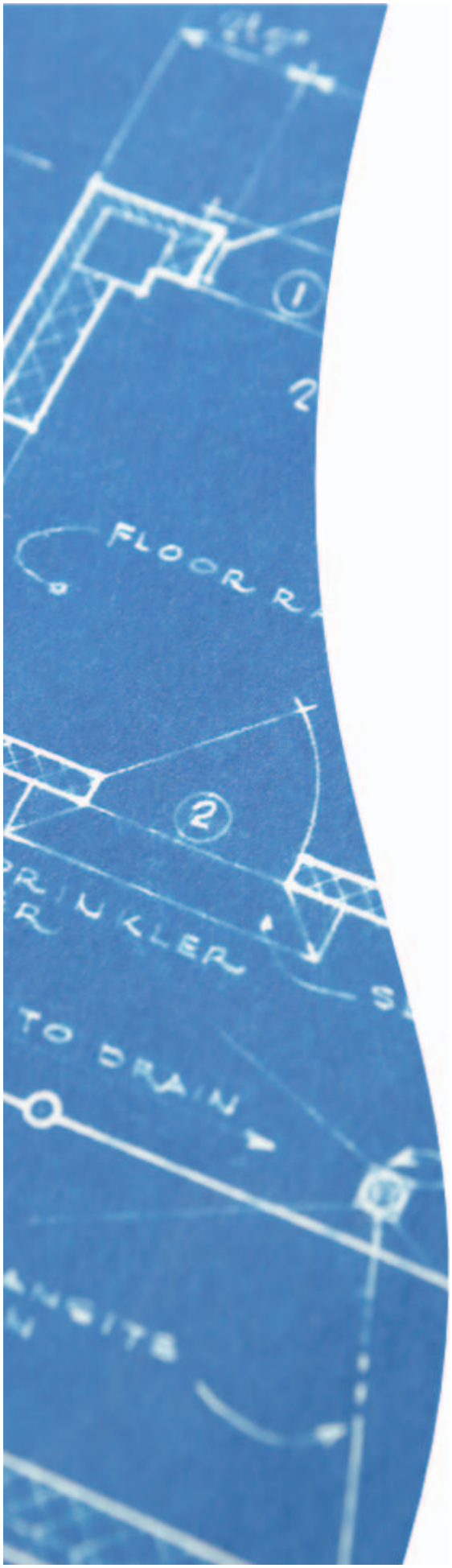

TUNING SYMANTEC BRIGHTMAIL ANTISPAM ON ULTRASPARC® T1 AND T2 PROCESSOR-POWERED SERVERS

Alan Yoshida, Sun ISV Engineering
Ramin Moazeni, Sun ISV Engineering
Steve Gaede, PointSource Communications

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Tuning Symantec Brightmail AntiSpam on UltraSPARC® T1 and T2 Processor-Powered Servers

Electronic mail is a business-critical function in virtually every enterprise, and it is also one that is under constant attack. Well-known viruses such as Melissa, and worms like SoBig have propagated through email and have disrupted user PCs and corporate networks worldwide. Fraudulent email messages find their ways into inboxes and tempt unsuspecting users into divulging personal information at phishing sites. As companies recognize that their intellectual property can easily leave their premises through email messages, filtering outbound and internal messages is becoming as important as protecting an organization from incoming traffic.

No email problem is more troublesome or visible, however, than unsolicited bulk email, commonly known as *spam*. Spam can have a huge impact on employee productivity, and because it also can serve as a vehicle to deliver malicious content including viruses, worms, and phishing attacks, many organizations tackle the spam problem as a first step in implementing a comprehensive email security strategy.

In recent years, the volume of spam has risen to epidemic proportions. Although estimates of the ratio of spam to legitimate email vary, it is widely agreed that it makes up at least 50 percent of email traffic today. This presents a particular challenge to anti-spam software. It must be intelligent enough to filter out a very high percentage of spam, while leaving virtually all legitimate email messages intact. As spammers continue to invent techniques in hopes of circumventing anti-spam software, the intelligence of anti-spam technology — and the processing power needed to detect and eliminate it — must stay ahead.

A Potent Combination of Technologies

The combination of Symantec Brightmail AntiSpam (SBAS) software and the UltraSPARC® T1 and T2 processors is particularly well suited to the demanding task of spam filtering: The UltraSPARC T1 and T2 processors are built to handle highly threaded, network throughput oriented applications, and Symantec Brightmail AntiSpam just such an application.

Symantec Brightmail AntiSpam

Symantec Brightmail AntiSpam works in conjunction with an enterprise Message Transfer Agent (MTA) such as the Sun Java™ System Messaging Server to analyze each incoming message and determine whether it should be classified as spam. SBAS uses standard methods such as heuristics and pattern matching, augmented with proprietary filtering methods including advanced signature technologies and

reputation-based source filters updated in real-time as Symantec analyzes and prepares countermeasures based on observations of current spam traffic.

UltraSPARC T1 and T2 Processors

In order to process large volumes of spam without impacting the throughput of an enterprise MTA, multiple messages must be processed concurrently — and concurrent processing of multiple threads is where the UltraSPARC T1 and T2 processors excel. The UltraSPARC T1 and T2 processors with CoolThreads™ technology are multi-core processors that utilize Chip Multi-Threading (CMT) to handle multiple threads concurrently, giving a significant performance advantage over typical single-threaded processors. The UltraSPARC T1 processor is available with up to eight cores and the ability to handle up to 32 threads concurrently. The UltraSPARC T2 processor is available with up to 8 cores and are able to handle up to 64 threads concurrently.

Delivering High Mail Filtering Performance

The performance advantage of running highly multithreaded software such as SBAS is so great that, out-of-the-box, with no tuning, Brightmail on a Sun Fire™ / Sun SPARC® Enterprise T2000 server with a single eight-core UltraSPARC T1 processor outperforms a Sun Fire V240 with two single-threaded UltraSPARC processors by more than 50 percent.

In order to best take advantage of the advantages of the CMT capabilities of the UltraSPARC T1 and T2 processors, administrators should make some relatively simple tuning adjustments to SBAS software. The result of taking the simple steps described in this Sun BluePrints™ article yielded a 5.2x improvement over the same installation with no tuning. Performing the same set of tuning steps on a Sun SPARC Enterprise T5120 server yielded an additional 2.33x performance improvement over the Sun Fire / Sun SPARC Enterprise T2000 server.

This Sun BluePrints article provides background information on SBAS software and UltraSPARC T1 and T2 processor-powered servers, the configurations used for performance measurements, the challenges presented by benchmarking anti-spam software, and the actual steps used to tune the hardware/software combination to achieve the reported performance levels. This article was originally published in October 2006 and reflected performance on the Sun Fire / Sun SPARC Enterprise T2000 server. It has been updated to reflect more recent measurements comparing a Sun Fire / Sun SPARC Enterprise T1000 server to a Sun SPARC Enterprise T5120 server using virtually the same tuning parameters.

How this Article is Organized

This Sun BluePrints article is organized into the following sections:

- “A Unique Match of Technologies” on page 3 describes SBAS and UltraSPARC T1 and T2 processor-powered servers.

- "Test Configuration" on page 5 describes the software and hardware configuration used to measure SBAS performance during the tuning effort.
- "Your Mileage May Vary" on page 7 discusses the differences between the test configuration and the real-world situations in which SBAS will be installed, and why different customers may observe different performance.
- "Tuning SBAS on the Sun Fire / Sun SPARC Enterprise T2000 Server" on page 9 details the steps that were taken in order to achieve the initial 5.2x speedup over the server's out-of-the-box configuration.
- "Measuring SBAS on th1e Sun SPARC Enterprise T5120 Server" on page 11 describes the additional 2.33x speedup that was obtained when comparing UltraSPARC T1 and T2 processor-powered severs.
- "Summary" on page 11 provides a recap of the results and how UltraSPARC T1 and T2 processor-powered servers are able to deliver outstanding performance.

A Unique Match of Technologies

The UltraSPARC T1 and T2 processors and SBAS software is a unique match of technologies. SBAS owes its accuracy to the sophisticated rules and heuristics used to detect and eliminate spam. In order to achieve this level of accuracy, the software requires significant CPU time to evaluate each incoming email. At a time when most Information Technology (IT) organizations are striving to deploy ever more applications in data centers that are often at the limit in terms of space, power, and cooling capacity, the servers based on the UltraSPARC T1 and T2 processors offer refreshing new options. Designed for highly multithreaded, network throughput-intensive applications, the servers based on these processors deliver high performance and low power consumption in the same space-efficient and cost-effective package.

UltraSPARC T1 and T2 Processor-Powered Servers

More specific details on Sun's UltraSPARC T1 and T2 processor-powered servers are available at *http://www.sun.com/coolthreads*.

Unlike traditional single-threaded processors, the UltraSPARC T1 and T2 processors are designed to support multiple threads per processor core, with the ability to rapidly switch between active threads as other threads stall waiting for memory requests to be fulfilled. Sun's CMT approach enables each processor core to switch among multiple active threads on each clock cycle. The result is a processor pipeline that is active doing useful work a higher percentage of the time, resulting in both excellent performance and lower power consumption for the amount of work done.

An additional source of these processors' energy efficiency is that they share some functional units on a per-processor and a per-core basis. While the UltraSPARC T1 processor shares, for example, single cryptographic processing unit on each processor, the UltraSPARC T2 processor shares a much more capable cryptographic processing unit per processor core. In addition, the UltraSPARC T2 processor is the first to integrate 10 Gbps Ethernet, PCI Express I/O directly onto the processor chip. This approach speeds the flow of I/O from memory through multiple DMA channels.

The UltraSPARC T1 processor is available with four, six, or eight cores, each of which can handle four concurrent threads for a total of 32 threads per processor. The UltraSPARC T2 processor is available with six or eight cores, each of which can handle eight concurrent threads for a total of 64 threads per processor. Sun offers a set of rack-mount server and blade products based on each processor.

UltraSPARC T1 Processor-Powered Servers

The Sun Fire / Sun SPARC Enterprise T1000 and T2000 servers are based on the UltraSPARC T1 processor. The two servers have very similar system architectures that suggest that they will deliver similar SBAS performance given identical configurations. The two servers differ mostly in their I/O and disk storage capacity: The Sun Fire / Sun SPARC Enterprise T1000 server supports up to two internal disk drives, and it has one PCI Express expansion slot. The Sun Fire / Sun SPARC Enterprise T2000 server supports up to four internal disk drives and it has three PCI Express and two low-profile PCI-X expansion slots. Both servers support up to 32 GB of main memory.

For organizations using blade servers, the Sun Blade T6300 Server Module supports up to four internal disk drives, a high degree of I/O flexibility through the Sun Blade 6000 Modular System chassis, and up to 32 GB of memory.

UltraSPARC T2 Processor-Powered Servers

The Sun SPARC Enterprise T5120 and T5220 servers are based on the UltraSPARC T2 processor. The two servers also have similar system architectures that suggest they will also deliver similar SBAS performance given identical configurations. The Sun SPARC Enterprise T5120 server supports up to four internal disk drives and offers one x8 PCI Express and two x4 PCI Express or XAUI combo slots. The Sun SPARC Enterprise T5220 server supports up to eight internal disk drives, two x8 and two x4 PCI Express slots and two x4 PCI Express or XAUI combo slots. Both servers support up to 64 GB of main memory.

The Sun Blade T6320 Server Module supports up to four internal disk drives, and utilizes the Sun Blade 6000 Modular System's flexible I/O subsystem. The server module can support up to 64 GB of main memory.

Symantec Brightmail AntiSpam

Symantec Brightmail AntiSpam provides complete server-side anti-spam and anti-virus protection. It processes incoming email traffic, identifying, analyzing, and discarding spam and virus attacks before they inconvenience users and overwhelm internal networks and email clients. SBAS runs each incoming email message through a gauntlet of filters designed to eliminate more than 95 percent of spam with an accuracy of 99.9999 percent — meaning that fewer than one false positive will occur in 1 million email messages. This high level of effectiveness along with pinpoint accuracy helps ensure that users continue to receive the legitimate email messages they need,

while keeping the vast majority of spam and virus-laden emails from ever reaching their inboxes.

SBAS uses a combination of filtering technologies, some of which are optional and can be configured by on-site administrators, and the majority of which are created by Symantec and updated on a minute-by-minute basis through a secure connection to one of Symantec's worldwide global operations centers. The types of filters are illustrated in Figure 1, with optional, locally-defined filters in orange. The remaining filters are managed and maintained by Symantec, and updated based on constant monitoring of special trap accounts strategically located on the Internet. Once an email has been reviewed and assigned a spam classification, it can be delivered normally, delivered with modified headers, deleted, delivered to the recipient's spam folder, saved or forwarded for administrator review, or quarantined to a Web-based interface where users can view caught spam.

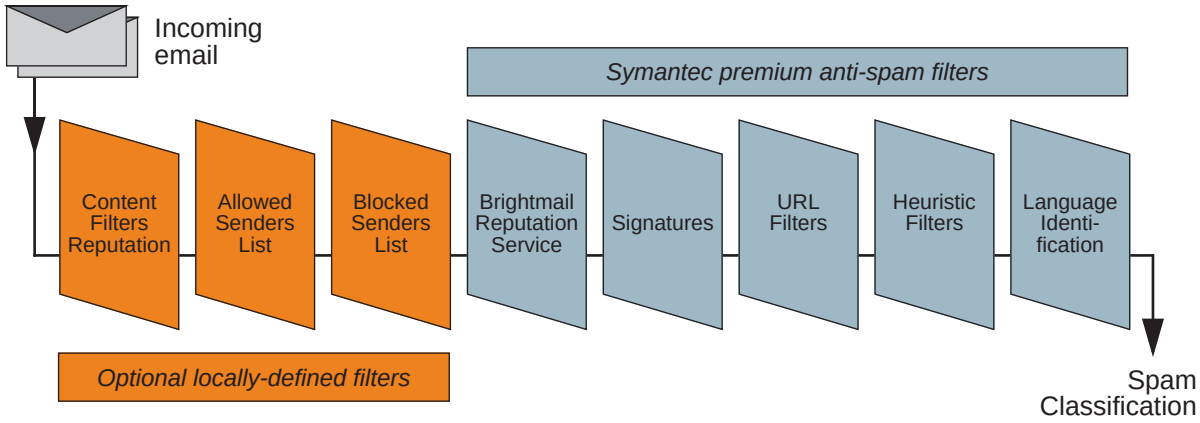


Figure 1. SBAS runs each email message through a gauntlet of filters, resulting in a spam classification that determines the disposition of each message.

Test Configuration

SBAS integrates with MTAs including the Java System Messaging Server, Sendmail, Microsoft Exchange, and Lotus Notes. A typical deployment scenario places SBAS on a gateway system, filtering all incoming email and transferring the filtered email to a layer of MTAs for local mail delivery. The software is flexible and scalable enough that it can be deployed in scenarios ranging from integrating with a single, central MTA, to one in which a high-availability, load-balanced group of MTAs process messages in parallel.

SBAS integrates with MTAs through an MTA-specific client that uses the Brightmail Engine Application Programming Interface (API) to transfer messages to the SBAS Scanner for analysis (Figure 2a). For the purpose of evaluating SBAS performance and its response to different tuning parameters, we used a simplified configuration where

Symantec's `bmi_send` load-generation tool is used drive a synthetic email workload through the SBAS Scanner using the same interfaces that an MTA would use (Figure 2b).

Systems Under Test

This Sun BluePrints series article was first published under the title "Tuning Symantec Brightmail AntiSpam on the Sun Fire T2000 Server," reflecting performance on UltraSPARC T1 processor-powered servers that were available at the time of the document's first publication. With the availability of UltraSPARC T2 processor-powered servers, the tests were re-run comparing a Sun Fire / Sun SPARC Enterprise T1000 server with a Sun SPARC Enterprise T5120 server.

Sun Fire / Sun SPARC Enterprise T2000 Server Measurements

The server used to host the SBAS Scanner was a Sun Fire / Sun SPARC Enterprise T2000 server with a single 8-core, 1.2 GHz processor, 16 GB of main memory, and two 73 GB internal SAS disk drives. The server was configured with the Solaris 10 6/06 Operating System and SBAS 6.0.4.

For the purpose of comparison, a Sun Fire V240 with two 1 GHz processors and 4 GB of memory was used with the Solaris 10 1/06 Operating System and SBAS 6.0.4.

Sun SPARC Enterprise T5120 Server Measurements

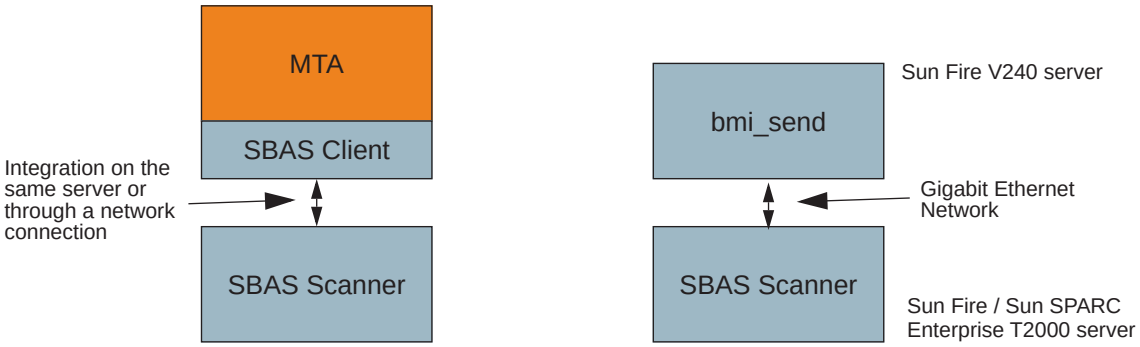
With the advent of servers based on the UltraSPARC T2 processor, we evaluated the possibility that performance could again double based on the UltraSPARC T2 processor's capability to process 64, rather than 32, concurrent threads. We fully tuned a Sun Fire / Sun SPARC Enterprise T1000 server and compared its performance to a Sun SPARC Enterprise T5120 server according to the instructions contained in this article and compared the end results.

Both servers were measured running Symantec AntiSpam software release 6.0.5 and the Solaris 10 8/07 Operating System. The Sun Fire / Sun SPARC Enterprise T1000 server was equipped with an eight-core, 1.0 GHz UltraSPARC T1 processor, 16 MB of main memory, and two 73 GB disk drives. The Sun SPARC Enterprise T5120 server was configured with an eight-core, 1.4 GHz UltraSPARC T2 processor, 32 GB of memory, and two 146 GB disk drives.

Load Generator Configuration

For both sets of measurements, we used a Sun Fire V240 server with two 1 GHz processors and 4 GB of main memory to generate the synthetic email workload. The load generator, `bmi_send`, can be tuned to apply an email workload using a specified number of threads. Varying the number of threads simulates a higher or lower message throughput from an MTA. The load generator was connected to the SBAS Scanner using a dedicated Gigabit Ethernet link.

The synthetic workload was created by Symantec by mixing a combination of valid email messages with actual spam captured by email trap accounts that Symantec maintains for the purpose of gathering and analyzing spam. For the initial set of tuning experiments we conduced on the Sun Fire / Sun SPARC Enterprise T2000 server, the workload contained 4800 messages, with an average message size of 30 KB. For the set of tuning experiments on the SPARC EnterpriseT5120 server, the workload contained 4800 messages with an average message size of 32 KB.



a) Typical deployment with MTA integration. *b) Test configuration using bmi_send*

Figure 2. Under normal circumstances, SBAS integrates with an MTA; for test purposes, Symantec's bmi_send load-generation tool replaces the MTA and SBAS client.

Your Mileage May Vary

Computer system performance measurements are typically performed in laboratory situations using workloads that are representative of actual customer workloads. They give a good sense of relative performance between systems and the impact of changes such as the tuning steps described in this Sun BluePrints article. They do not, however, exactly predict the performance that customers will see in real-world deployments. In the case of benchmarking and tuning SBAS, customers are likely to see their own performance vary up or down from the measurements presented in this article for a number of reasons:

- *Every workload is different.*

  The email workload driven by `bmi_send` was derived from actual spam captured by Symantec's email trap accounts, and from actual email sent to Symantec's corporate headquarters. The nature of spam is constantly changing, as is the amount of processing time needed to determine whether an email message is spam. Likewise, average email message sizes vary over time, and from company to company. Although every effort was made to make the body of email used by bmi_send representative of actual current email, larger or smaller average message sizes will have an impact on SBAS performance. The workload provided to Sun by Symantec changes significantly over time, and the end results in terms

of messages processed per second cannot be compared over time. Performance on the Sun Fire / Sun SPARC Enterprise T2000 server measured in September 2006 is dramatically different from tests with a new body of email done in September 2007, as discussed in “Measuring SBAS on th1e Sun SPARC Enterprise T5120 Server” on page 11.

- *Real-world configurations are different.*
  The system configuration used to measure and tune SBAS performance did not include an MTA. The same API was used to drive the synthetic workload as is used in real-world configurations, but the complexities of real MTAs could cause overall email handling performance to vary from the values reported in this article. For example, MTAs increase the overall CPU time and latency for processing each email message, and any delay transmitting messages to or from the SBAS Scanner could cause overall performance to fall below the measurement for the Scanner alone. The best way to evaluate this variable is to consider the performance numbers reported in this article as representative of SBAS performance when coupled with a well-tuned MTA.

- *Anti-spam rules are constantly changing.*
  One of the key benefits of SBAS is that the rules and heuristics used to process email are updated as often as every 5-10 minutes. As Symantec observes new types of spam arriving in email trap accounts, it uses both automated and manual procedures to update rule sets and effectively eliminate the new type of spam. These rule set updates may change the order in which rules are applied, increasing efficiency for today’s most commonly-used techniques, and they may include specific new rules or heuristics for detecting some of the more sophisticated spam.

  Customer SBAS implementations access these rule-set changes by periodically contacting Symantec logistics servers over an SSL connection. Although the benchmark used in this tuning exercise kept the body of email constant, the SBAS rule set was not held constant, so there could be variations even between sets of measurements due to automated changes in the rule sets. As a result, the performance measurements reported in this article should be considered as guidance, and not as an absolute value that any specific customer site should see. Your mileage may vary, and it may vary higher or lower than the numbers reported here.

Tuning SBAS on the Sun Fire / Sun SPARC Enterprise T2000 Server

In September 2006, Sun installed SBAS onto the Sun Fire / Sun SPARC Enterprise T2000 server and also onto a dual-processor Sun Fire V240 server(See “Test Configuration” on page 5.). The tuning steps were developed by testing and experimenting with a wide range of parameters and values, and the results of that experimentation is presented here.

Initial Installation Performance

With an ‘out-of-the-box’ installation, `bmi_send` was configured to maintain 210 concurrent connections when driving the SBAS implementation on the Sun Fire / Sun SPARC Enterprise T2000 server. The base throughput was 18 messages/sec. For comparison, the same body of email was used to drive the Sun Fire V240 server, achieving a base performance of 11.4 messages/sec. Out of the box, the Sun Fire / Sun SPARC Enterprise T2000 server outperformed the Sun Fire V240 server by 58 percent.

Increasing Service Threads

SBAS creates a separate thread to process each incoming email message up to a limit specified by the parameter `maxServiceThreads`. The higher the `maxServiceThreads` parameter, the more messages that SBAS can process in parallel. The default maximum value is 5. With the ability of the UltraSPARC T1 processor to handle up to 32 threads concurrently in the processor itself, the default thread limit is obviously low. Experimentation showed the best results with 150-200 threads. With the value set to 180 threads, SBAS handled 57 messages/sec. This more than tripled the software’s spam-processing capability with a factor of 3.17x the base performance.

The `maxServiceThreads` parameter value is stored in the file `/opt/symantec/sbas/Scanner/etc/bmiconfig.xml`. Use a text editor and locate the following line:

```
<program xsi:type='bmserverType' name='bmserver'>
```

After the line above, and before the end of the section noted by the next `</program>` line, add a line:

```
<maxServiceThreads>180</maxServiceThreads>
```

Deterministic Finite Automata (DFA)

The `DFA` parameter dictates whether some heuristics are pre-compiled in order to speed performance at the expense of using more memory. The default value conserves memory by not pre-compiling heuristics. After changing the `DFA` parameter to pre-

compile heuristics, performance increased from 57 messages/sec. to 84 messages/sec., an improvement of an additional 47 percent.

The DFA parameter value is stored in the file `/opt/symantec/sbas/Scanner/etc/bmiconfig.xml`. Locate the line:

```
<DFA enabled='false'/>
```

and modify it to:

```
<DFA enabled='true'/>
```

Integrating Multi-Threaded Malloc

`Mtmalloc` is a version of the standard UNIX® `malloc` memory allocation library that is especially tuned for multithreaded programs. The Solaris OS `mtmalloc` library is tuned to minimize lock contention resulting in a lower probability that a thread will be suspended while waiting to obtain a lock within the memory allocation library. Changing the `malloc` library used by SBAS resulted in an increase from 84 messages/sec. to 94 messages/sec., an improvement of an additional 12 percent.

To change the malloc library used, change the `LD_PRELOAD` environment variable to point to the `mtmalloc` shared library. This can be done by modifying a set of shell commands that set environment variables for SBAS located in: `/opt/symantec/sbas/Scanner/etc/brightmail-env`. Add the following lines to the file:

```
LD_PRELOAD=libmtmalloc.so
export LD_PRELOAD
```

Raising The Number of Open Files

When these tests were re-run on the Sun SPARC Enterprise T5120 server, the UltraSPARC T2 processor's 64 threads allowed SBAS software to perform many more concurrent activities, causing it to run beyond the number of open file descriptors allowed by the Solaris 10 OS. In order to overcome this limitation, we changed the maximum number of open files from 1024 to 4096 in the SBAS startup file /etc/init.d/mailwall. This change did not cause a performance increase; it eliminated an error when the limit was set to 1024. The appropriate line in the file is:

```
ulimit -n 4096
```

Measuring SBAS on th1e Sun SPARC Enterprise T5120 Server

With the release of servers based on the UltraSPARC T2 processor, we evaluated whether the increase from 32 to 64 concurrent threads supported by the new processor would result in a corresponding doubling of SBAS performance. Because of the number of variables that had changed over the course of the year since the original Sun Fire / Sun SPARC Enterprise T2000 server measurements were taken, we decided that there was no alternative but to compare two servers using the current version of the Solaris OS, SBAS software, rule sets, and test body of email messages.

We compared performance of an UltraSPARC T1 processor-powered Sun Fire / Sun SPARC Enterprise T1000 server to an UltraSPARC T2 processor-powered Sun SPARC Enterprise T5120 server using the configurations described in “Sun SPARC Enterprise T5120 Server Measurements” on page 6. Rather than comparing the two systems at each step of the tuning process, we measured only the fully tuned systems.

This round of measurements showed more than a doubling of performance between the UltraSPARC T1 and T2 processor-powered systems. Specifically, we measured a speedup factor of 2.33 using the UltraSPARC T2 processor. This measurement is significant because it shows that the additional processing capacity of the UltraSPARC T2 processor can be utilized effectively by Symantec Brightmail AntiSpam software.

We cannot underscore more highly that, in comparing absolute performance in terms of messages processed per second, “your mileage may vary.” The Sun Fire / Sun SPARC Enterprise T1000 and T2000 servers should deliver similar performance with similar processor speeds and memory configurations. But due to the changes in rule sets and the body of test email, the Sun Fire / Sun SPARC Enterprise T1000 processed 15.2 messages/sec. compared to the earlier Sun Fire / Sun SPARC Enterprise T2000 server immurements of 94 messages/sec. Likewise, the Sun SPARC Enterprise T5120 server processed 35.4 messages/sec. using the current rule sets and test email.

Summary

Eliminating spam is one of the top priorities for IT organizations implementing a comprehensive email security policy. Spam not only saps employee productivity, it can put user workstations, user personal information, and enterprise networks at risk. As the volume of spam and the sophistication of spammers increases, so does the processing power required to filter out virtually all unsolicited bulk email messages while minimizing the risk of false positives.

One potent combination of technologies for fighting spam is SBAS and UltraSPARC T1 and T2 processor-powered servers. SBAS integrates with the leading mail transfer agents, examines every incoming email, and provides a spam classification that can be used to direct the disposition of each message. SBAS gains much of its power from the near real-time filtering rule updates based on the latest spam techniques for which

Symantec is continuously developing countermeasures. Software such as SBAS must be highly multithreaded in order to process large volumes of spam concurrently, and no commercially-available microprocessor has the ability to process more concurrent threads at a hardware level than the UltraSPARC T1 and T2 processors with CoolThreads technology.

Most commercial, multithreaded software strikes a balance between increasing throughput by using a large number of threads, weighted against the increase in costly context switch overhead that is a hallmark of typical single-threaded, highly pipelined processors. In contrast, the UltraSPARC T1 and T2 processors thrive on multiple threads, with a single 8-core processor able to handle 32 and 64 threads, respectively. Most commercial software needs some tuning to best utilize a processor with zero internal thread-switching overhead, and SBAS is no exception. After tuning both the SBAS operating parameters and the Solaris OS shared library environment, Sun was able to increase performance from an out-of-the-box 18 messages per second to 94 messages per second, a 5.2x improvement (Figure 3). Comparing the tuned Sun Fire / Sun SPARC Enterprise T2000 performance to out-of-the-box Sun Fire V240 (dual processor) performance, an 8.2x increase was achieved. Most of the performance improvement is directly related to increasing the thread count in SBAS and reducing the contention for locks that arises from having a large number of active threads. When we compared UltraSPARC T1 and T2 processor-powered servers, we measured an additional speedup of 2.33x when comparing two fully-tuned servers. Even more astonishing is the fact that this level of performance was obtained while the server was drawing a mere 287 watts of power.

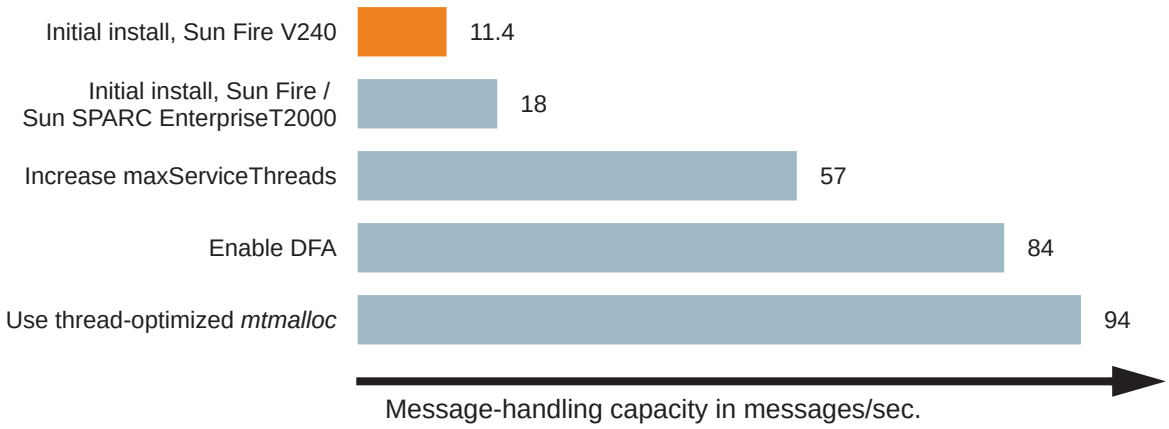


Figure 3. The bottom line: tuning the SBAS Scanner yielded a 5.2x improvement over the initial installation on a Sun Fire / Sun SPARC Enterprise T2000 server, and an 8.2x improvement over the initial install on a Sun Fire V240 server.

As with any performance measurements made with synthetic workloads, customers need to remember that their mileage may vary. Every email workload is different, spam techniques and countermeasures change in real time, and real-world configurations vary from the test configuration used in Sun's laboratories. Nevertheless, the series of tuning steps and their results give an indication of the kind of performance improvement that UltraSPARC T1 and T2 processor-powered servers can deliver in comparison to traditional, highly pipelined microprocessor-based servers.

About the Authors

Alan Yoshida is a Staff Engineer in the Market Development Engineering group at Sun Microsystems. As the lead engineer for the Symantec relationship within MDE, Alan's primary responsibility is helping to make sure that Symantec products run well on Sun platforms.

Ramin Moazeni is a Member of Technical Staff in the Market Development Engineering group at Sun Microsystems. He has been working with independent software vendors on performance engineering and in porting of their applications onto Sun platforms.

Steve Gaede is a technology consultant and writer who has lent his engineering and technical marketing expertise to various projects at Sun Microsystems since 1994. He works through PointSource Communications and his technically-focused company, Lone Eagle Systems, Inc.

Acknowledgments

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References

Information on the UltraSPARC T1 and T2 processors and servers powered by them is available at:

- `http://www.sun.com/coolthreads`

Information on the Sun Blade 6000 Modular System and UltraSPARC T1 and T2 processor-powered server modules is available at:

- `http://www.sun.com/blades`

Information on Symantec Brightmail AntiSpam is located on Symantec's Web site at:

- `http://www.symantec.com/business/products/overview.jsp?pcid=2242&pvid=835_1`

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