Current Analysis **Advanced Lab Testing and Analysis** iometrix THE STANDARD FOR TESTING

Cisco Systems
SAMI-based GGSN, 7613

Product Profile

Vendor:
Cisco Systems

Product:
SAMI-based GGSN, 7613

Target Markets:
The GGSN will be deployed to provide scalable content services gateway for mobile clients. It resides between the Core IP backbone network and the GPRS IP network generally collocated at an ISP POP or Regional Data Center.

Testing Period:
November 2008

Report Released:
December 29, 2008

Software Tested:
12.2(33)SRB2 for 7600
GGSN Release 8.0
124-15.XQ1.bin

Features Tested:

• Packet Switching and Throughput properties of a Single GGSN

• GGSN Performance Scaling in the 7613

Executive Summary

Cisco Systems engaged Current Analysis and Iometrix to test and validate the performance of its Gateway GPRS Support Node (GGSN) when hosted on the largest of the 7600 series router, the 7613. A typical GGSN gateway provides IP connectivity to mobile users, Internet, wireless application protocol WAP, multimedia messaging and to virtual private networks (VPNs). Cisco's GGSN is based on the Service Application Module for IP (SAMI) technology running on a 7600 series platform, which offers mobile operators a highly scalable approach to meeting network requirements.

In order to characterize the SAMI performance when operating as a GGSN, two separate test cases were executed:

- The first series of tests were designed to determine the baseline performance in terms of basic packet switching and throughput properties of a single SAMI in the 7613 platform, so providing visibility into how a single SAMI would perform under varying packet sizes such as the GGSN would encounter as it processed various 2G, 3G and emerging 4G traffic loads;
- The second series of tests were designed to determine the impact in performance as additional SAMIs also operating as GGSNs are added to the chassis, so showing how the system would scale to accommodate incremental growth in network traffic.

To facilitate the testing, Spirent Landslide testers were used to simulate a range of network traffic loads. The tests were designed to provide intermediate results, as well as aggregate system level results to show whether the Cisco GGSN was able to provide the requisite capacity and scale required by a mobile operator.

Key results of the tests are as follows:

- Each Sami GGSN maintained a packet switching rate of 1.3M packets per second across the range of packets sizes typically seen on a mobile 3G network today (64byte to 768 byte packet size).
- Each SAMI module was capable of delivering 9.36 Gbps of throughput when configured at an average packet size of 1024 bytes and 5.74 Gbps of throughput when configured at an average packet size of 512 bytes. The packet throughput for 1024 byte packets was slightly in excess of 1 Mpps (1.10 Mpps). At a packet size of 1460 bytes the SAMI is capable of essentially saturating a 10 Gbps interface or running at line rate.
- The testing also revealed that each SAMIs acted as an independent module with no overhead performance impact when an additional SAMI is added to the test configuration. This shows a GGSN could be scaled linearly by adding SAMI modules to the 7613 and could result in a throughput level from 9.36 Gbps for a single SAMI to a maximum of 8 SAMIs supporting 74.88 Gbps of throughput.

- Round trip packet delay, latency and CPU utilization were all recorded for the various data points and showed a similar linear relationship as a function of throughput and packet size. For additional detail refer to the test results sections below. .

Market Overview and Analysis

The Internet has transformed nearly every facet of telecom; mobile networks are no exception. Where initial analog and 2G wireless networks were designed to provide basic voice services, today's 3G (evolving into 4G) networks deliver a full complement of voice and broadband data applications. To be sure, we are at a very early stage in the lifecycle of these networks and of mobile broadband itself. In fact, there are numerous reasons to believe that mobile broadband traffic will grow at a very strong pace over the next few years.

Why?

- New 3G and 4G technologies – HSPA, HSPA+, WiMAX, LTE, and UMB – are emerging, all of which promise to inject new capacity into the mobile Radio Access Network.
- Internet and data applications such as e-mail, instant messaging, online file backup, and even basic web surfing are becoming a integral part of people's lives, driving usage up over fixed and mobile networks alike.
- New services such as mobile TV, social networking, and the mobile enterprise (including e-mail and collaboration applications) are driving people to use mobile networks in new ways.
- The proliferation of operator-deployed WiFi networks is delivering high-speed access outside of, and in addition to, 3G coverage and allowing operators to target mobile data users with an inexpensive technology widely available in most laptop PCs.
- The proliferation of multimode devices (2G and 3G, 3G and WiFi) is providing an incentive for users to take advantage of mobile broadband service availability while still promising access to familiar voice services.
- Advanced user interfaces encourage the use of mobile broadband services by making it easier for users to access data applications and services.

In short, demand for Internet and data applications is high, yet still on the rise. Combined with an abundance of mobile broadband networks, some users have come to expect and/or hope for (and in some cases rely on) Internet access wherever they go. As more and more people join their ranks, these trends will doubtless have an impact on the data gateways – PDSNs, GGSNs, ASN gateways – linking wireless base stations and users into the Internet and other data networks to access a wide variety of service offerings. In particular, a number of gateway features stand out as prerequisites, the first two of which form the subject of this testing report.

- **High Capacity.** Gateway capacity – session capacity, application capacity, data throughput – is critical for ensuring that a gateway can keep up with growing traffic demands and that users get access to the applications they want, when they want them.

Perhaps more than any other requirements, capacity will be key as mobile data usage ramps up and operators look to conserve on OpEx and CapEx by avoiding the need to constantly purchase and deploy new gateway assets.

- **Scalability.** In the run-up to strong service uptake, a gateway offer must be able to support a high degree of capacity scalability: evolving from limited capacity up-front to higher capacity as network demands warrant.
- **Reliability.** Gateways must be highly available products in order to provide a consistent user experience as well as consistent revenue flows.
- **User Applications.** Any gateway offer must be able to provide consumer and enterprise mobile data users with a consistent set of capabilities and applications, such as network access, firewall generation, IPSEC capabilities, and content filtering.
- **Operator Applications.** Mobile data gateways provide other key functionality such as: billing interfaces, deep packet inspection and content charging tools, lawful intercept, mobility management (including home agent functionality), QoS support including DiffServ marking, and support for a broad set of routing protocols.

Cisco's gateway solution leverages its widely-deployed and market-proven 7600 Routing platform – including the Cisco 7604, 7606, 7609 and 7613 – with basic session capabilities and application functionality hosted on Cisco Service Application Module for IP (SAMI) blades: PDSN, GGSN, ASN, Home Agent, content charging, content filtering, etc. Combined with Cisco's broad support for diverse routing protocols and redundancy options, the result is access to a wide array of applications with card-level upgrades promising platform evolution in line with service uptake and market trends.

Objectives

Cisco Systems engaged Current Analysis and Iometrix to create and execute a testing program designed to provide a benchmark for the Cisco GGSN, which is based on Cisco's Service Application Module for IP (SAMI) technology. In order to characterize the SAMI performance in a 7600 series platform, the testing objectives were divided into two separate test suites, each with its own objective:

• **Test Suite 1** – Baseline under a heavy and sustained load the performance characteristics in terms of throughout and latency for the various packet sizes (64, 128, 256, 384, 512, 768, 1024, 1460 and IMIX) the Packet Switching and throughout properties of a single SAMI within a 7613 platform.

• **Test Suite 2** – Run the same tests with two SAMIs installed on the 7613 platform to measure the scalability of the system based on packet sizes of 1024 and 1460 bytes; then extrapolate these results to determine overall system behavior for a 7613 loaded with 4 SAMI's configured as GGSNs.

Each of the benchmark Test Suites were run using the conditions described below in "Test Methodology." To facilitate the testing, multiple Spirent Landslide test sets were used, half of them configured as GI interfaces and the other half configured as GN interfaces. The tests were designed to provide intermediate results as well as an aggregate system level result to measure the capacity and scalability of the Cisco GGSN system.

Test Methodology

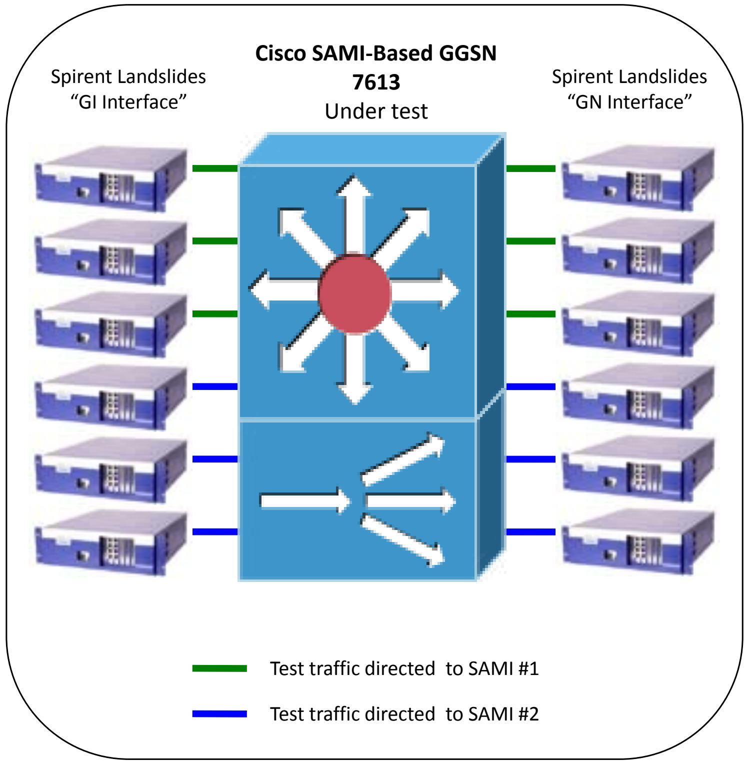
Current Analysis and Iometrix developed a test methodology that emulates a highly loaded system such as a GGSN would typically experience in a mobile operator's network. Leveraging the Spirent Landslide testing platforms, Current Analysis and Iometrix defined a benchmark that uses UDP traffic to benchmark the Cisco 7613 SAMI-based GGSN from a throughput and latency perspective.

The testing was designed to provide two of the most critical performance metrics noted in the "Market Review" section above. This test report addresses the throughput and capacity metrics.

- **For throughput** – the overall packet switching and throughput properties of the system were tested using various common packet sizes (64, 128, 256, 384, 512, 768, 1024, 1460 bytes and IMIX). Each fixed packet size was executed on the SAMI cards and the results were recorded. This test provides a metric for the overall system throughput and highlights the impact that packet size has on the performance of the overall solution.
- **For scalability** – a test scenario was used that simulated the performance of two SAMI modules with packet size of 1024 bytes for one SAMI and 1460 for the other. The test sets were configured to set up 384,000 calls per SAMI. To determine the maximum throughput, the rate was increased until the GGSN began dropping packets. The rate was then lowered, to just below the "drop packet" threshold, and executed for 10 minutes. The overall throughput in Gbps was then recorded and used for the final system test configuration.

Test Configuration

The following diagram shows the high-level test configuration used for the Cisco GGSN testing.



Test Suite 1 - Switching and Throughput properties of the base platform

This test suite measured the baseline performance of a SAMI running as a GGSN in a 7613 hardware platform for its bi-directional throughput and latency.

For this test each processor was configured to route data from one VLAN to another and configured the Spirent Landslide test tool to generate 600 calls per second up to 384,000 calls through the GGSN with a single SAMI.

The GGSN configuration was as follows: one APN, no VFR's, locally assigned IP addresses, static routing, transparent PDP's, no accounting, charging disabled and with redundancy.

UDP packets were sent through the SAMI for 10 minutes to determine the "no drop" packet and throughput rate (pps), bi-directional throughput (bps), latency (μs) and CPU utilization (%), for the following packet sizes:

- 64 bytes
- 128 bytes
- 256 bytes
- 384 bytes
- 512 bytes
- 768 bytes
- 1024 bytes
- 1460 bytes
- IMIX traffic: 85:3,171:1,553:1,1419:4

Test 1 results for a single SAMI module running GGSN are as shown in Table 1 below.

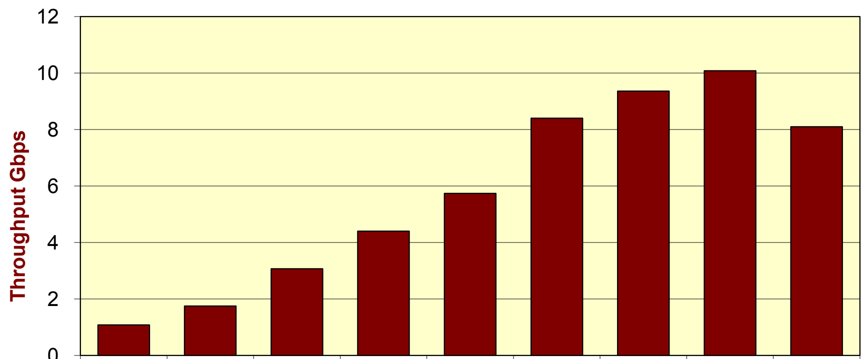
Table 1: Performance Results Test Suite 1 - Packet Switching and Throughput Properties

Ethernet Frame Size (Bytes)	64	128	256	384	512
Packet rate (PPS)	1,300,000	1,300,000	1,300,000	1,300,000	1,300,000
Throughput (bps)	1,081,600,000	1,747,200,000	3,078,400,000	4,409,600,000	5,740,800,000
Round-trip delay (us)	580 to 640	580 to 640	580 to 640	580 to 640	580 to 640
Latency (us)	290 to 320	290 to 320	290 to 320	290 to 320	290 to 320
Packet success ratio	99.999%	99.999%	99.999%	99.999%	99.999%

Ethernet Frame Size (Bytes)	768	1,024	1,460	IMIX
Packet rate (PPS)	1,300,000	1,100,000	840,000	1,300,000
Throughput (bps)	8,403,200,000	9,363,200,000	10,080,000,000	8,101,600,000
Round-trip delay (us)	580 to 640	580 to 640	580 to 640	580 to 640
Latency (us)	290 to 320	290 to 320	290 to 320	290 to 320
Packet success ratio	99.999%	99.999%	99.999%	99.999%

Figure 1 shows the performance throughput graphically in pps as a function of packet size for Test 1.

Figure 1
Sustained Throughput Rates per Packet Size - Single SAMI



	64	128	256	384	512	768	1024	1460	IMIX
Series1	1.08	1.75	3.07	4.4	5.74	8.4	9.36	10.08	8.1

Test Suite 2: Throughput using two SAMI modules running GGSN

This test suite shows the performance impact and interaction of running multiple SAMI's operating GGSN running in a 7600, to determine the platform's scaling characteristics.

For this test each processor was configured to route data from one VLAN to another and configured the Spirent Landslide test tool to generate 600 calls per second up to 384,000 calls through each SAMI through the GGSN with two SAMI's installed in the 7613.

The GGSN configuration was as follows: one APN, no VFR's, locally assigned IP addresses, static routing, transparent PDP's, no accounting, charging disabled and with redundancy.

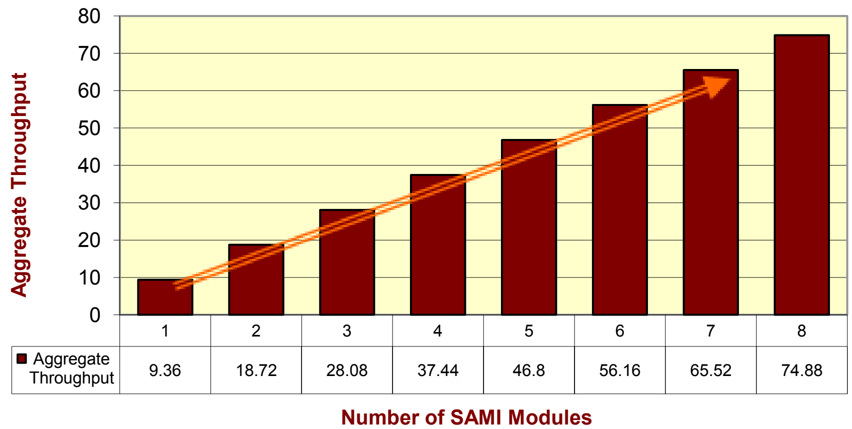
UDP packets of 1024 byte size were sent through one SAMI and 1460 byte packets through the second SAMI for 10 minutes to determine the "no drop" packet and throughput rate (pps), bi-directional throughput (bps), latency (μs) and CPU utilization (%), for this test scenario.

The results of Test 2 for the two GGSN SAMI modules are shown in Table 2 below. The results show no degradation in throughput as the second SAMI is loaded. This shows that that each SAMI effectively operates independently within a 7613 chassis. Figure 3 shows the extrapolated performance of a Cisco 7613 system loaded with varying numbers of GGSN SAMI modules.

Table 2: Performance Results for Test Suite 2

UDP Packet Size (Bytes)	SAMI #1 - 1024	SAMI #2 - 1460
Packet rate (PPS)	1,070,000	830,000
Throughput (bps)	9,501,600,000	9,960,000,000
Round-trip delay (us)	580 to 640	580 to 640
Latency (us)	290 to 320	290 to 320
Packet success ratio	99.999%	99.999%

Figure 2
Aggregate Throughput in Gigabits



Conclusions

These test results underscore the expected linear performance, in a mobile operator's network, of a SAMI-based GGSN.

Test 1 identified the performance level of the SAMI under the different packet sizes of 64, 128, 256, 384, 512, 768, 1024 1460 bytes and IMIX traffic – this shows the mobile operator how well the GGSN will perform based on varying applications that present different lengths of packet traffic.

Test 1 was conducted first with a single SAMI module at the defined packet sizes. As shown in Table 1 at the lowest packet size, 64 bytes, the SAMI throughput was approximately 1.1 Gbps, and as expected for larger packet sizes the SAMI throughput increased to a maximum of 10.0 Gbps at packet size 1460 – effectively line rate for a 10 Gbps interface. The contribution to the Round-trip delay from line latency when a high speed interface running at 10Gbps were used would only contribute a 2μs delay to the total round-trip measurement. This means the measured value was largely a function of the unit under test, not the delay from line latency.

Also worthy of note is the fact that the CPU utilization decreased as packet size increased, indicating the efficiency of the system when processing larger frames and consistent with most hardware architectures. The results are shown in Table 1. Figures 1 graphs the throughput as a function of packet size and shows a linear relationship.

Test 2 shows that the overall throughput based on the number of SAMI modules. Test 2 determined the actual throughput by adding 2 SAMI modules, each under an identical load condition. A linear increase was observed in throughput for each SAMI added to the system indicating that the overall switching and throughput capacity of the Cisco 7613 router is matched to the GGSN application. The throughput observed was identical on each SAMI for the measured packet sizes, indicating that as SAMI modules are added there is no additional overhead penalty incurred on a system level, and thus that the aggregate throughput grows incrementally. For the SAMI running a packet size of 1024 the measured throughput was still 9.360 Gbps. For the SAMI running packet size of 1460 was able to achieve a measured throughout rate of 10.0 Gbps or line rate.

Finally, to project a more fully loaded system, the results obtained from a single SAMI were extrapolated by taking the single SAMI rate and projecting it over the equivalent of 8 SAMI modules the maximum supported in the 7613, yielding an aggregate of 74.88 Gbps for a system loaded with 8 SAMIs as shown in Figure 3. For packet throughput the results are approximately a million packets per second per each SAMI.

Lab Testing Mission Statement

Current Analysis and Iometrix share a common vision to develop rigorous, standards-based methodologies essential to the meaningful evaluation of advanced enterprise and carrier networking equipment. Current Analysis and Iometrix collaborate to develop and execute test methodologies that set new standards for quality and relevance in enterprise and carrier networking equipment testing.

Current Analysis and Iometrix perform independent, commissioned product testing to measure and validate relevant, real-world performance of a product from a single vendor. Testing methodologies are designed and executed exclusively by Iometrix and Current Analysis. Current Analysis and Iometrix share the belief that equipment vendors must be held to a higher level of accountability in lab testing engagements, and together we deliver testing methodologies and benchmarks that are credible and relevant to the end user.

Acknowledgements

Current Analysis and Iometrix would like to specifically thank Spirent for providing extensive equipment resources and support throughout the course of this test. Spirent supported the Iometrix lab by supplying us with pairs of its advanced Landslide platforms. The test equipment enabled Current Analysis and Iometrix to develop and execute the testing methodologies described above.