2 (WCCPv2) to intercept all TCP traffic and send it to the Cisco WAAS module. Traffic is optimized and then sent across the WAN link to the core router, which also uses WCCPv2 to intercept the optimized traffic and send it to the Cisco WAE on that side. The Cisco WAE on the core side deoptimizes the traffic and sends it to the server. Data coming back from the server follows the reverse path, and the cycle begins again.

In a real-world scenario, security would be of concern, so some kind of encryption should be added to the tunnel. This can be performed either by the routers, using IP Security (IPsec) on the GRE interfaces, or through the use of an external VPN solution that sits between the two Cisco WAAS devices.

The routers on each side are running Cisco IOS® Software Release 12.4(15)T7 and Cisco WAAS Software Version 4.1.1

## Test Methodology

Each test is performed three times:

- A baseline test is run with WCCP disabled so that no traffic goes to Cisco WAAS, and thus no optimization occurs.
- Next, WCCP is enabled, the caches on the Cisco WAAS devices are cleared, and the test is run again against these "cold" (empty) caches. This test shows the performance gain from TCP optimizations and compression on files that have not passed through the Cisco WAAS devices previously.
- Finally, a test is performed using the same file set, but without clearing the Cisco WAAS cache beforehand. This is a "warm" hit test, in which much or all of the data can be retrieved locally instead of having to go over the WAN link.

For all the tests, a file set made up of Microsoft Word, PowerPoint, and Excel files of different sizes is used. Additionally, for some of the tests, a compressed 5.5-MB file (Zip format) is added to show how compressed files are handled. Table 1 summarizes the file set.

**Table 1.** Test File Set

Size	Filename
112,640	100K.ppt
1,006,592	1M.doc
1,054,720	1M.xls
218,112	200K.ppt
2,055,168	2M.doc
2,108,928	2M.xls
524,800	500K.ppt
57,344	50K.doc
53,248	50K.xls
108,032	100K.doc
105,472	100K.xls
1,100,288	1M.ppt

Size	Filename
219,136	200K.doc
222,208	200K.xls
1,960,448	2M.ppt
513,024	500K.doc
468,480	500K.xls
48,640	50K.ppt
5,642,167	5M.zip
17,579,447 bytes	18 files

For test details, see the test descriptions and results that follow.

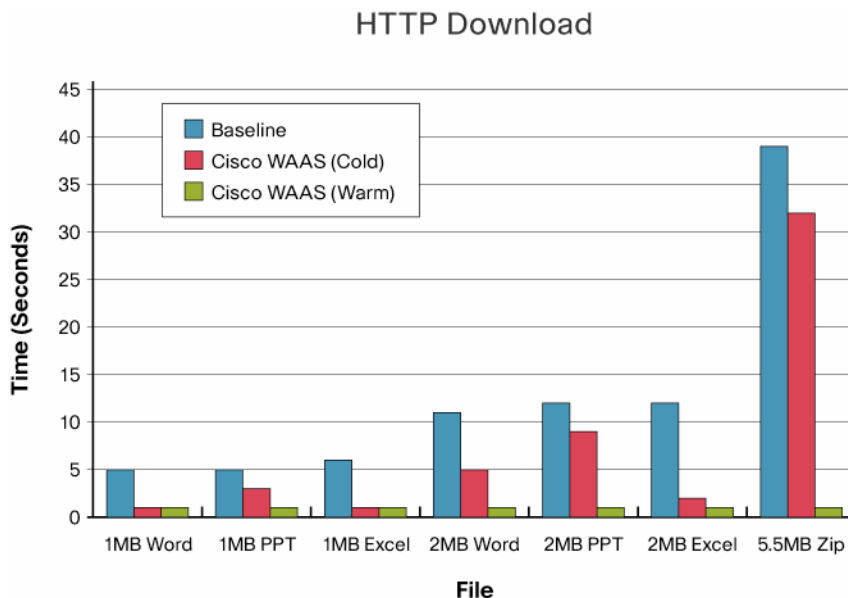
### Test 1: HTTP Download

The first test is a simple download of a set of files (described in the preceding section) using Microsoft Internet Explorer. Each file was downloaded individually from a webpage containing links, so each download required a new session setup and teardown. Average round-trip time (RTT) during this test was 146 milliseconds (ms). Table 2 and Figure 3 summarize the results.

**Table 2.** Test 1 Data

File	Baseline (Seconds)	Cisco WAAS (Cold)	Cisco WAAS (Warm)
1-MB Word	5	1	1
1-MB PowerPoint	5	3	1
1-MB Excel	6	1	1
2-MB Word	11	5	1
2-MB PowerPoint	12	9	1
2-MB Excel	12	2	1
5.5-MB Zip	39	32	1

**Figure 3.** Test 1 Optimization Results



In all cases, Cisco WAAS improves performance by a significant amount. Files that are heavily compressible, such as Microsoft Word and Excel documents, show the most improvement, while even heavily compressed files like the Zip file show improvement due to the TCP optimizations being used. The warm tests are all served directly from the cache because the file has not changed, which allows the local Cisco NME to serve data at LAN speeds instead of having to transfer data over the WAN.

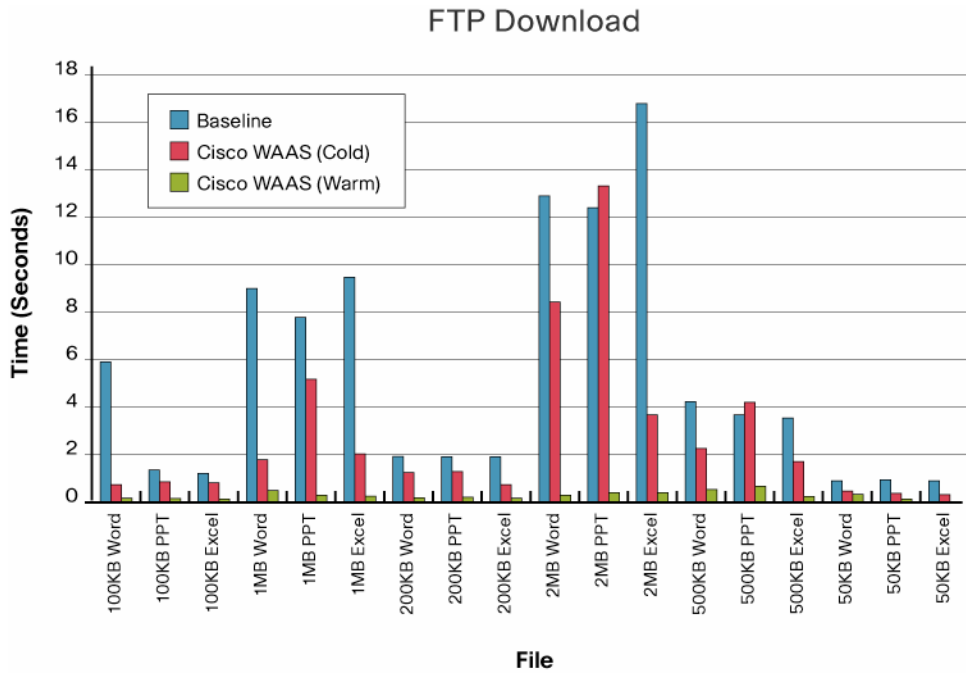
## Test 2: FTP Download

Like the first test, the second test is a simple download speed test, but this time using FTP as the protocol. A similar (though slightly expanded) file set is used in this example, and the average RTT during the test was 153 ms. Results are slightly more detailed because of the client being used, which can work in hundredths of a second (Table 3 and Figure 4).

**Table 3.** Test 2 Data

File	Baseline (Seconds)	Cisco WAAS (Cold)	Cisco WAAS (Warm)
100-KB Word	5.89	0.72	0.16
100-KB PowerPoint	1.34	0.84	0.14
100-KB Excel	1.2	0.8	0.11
1-MB Word	8.98	1.78	0.48
1-MB PowerPoint	7.77	5.16	0.27
1-MB Excel	9.45	2.02	0.23
200-KB Word	1.91	1.24	0.17
200-KB PowerPoint	1.89	1.27	0.19
200-KB Excel	1.89	0.72	0.16
2-MB Word	12.88	8.41	0.28
2-MB PowerPoint	12.39	13.31	0.39
2-MB Excel	16.77	3.66	0.38
500-KB Word	4.22	2.25	0.52
500-KB PowerPoint	3.67	4.19	0.66
500-KB Excel	3.53	1.69	0.22
50-KB Word	0.89	0.45	0.32
50-KB PowerPoint	0.92	0.36	0.11
50-KB Excel	0.89	0.3	0.13

Figure 4. Test 2 Optimization Results



Like HTTP, FTP shows an improvement in nearly all cases in a cold-cache condition, and dramatic improvement in a warm-cache condition. The exceptions in this case are the two Microsoft PowerPoint files that show slightly longer download times for the cold-cache run. Although Microsoft PowerPoint files do not tend to be as compressible as other files in other formats, this behavior here may just be due to packet loss on the network at that moment. As before, all warm-cache hits are served directly from the remote Cisco NME.

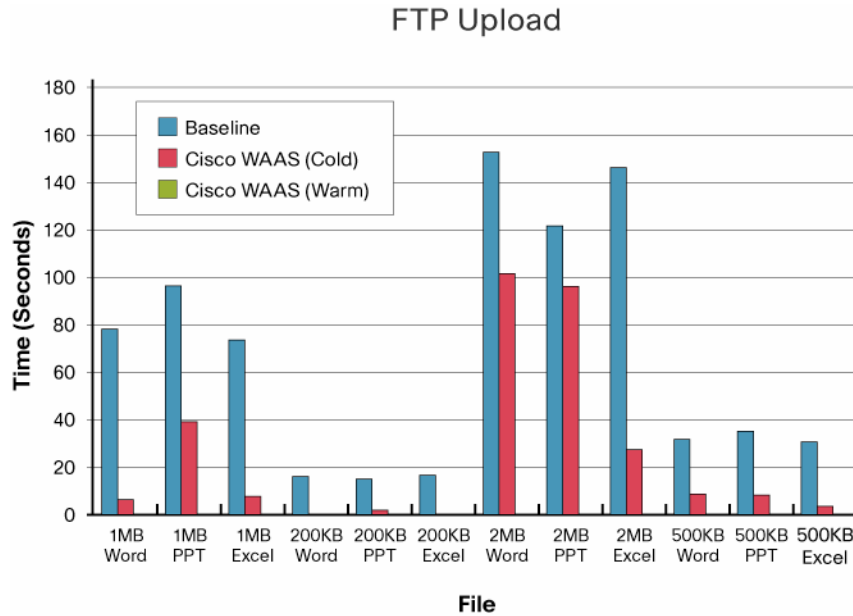
**Test 3: FTP Upload**

Because 3G wireless networks use asymmetric bandwidth limits, it is important to test traffic in each direction. The download speed can be many times faster than the upload speed, and because the duration of transfers is longer, data is more likely to experience packet loss. The upload test uses the same file set as the prior download test, minus some of the smaller files, and was performed with the network exhibiting an average RTT of 156 ms (Table 4 and Figure 5).

Table 4. Test 3 Data

File	Baseline (Seconds)	Cisco WAAS (Cold)	Cisco WAAS (Warm)
1-MB Word	78.2	6.36	0.08
1-MB PowerPoint	96.48	39.16	0.09
1-MB Excel	73.66	7.77	0.13
200-KB Word	16.08	0.03	0.02
200-KB PowerPoint	15.02	1.91	0.02
200-KB Excel	16.59	0.03	0.02
2-MB Word	152.75	101.55	0.17
2-MB PowerPoint	121.69	96.17	0.16
2-MB Excel	146.22	27.38	0.19
500-KB Word	31.77	8.67	0.03
500-KB PowerPoint	35.16	8.23	0.03
500-KB Excel	30.69	3.5	0.05

Figure 5. Test 3 Optimization Results

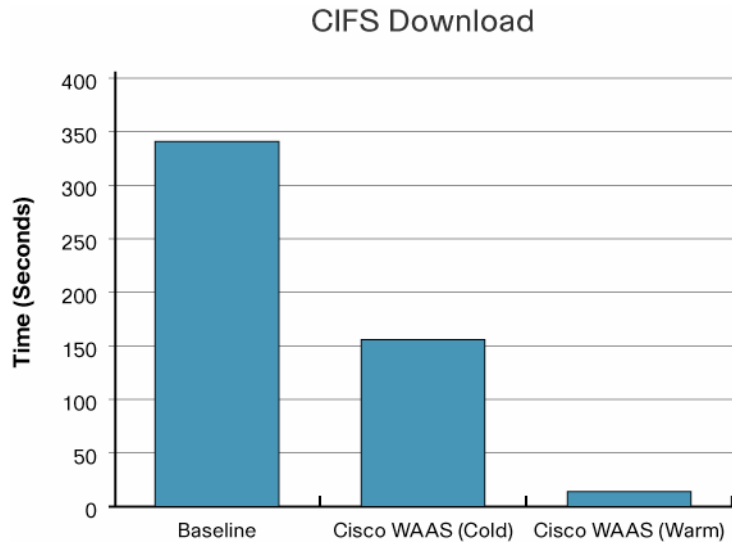
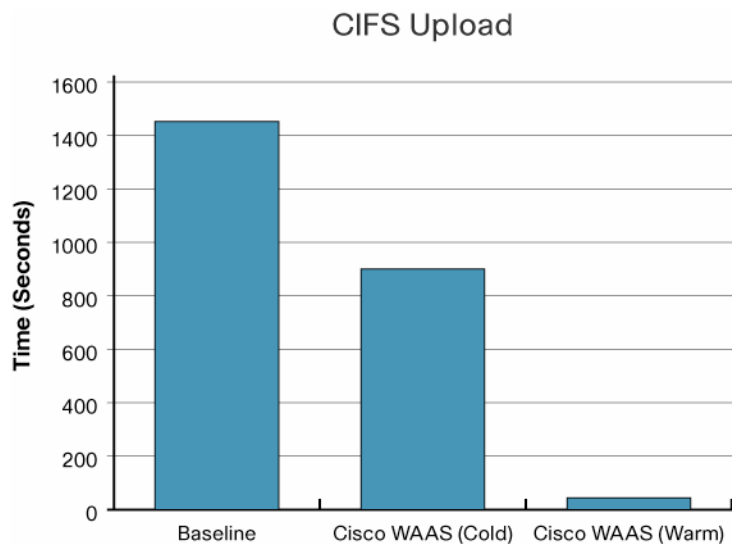


The upload results show consistently higher performance in all cases, with substantial improvement in most cases. The 2-MB Microsoft Excel file, for example, is transferred in 27 seconds with Cisco WAAS as opposed to 146 seconds without Cisco WAAS.

#### Test 4: CIFS Download and Upload

The file set used in Test 4 is the same one used in Test 1, totaling about 20 MB. The client mounts a share from the server as a drive and then copies the files using Microsoft Windows Explorer from the mapped drive to a local directory. CIFS is important to test because of the way it operates and its potential inefficiency across a WAN link. In this environment, all CIFS authentication is performed using Kerberos on Microsoft Active Directory, and everything—from the initial session setup to the file security descriptor queries—must go over the WAN link to Microsoft Active Directory. Part of what makes Cisco WAAS effective is its ability to reduce the number of messaging packets that need to traverse the WAN link. In this case, the main concern is often latency, rather than lack of bandwidth, because of the number of control messages involved.

Rather than looking at individual files, this test looks at the group of files in its entirety. First is a download test and then is an upload test, again to deal with the different upload and download speeds. For the download test, the average RTT was 151 ms (Figure 6), and for the upload test, the average RTT was 154 ms (Figure 7).

**Figure 6.** Test 4 Optimization Results: Download**Figure 7.** Test 4 Optimization Results: Upload

Again, the difference between uplink and downlink speeds is very apparent, but Cisco WAAS achieves significant improvement in both directions.

### Test 5: CIFS File Open

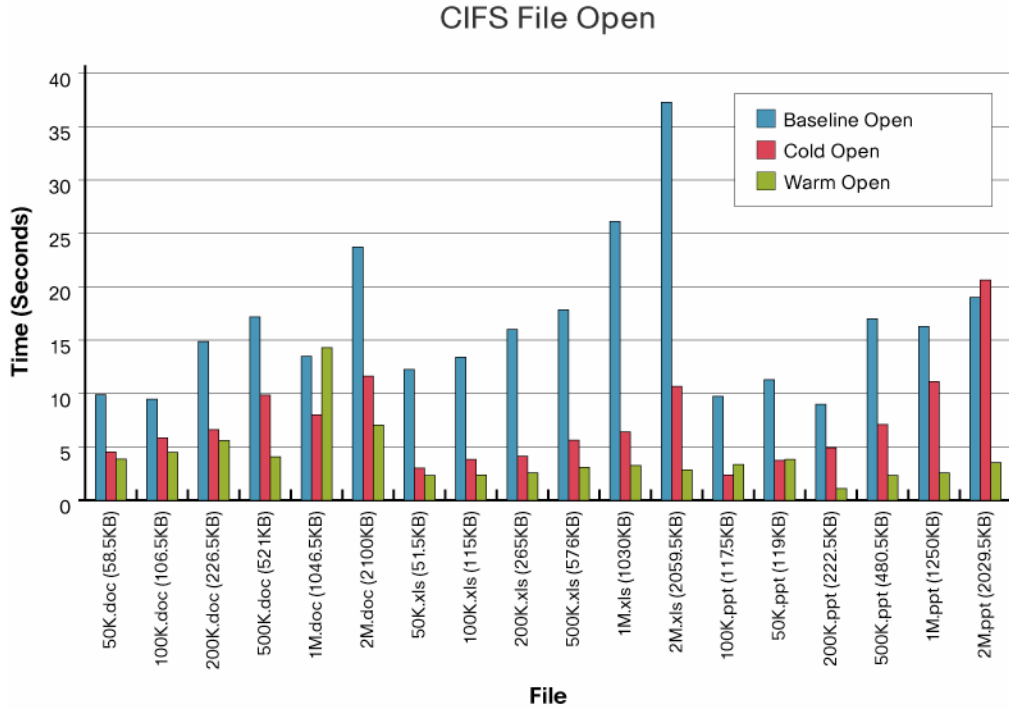
The previous four tests assess raw file transfer speed, which is useful for some situations but can have little to do with the way applications behave when accessing files over the WAN. A file copy operation simply checks whether the user has access to the file, and then transfers the associated file. An application generally has more work to do, particularly when dealing with locks on a file.

For this test, the automated Cisco Wide Area File Services Software (WAFS) Benchmark Tool was used to generate the results. This tool is a kind of script that uses a real data set (which happens to be the same set of files used in the other tests) along with Microsoft Office applications to perform file operations in a real-world way. The tool is freely available in the Cisco WAAS Software Download section at <http://www.cisco.com>.



The first test is a file open test, in which the application is started, and the file (Microsoft PowerPoint, Excel, or Word) is opened within the application. The timer stops when the file is completely open and editable by the application (Figure 8).

**Figure 8.** Test 5 Optimization Results



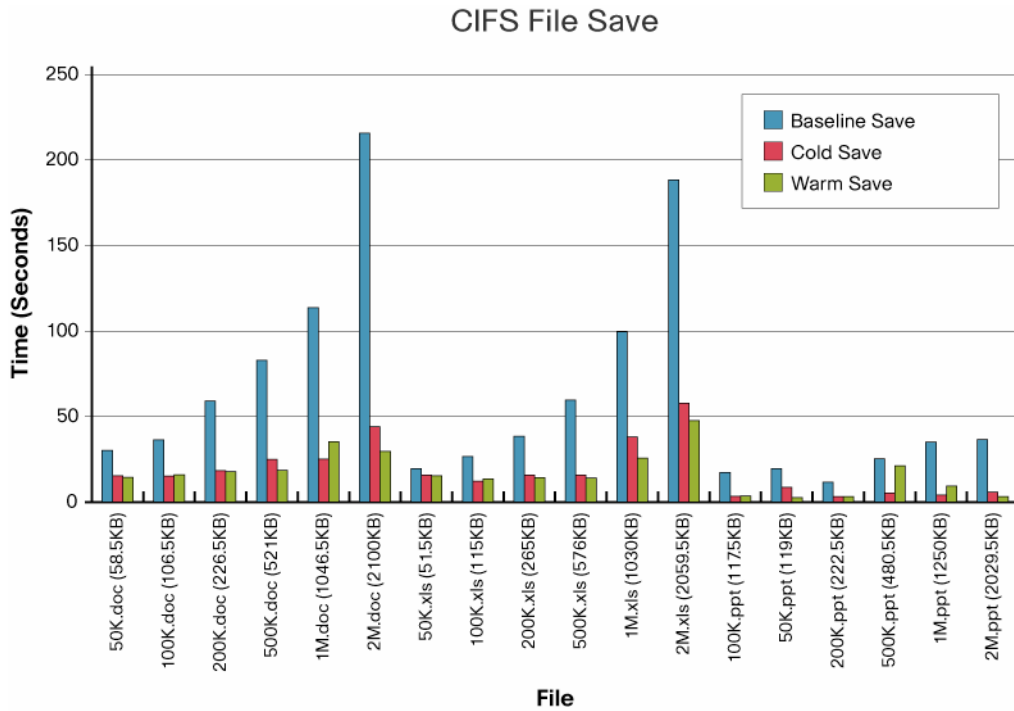
These results are in some ways more interesting than the raw file transfers in that they show more variability, particularly for the warm-cache hits. With only a few exceptions, the cold-cache results are improved, as expected based on the prior tests. The warm-cache tests, however, show how the applications are accessing the files. While the direct file transfers only have to check to validate access to a file, applications like those in Microsoft Office do a little more work, particularly when locking a file for editing, so while there is still a big difference between cached and noncached content, more activity over the WAN back to Microsoft Active Directory occurs.

**Test 6: CIFS File Save**

The other test that the Cisco WAFS Benchmark Tool performs modifies and saves a file. Microsoft Office applications work by writing to a temporary file first, usually in the format ~wrdxxxx.doc, and then after the write is complete, replacing the original file with the temporary file. This behavior means that the written file is transferred back over the WAN link in its entirety, and all the associated CIFS operations need to be performed to create, rename, and delete the temporary file.

In this test, after the file is opened, Cisco WAFS tells the application (Word, Excel, or PowerPoint) to add a line to a file, and then it saves that file, measuring the time it takes to do so (Figure 9).

Figure 9. Test 6 Optimization Results



Again, application behavior results in variability of performance, because while cached data does not need to be transferred over the WAN, all the file operations do, so as to maintain the integrity of the data. In some cases, this behavior means that the file write operation from the Cisco WAE back to the server happens almost instantaneously, but the acknowledgements and security descriptor sets take time to traverse the WAN link. This test provides another example of instances in which latency can be a much bigger factor than bandwidth. However, Cisco WAAS shows substantial improvement over the baseline results in all cases.

Table 5 shows the raw data for these tests (all results in seconds).

Table 5. Raw Data for All Test Results

File	Baseline Open	Baseline Save	Cold Open	Cold Save	Warm Open	Warm Save
50K.doc (58.5KB)	9.905	30.203	4.532	15.484	3.859	14.578
100K.doc (106.5KB)	9.484	36.5	5.844	15.219	4.5	16.016
200K.doc (226.5KB)	14.859	59.203	6.609	18.375	5.61	17.907
500K.doc (521KB)	17.173	83.032	9.875	25.032	4.078	18.562
1M.doc (1046.5KB)	13.485	113.766	7.999	25.14	14.312	35.312
2M.doc (2100KB)	23.734	215.625	11.625	44.14	7.032	29.672
50K.xls (51.5KB)	12.25	19.547	3.015	15.859	2.328	15.406
100K.xls (115KB)	13.39	26.703	3.829	12.25	2.36	13.61
200K.xls (265KB)	16	38.515	4.141	15.75	2.578	14.407
500K.xls (576KB)	17.828	59.781	5.641	15.75	3.094	14.078
1M.xls (1030KB)	26.126	99.579	6.407	38.109	3.265	25.766
2M.xls (2059.5KB)	37.296	188.297	10.657	57.922	2.845	47.657
100K.ppt (117.5KB)	9.75	17.375	2.376	3.375	3.36	3.578
50K.ppt (119KB)	11.312	19.625	3.734	8.781	3.844	2.719
200K.ppt (222.5KB)	8.984	11.703	4.905	3.219	1.094	3.297
500K.ppt (480.5KB)	17.016	25.344	7.11	5.375	2.328	21.265

File	Baseline Open	Baseline Save	Cold Open	Cold Save	Warm Open	Warm Save
1M.ppt (1250KB)	16.28	35.172	11.125	4.156	2.563	9.484
2M.ppt (2029.5KB)	19.016	36.734	20.64	5.984	3.531	3.328

## Conclusion

3G wireless networks represent a viable solution for branch-office connectivity, but the technology has inherent limitations that can be mitigated through the use of WAN optimization technologies such as Cisco WAAS. Through the use of TCP optimization, compression, caching, and application optimization, Cisco WAAS provides a greatly improved user experience for remote offices and can be deployed in a small, integrated footprint at those sites.

## For More Information

Cisco Application Networking Services: <http://www.cisco.com/go/applicationservices>

Cisco Application Networking partner portal: <http://www.cisco.com/go/optimizemyapp>

Cisco WAAS Software product information: <http://www.cisco.com/go/waas>



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