Miercom

LAB TESTING SUMMARY REPORT

September 2001
Report 101001

Product Category:

Gigabit Routers

Vendor Tested:

Charlotte's Web Networks

Product Tested:

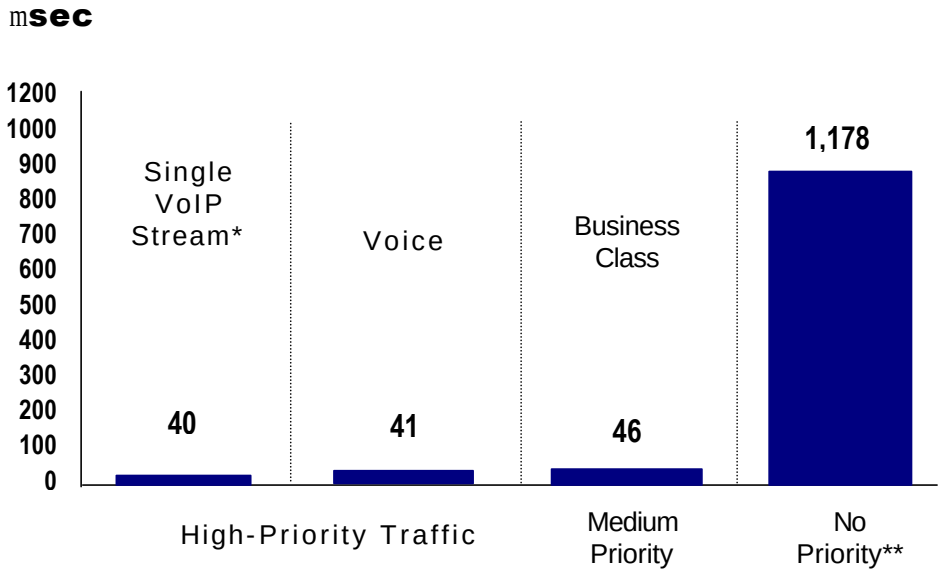
Aranea-1

Key findings and conclusions:

- **Aranea-1 met or exceeded performance levels of core routers tested by Miercom, including the Cisco 12410 and Juniper M160 tested in June 2001**
- **Delivered maximum line rate achievable on 32 concurrent ports for 40-, 512-, and 1500-byte packets**
- **Policed congested traffic without compromising performance, latency or jitter**
- **Learned 200,000 routes while forwarding traffic at line rate in 40 seconds (on average)**

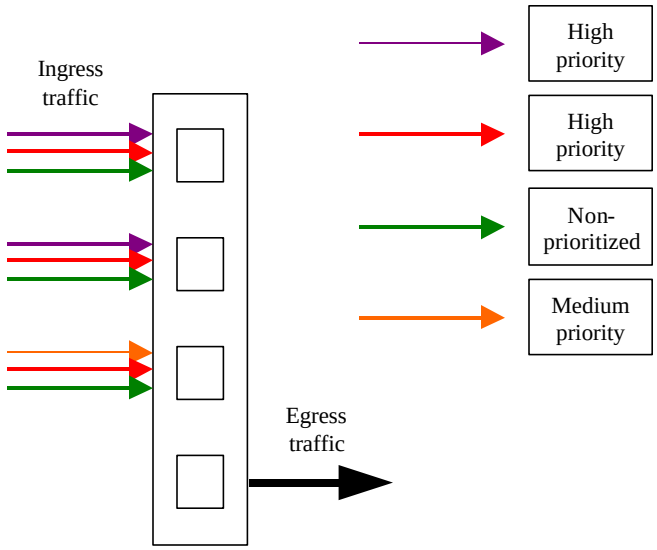
Charlotte's Web Networks engaged Miercom to conduct analysis and performance validation tests of its Aranea-1 Gigabit router. The goal of this testing was to determine the impact of core routers for high-priority, time-sensitive traffic, such as voice-over-IP (VoIP) and video. We assessed the performance of the Aranea-1 in the following areas: Aggregate throughput (on 32 OC-48 fully loaded ports); Class of Service; including Business Class traffic; BGP learning rate; policing under congestion; and traffic policing with a large number of flows. We also tested the Aranea-1's ability to fail over under a warm reboot and resume operations after a power reset. We tested the Aranea-1 running AraneOS™ 2.1.29B software. Miercom engineering staff conducted the tests at an approved Miercom testing lab in Israel in August 2001.

Average Latency: Prioritized and Non-prioritized Traffic

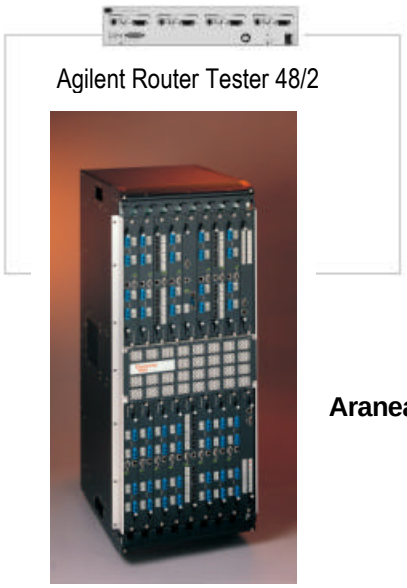


**Numbers shown are an average of the 32K-bps and 64-Kbps streams.*
***Consisted of three streams of 45 percent background traffic.*

Test-bed Setup and Methodology



Various levels of traffic (high, medium, no priority) were transmitted over three of the interfaces. Egress traffic was transmitted over the fourth interface.



Aranea-1

About the testing…For testing, we used 16 Agilent P48/2 Router Testers connected to a core router (systems under test, SUT, was the Charlotte Web Networks' Aranea-1 core router) with single-mode fiber-optic cables to create 200,000 BGP routes and generate and analyze our traffic streams. Each test was conducted three times and averaged for our final results. Our first test measured aggregate throughput. The Agilent tests applied a bi-directional load of 40-byte and 1500-byte frames across 32 ports concurrently. We sent the 32 separate streams across all 32 interfaces in a port-to-port (unmeshed) configuration; we later repeated the tests in a full-mesh configuration. Frames were sent at 100 percent of the theoretical maximum rate for OC-48 for each packet size; the number of frames received was compared to the number of frames transmitted. In the event of packet loss, the delivery rate of frames transmitted was reduced incrementally and repeated until all frames transmitted were received. The results were reported as average frames per second and percent of theoretical maximum.

In Class of Service (CoS) tests, for each module, we created three separate ingress UDP streams of 80-byte packets with a fixed source port of 50,000 and a fixed destination port of 60,000 at two percent of the theoretical maximum rate. The first two-percent stream was sent in 50-packet bursts, the second in 250-packet bursts, and the third in 500-packet bursts, with a gap of 690 microseconds between bursts. On the first interface, using the same traffic type, we added a single 64-Kbps stream with 100 pps and 5 packets per burst. On the second interface, we added a single 32-Kbps stream with 50 pps and 3 packets per burst. All five streams were forwarded through the fourth interface on the module and captured by the Agilent. The tests were run for 30 seconds each. We recorded packet loss, packets per second, and latency of all five streams. Next, we added three separate ingress streams of 45 percent of the theoretical maximum rate of 1500-byte packets. This caused an over-subscription on the egress interface and forced the SUT to discard some traffic. We recorded the results for all eight traffic streams. We then enabled queuing features and applied high priority to the first five streams and low priority to the remaining traffic streams. We reran the tests and recorded the results. For our last test, we added another separate traffic stream representing "business class" traffic with mixed packet sizes and medium priority at 20 percent of the theoretical maximum rate. We ran the tests again and recorded the final results.

For the BGP learning rate tests, we began traffic streams and BGP routing packets simultaneously then recorded how many seconds before the first packet was forwarded across the router and how many seconds before traffic was forwarded across all routers. We recorded the rate at which the traffic was actually routed using the learned routes. Next, we tested policing under congestion. Two OC48 ports sent full wire traffic to a third OC-48 port. Each port sent four different traffic flows identified by a combination of their TCP source and destination ports. Initially, no policing was enforced; hence, a 50 percent drop is expected for each of the flows, along with high latency. Then each flow was associated with a specific rate, thus eliminating over subscription. The result was the deterministic drop rate, which is unique to every flow, and minimal delay. Next we tested traffic policing with a large number of flows. One OC-48c port was used to transmit to 15 egress OC-48c interfaces; 15 flows were identified for each egress interface. The Agilent Router tester allowed a maximum of 15 x 15 (or 225) flows. Each flow was a unique combination of destination IP, source IP, TCP/UDP ports and policed rate. The router rate-limited each flow according to a pre-defined configuration and sent all the flow traffic to its destination.

The tests conducted in this review were conducted in a fashion as similar as possible to previously conducted reviews on competitive products using testing information contained in other performance test reports which are publicly available. Competitive products were not tested in a side-by-side fashion in the same testing period, however, and are therefore not directly compared in the charts of this report. General references are made to established norms and trends in test results observed previously to establish a frame of reference for core routing products of this class to allow further elaboration on the results of this product tested.

Performance Results

Aggregate throughput: We conducted tests to determine the fastest rate at which the total frames transmitted is equal to the total frames received. The Aranea-1 achieved 100 percent of the theoretical maximum rate for all packet sizes (40-, 512- and 1500-byte IP packets). (See Table 2)

Table 1: Maximum Per-Port Throughput (32 ports under load)

Packet Size (Bytes)	PPS per port	Mbps per port
40	6,112,653	1,956.05
512	574,744	2,354.15
1,500	198,472	2,381.67

The throughput numbers depicted above represent the individual per port loads applied by the router test equipment and egress traffic forwarded by the router.

Previous products tested from other vendors have revealed similar line speed performance when traffic is applied comprised of large packet sizes, but have limited throughput capability when tests are applied using small packets.

The throughput tests previously conducted in the standard core router suite consisted of 'port to port' configuration tests. Testing was repeated on the Aranea-1 in a full mesh or 'many to many' configuration. These more aggressive tests further proved the Aranea-1 could provide wire-speed throughput regardless of packet size and traffic flow though the router.

Class of Service (CoS) Performance: The Aranea-1, which employs a robust scheme of class of service via Weighted Round Robin (WRR) queuing, traffic policing, and extensive access list support, proved it could prioritize 32-Kbps and 64-Kbps voice streams, as well as VoIP traffic, transmitting the streams with **no packet loss**. (See Tables 3 and 4 on next page for complete results.)

Latency: The Aranea-1 transmitted 32-Kbps and 64-Kbps voice streams and three two-percent voice (VoIP) streams with very low average latency, averaging 42 µsec. By contrast, we've observed average latency rates on products of this class that were as high as we 399.7 µsec in similar tests. An even more dramatic performance difference was noted when comparing the results from no-priority, 45-percent background traffic. The Aranea-1 continued to forward the low priority traffic with understandably higher latency and jitter but proved generally better than other products tested.

The cumulative effect of high latency on network traffic – especially voice and video traffic – results in unintelligible output and should be considered a critical factor when assessing routers for use in converged networks. (See Tables 3 and 4 on the next page for complete latency results.)

Table 2: Charlotte's Web Networks Aranea-1 Throughput Test Results (based on 32 ports)

	40-Byte Port-Port		40-Byte Mesh		512-Byte Port-Port		1500-Byte Port-Port	
	IP TX Packets	IP RX Packets	IP TX Packets	IP RX Packets	Stream TX Pkts	Stream RX PKts	Stream TX Pkts	Stream RX Pkts
Aggregate packets	5.9B	5.9B	5.9B	5.9B	551.8M	551.8M	190.5M	190.5M
Aggregate PPS	195.2M	195.2M	195.4M	195.4M	18.4M	18.4M	6.4M	6.4M
Aggregate Mbps	62.5	62.5	62.5	62.5	75,333	75,333	76,213	76,213
Avg PPS per port	6.1M	6.1M	6.1M	6.1M	574.7K	574,744	198.5K	198.5K
Avg Mbps per port	1952.4	1952.4	1954.4	1954.4	2354.2	2354.2	2381.7	2381.7

All numbers shown are rounded up. B = billion; M = million

No packet loss was recorded, although there were slight variations in offered load.

Table 3: Charlotte Web Networks Aranea-1
Class of Service Performance – Prioritized by Traffic Type*

Type of Traffic*	Percent of Packet Loss	Avg. Latency (msec)	Jitter (msec)	% Packets out of Sequence	PPS	Mbps
32-Kbps Voice	0.00	42.8	34.1	0.00	50	0.03
64-Kbps Voice	0.00	43.1	35.5	0.00	100	0.06
2% Voice Stream 1 (VoIP)	0.00	40.0	38.0	0.00	67,306	43.08
2% Voice Stream 2 (VoIP)	0.00	44.1	39.1	0.00	67,310	43.08
2% Voice Stream 3 (VoIP)	0.00	44.5	39.4	0.00	67,316	43.08
45% Background Traffic	30.29**	985.7	1,136.1	NA***	62,269	747.23
45% Background Traffic	30.43**	897.8	1,138.0	NA	62,142	745.71
45% Background Traffic	30.44*	898.0	1,117.6	NA	62,128	745.54

Table 4: Charlotte's Web Networks Aranea-1
Class of Service Performance including "Business Class Traffic"

Type of Traffic*	% of Packet Loss	Avg. Latency (in msec)	Jitter (in msec)	% Packets out of Sequence	PPS	Mbps
32-Kbps Voice	0.00	39.5	33.1	0.00	50	0.03
64-Kbps Voice	0.00	39.7	33.9	0.00	100	0.06
2% Voice Stream 1 (VoIP)	0.00	38.3	37.2	0.00	67,306	43.08
2% Voice Stream 2 (VoIP)	0.00	41.7	37.9	0.00	67,310	43.08
2% Voice Stream 3 (VoIP)	0.00	41.6	39.4	0.00	67,317	43.08
45% Background Traffic	46.89**	1,206.5	1627.3	NA***	47,436	569.23
45% Background Traffic	46.99**	1,209.1	1620.5	NA	47,349	568.19
45% Background Traffic	41.72**	1,118.5	1490.5	NA	52,057	624.69
Business Class Traffic	0.00	45.5	104.2	0.00	76,898	922.78

**VoIP traffic consisted of 80-byte packets; background traffic consisted of 1500-byte packets, and "Business Class" consisted of various packet sizes. Voice streams represent 3 x DS3's of VoIP gateway traffic coming into the core; the 32/64-Kbps voice streams show behavior for a single call.*

***Since the background traffic streams were oversubscribed at 135 percent, packet loss was expected.*

****For background traffic, sequence errors are miscounted when background packets are dropped.*

Jitter (inter-arrival delay): High-quality voice and video traffic requires a constant packet arrival rate with minimal jitter. The greater the jitter introduced, the larger the jitter buffer a VoIP gateway, for example, must support to deliver packets at a constant rate. Overall, the jitter rate on the Aranea-1 router was on par with competing products we've tested and far better than some. The jitter on the Aranea -1 averaged about 39 µsec (transmitting a 2-percent voice stream). It should be noted that products previously tested have failed this test with results observed hundreds of times worse measured in **milliseconds**.

Both jitter and latency on the business-class stream is higher because it uses random-size packets, and traffic is sent with medium-priority.

Packet sequence: The percent of packets arriving out of sequence is an important factor when assessing routers for use in networks that will carry VoIP traffic. Packets that arrive out of sequence have to be re-ordered by the VoIP gateway to maintain high voice quality. This requires enlargement of the VoIP gateway jitter buffers, which would negatively impact the total latency budget for the network.

In assessing the percent of packets arriving out of sequence, we found that the Aranea-1 has no out of sequence errors that were not otherwise attributed to dropped packets in the low-priority traffic streams. However, in previous studies packet sequence errors from 27 percent up to 95 percent on competitive products we've tested.

Performance Results – continued

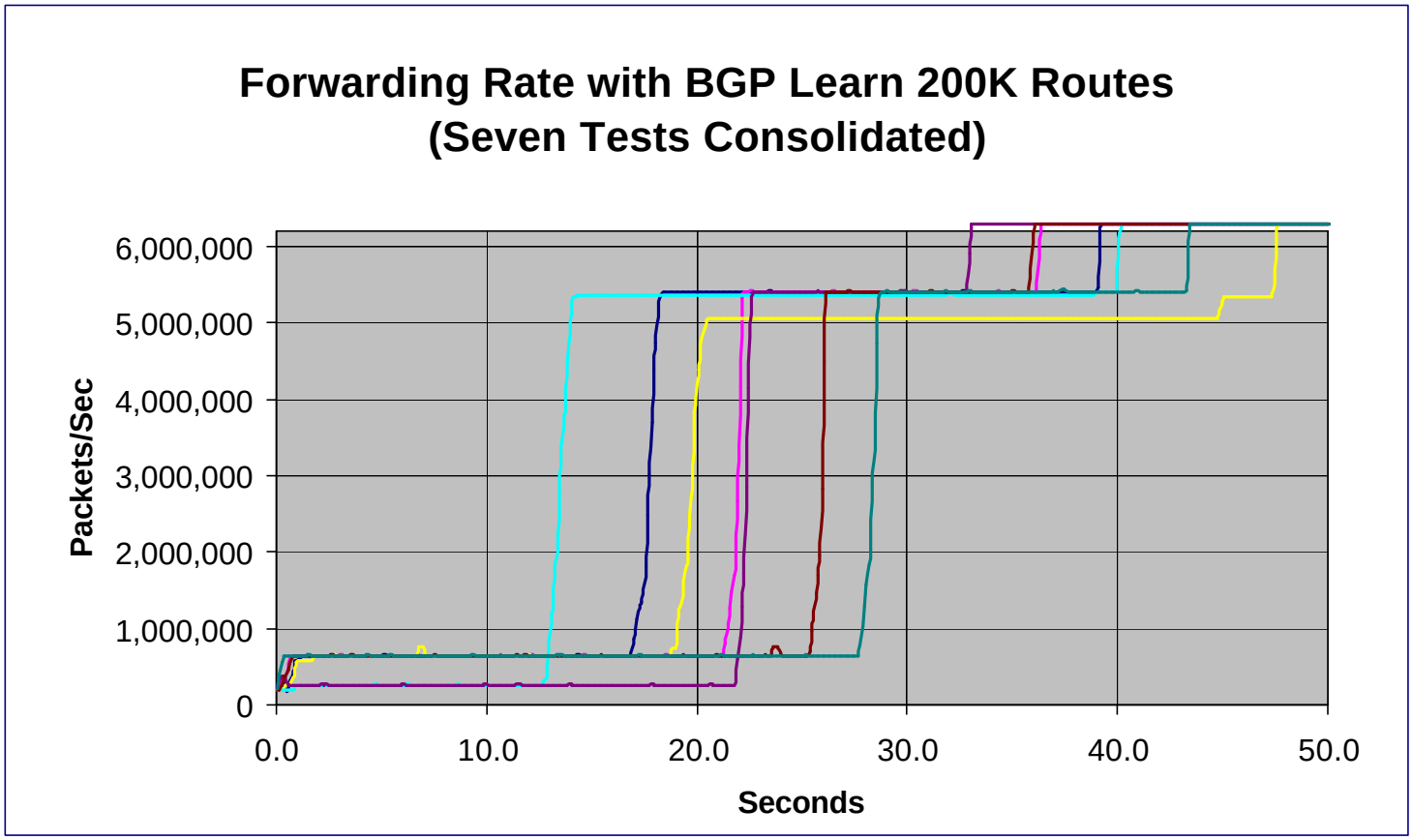
BGP Learning Rate: In this test, we analyzed the ability of the Aranea-1 router to restart in an active network. Starting with a "clean" routing table, we determined how much time was required for the router to learn (via BGP-4) 200,000 routes and forward traffic at line rate. (See the chart below for details.)

The Aranea-1 forwarded 40-byte packets on all 200,000 routes in about 45 seconds, while under full load. Other Gigabit routers tested recently by Miercom could not reach the BGP learning rate even after seven minutes when under a full load. These routers could, however, reach the learning rate in 45 seconds under reduced loads of 67.2 percent.

Traffic policing: We tested the traffic-policing ability of the Aranea-1 in two tests. In the first, we analyzed policing under congestion. Two OC-48 ports sent traffic at full wire speed to a third OC-48 port. (See "About the testing" for complete details of the tests.) Initially, no policing was enforced and, as expected, 50 percent of the traffic was dropped. However, when policing was enabled, the remaining traffic was forwarded without impacting performance and with minimal latency and jitter.

We also tested the ability of the Aranea-1 to separately police and forward a large number of flows (per destination IP, source IP and TCP/UDP ports) with a very fine granularity and without compromising latency or jitter. (See "About the testing" for details about the tests.) The Aranea-1 demonstrated that it could police a large number of flows very accurately. The flows were policed to the exact rate to which they were limited, without compromising latency and jitter. The flows configured to drop all packets did so.

Fault tolerance and redundancy: The Aranea-1 supports redundant power supplies, routing engine modules and switching fabric modules as options. Tests showed that the product could conduct a full system reboot (recovery from power failure) to normal operation within 2 minutes 40 seconds with a typical configuration and 3 minutes 30 seconds for a complex configuration, which is well within the five-minute maximum budget for "High Availability and Reliability" certification.



Conclusions

Based on Miercom's experience testing VoIP equipment, we conclude that the cumulative effect of high latency, jitter and sequence errors on VoIP traffic is detrimental, introducing severe network problems. Performance testing conducted recently by Miercom demonstrated that the Charlotte's Web Networks Aranea-1 Gigabit core router prioritized traffic (consisting of 32-Kbps and 64-Kbps voice streams and three VoIP streams) without packet loss or sequence errors, and with tight jitter control, even during congestion. The Aranea-1 also delivered the maximum line rate achievable on 32 concurrent ports when tested with 40-, 512- and 1500-byte packets.

Charlotte's Web Networks Aranea-1

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