

Abstract

EEMBC® version 2.0 Networking benchmarks offer significant improvements over the previous version. Not only are several problems fixed, but additional benchmarks have been added based on input from the networking industry. Improved versions of Open Shortest Path First, Packet Flow and Route Lookup benchmarks from version 1.1 are included in version 2.0 as well as the addition of Quality of Service (QoS), IP Reassembly, Network Address Translation (NAT) and Transmission Control Protocol (TCP). IBM is one of the first companies to publish results for the EEMBC Networking version 2.0 benchmark suite with its PowerPC® 750GX processor. With 1 Mbyte of integrated L2 cache and a clocking speed of 1 GHz, the 750GX is an ideal choice for a networking application such as one addressed in this benchmarking suite. This application note gives a better understanding of these new industry standard benchmarks and the 750GX results.

EEMBC Networking Version 2.0

There has been much interest in the EEMBC Networking benchmarks since the first set of scores were available in March 2000. These industry-standard benchmarks have made it easier for the networking industry to choose processors for their routers and other communications products.

Over time benchmarks become outdated, but once a benchmark is public there can be no changes made if those changes impact published results. As more and more companies ran the benchmarks, they discovered that some of them could be improved to better reflect real applications. To address these issues EEMBC created the version 2.0 benchmarks. The first version 2.0 suite to be released is Networking. Eventually version 2.0 benchmarks will replace version 1.1, but as there are many version 1 results available, this will not happen overnight.

IBM 750GX Processor

IBM has been a member of EEMBC from the start and was active in the development of these benchmarks. IBM is one of the first companies to publish results of the Networking version 2.0 benchmarks with its 750GX processor.

The PowerPC 750GX expands the capabilities of the IBM PowerPC 7xx processor family to support more performance-demanding and power-sensitive applications. Running at frequencies up to 1.0 GHz, the 750GX includes 1 MB of internal L2 cache, 4way set-associative, running at core frequency with cache locking by way, additional L2 cache buffers allowing pipelining of up to four data cache miss operations, and the capability for up to 200-MHz operation of the 60x system bus interface with additional bus pipelining. The IBM PowerPC 750GX is ideally suited for a variety of systems, including networking, communications, storage, imaging, computing and consumer applications.

The EEMBC Networking Version 2.0 benchmarks were run on an IBM 750GX evaluation board. The processor speed was 1 GHz and the memory speed was 200 MHz. The compiler used for these benchmarks was MULTI version 4.0 from Green Hills Software. MULTI version 4.0 is the latest release from Green Hills Software and shows improvements over the previous version, 3.6.1, which was used to benchmark IBM processors in the past. IBM works closely with Green Hills Software so that you can easily achieve out-of-the-box performance on PowerPC processors without hand tuning your source code.

Networking Version 2.0 Benchmarks

In version 2.0 the EEMBC Net_{mark}TM is replaced by the IP_{mark}TM and the TCP_{mark}TM. 750GX achieved a TCPmark of 467.1 and an IPmark of 286.1.

There were three Networking benchmarks in EEMBC version 1 and there are seven in version 2. The three original networking benchmarks have been modified so you can not directly compare their scores to the version 1 scores. There are four benchmarks which are completely new for version 2.0. The version 2.0 benchmarks are briefly

described in the following sections. For more detailed information about each benchmark refer to the datasheets on the EEMBC web site, www.eembc.org.

This Application Note will analyze each benchmark in the version 2.0 networking suite. A pie chart is used to show the instruction mix. The pie charts were derived by profiling the instructions executed during the timed portion of the benchmark. These pie charts can be interesting because compare/branch and load/store instructions will often cause processor pipeline stalls that will affect benchmark performance. Another test that was done was to run the benchmark with the 750GX's L2 cache disabled. This can explain why the 750GX may perform better than a processor with a higher clock speed and a smaller L2 cache.

Route Lookup Benchmark

The Route Lookup benchmark is from version 1 and tests the processor's ability to route IP packets using the Patricia Tree algorithm. The only changes made to the benchmark were for compatibility with the version 2 EEMBC Test Harness.

The 750GX processor achieves 5815 iterations per second on this benchmark because of the efficiency of its Power Architecture[™] instruction set. The Route Lookup benchmark consists mainly of compare and branch instructions. The code and data accesses easily fit in the 750GX's L1 caches.



OSPF Version 2 Benchmark

The Open Shortest Path First Version 2 benchmark is slightly modified from version 1.1 to make it more realistic. The benchmark tests the Dijkstra shortest path first algorithm, which is widely used in routers and other networking equipment. The version 2.0 code has been slightly modified to not find the shortest path right away. This small change has lowered the benchmark score by an order of magnitude, but made the benchmark more realistic.

The 750GX scored 3007 iterations per second as compared to 20343 iterations per second on version 1.1 of OSPF. More than half of the instructions executed in the OSPFV2 benchmark are a type of compare or branch instruction. Like the Route Lookup, the code and data accesses fit easily in the L1 caches.



IP Packet Check Benchmarks

The IP Packet Check benchmarks are derived from the version 1.1 Packet Flow benchmarks, which simulate a subset of the IP packet routing function. The benchmark code has a feature where packet alignment can be adjusted by the processor vendor at compile time. This adjustment couldn't be done with the version 1.1 benchmarks without changing the amount of work that was accomplished. Version 2.0 fixes that problem.



In version 2.0 there are four buffer sizes that are used 0.5, 1, 2 and 4 Mbytes. The 4 Mbyte buffer size was not reported in the version 1 Packet Flow benchmarks.

The 750GX achieves 40574, 18339, 9102 and 4513 iterations per second in the IP Packet Check 0.5M, 1M, 2M and 4M benchmarks. Its 1 Mbyte L2 cache and 200 MHz system bus make the 750GX a prime choice for this type of application.



QoS Benchmark

The Quality of Service benchmark is new for version 2.0. The benchmark is based on NetBSD and simulates the processing undertaken by bandwidth management software used to "shape" traffic flows to meet Quality of Service (QoS) requirements. Because it is based on NetBSD, it is likely to match real networking applications.

The 750GX achieves 190 iterations per second for the QoS benchmark.The benchmark is very compute-intensive and the code and data accesses easily fit within the L1 caches.



IP Reassembly Benchmark

The IP reassembly benchmark simulates the reassembly process that must occur when large IP packets are fragmented into multiple frames. This benchmark is also derived from NetBSD.

About 80% of the IP Reassembly benchmark's instructions are equally divided between load/store and compare/branch. The combination of its Power Architecture instruction set and its 1 Mbyte L2 cache help the 750GX achieve a high score of 3315 iterations per second on this benchmark.



NAT Benchmark

The Network Address Translation benchmark simulates work done by a router when one address group must be translated to another address group. This code is also based on NetBSD.

The instruction mix for the NAT benchmark is similar to that of the IP Reassembly benchmark, except with a few multiply and divide instructions (included in the pie chart as part of "Other"). As in the IP Reassembly benchmark, the combination of its Power Architecture instruction set and its 1 Mbyte L2 cache help the 750GX achieve a high score. The 750GX scores 3767 iterations per second on the NAT benchmark.



TCP Benchmarks

The Transmission Control Protocol benchmarks simulate an RFC793 TCP client-server application. Functions included in the benchmark are:

- Data transfer full duplex continuous data stream of octets
- Reliability sequence/acknowledge number
- Flow control queuing and window
- Application layer interface
- Network layer interface

There are three data configurations for this benchmark. TCP Jumbo uses all large packets, TCP bulk uses packets that would be typical in FTP for example and TCP mixed uses a mixture of activity. The 750GX achieves 81115 iterations per second on the TCP Jumbo benchmark, 51974 iterations per second on the TCP Bulk benchmark and 24168 iterations per second on the TCP Mixed Benchmark. A large portion of the instructions are data loads and stores. The 750GX's L2 cache 750GX improves the TCP Jumbo benchmarks, somewhat improves the TCP bulk benchmark and has almost no effect on the TCP mixed benchmark.



The main problem with this benchmark is that almost 70% of the time is spent in the memset function. memset is a C library function which is not typically called when coding for speed. The benchmark code calls memset to zero-out portions of memory. When using IBM's EPOS (Embedded PowerPC Operating System) to perform a similar function, there were no calls to memset. The TCP code in EPOS is based on NetBSD.

Conclusions

The long awaited release of EEMBC Networking Version 2.0 benchmarks is here and IBM is one of the first in line to show off its newest member of the PowerPC 7xx family of processors.

The following table summarizes the EEMBC Networking Version 2.0 benchmark scores for 750GX at 1 GHz. It also includes the impact of disabling the 750GX's L2 cache





Table 1. 750GX Benchmark Scores

| | Iterations per second | L2 cache disabled |
|----------------------------|-----------------------|----------------------|
| TCP Jumbo | 81115 | 74% |
| TCP Bulk | 51974 | 18% |
| TCP Mixed | 24168 | 0% |
| IP Packet Check (0.5MB) | 40574 | 30% |
| IP Packet Check (1MB) | 18339 | 67% |
| IP Packet Check (2MB) | 9102 | 70% |
| IP Packet Check (4MB) | 4513 | 70% |
| QoS | 190 | 0% |
| Route Lookup | 5815 | 1% |

Table 1. 750GX Benchmark Scores

| | Iterations per second | L2 cache disabled |
|-----------------------|-----------------------|----------------------|
| OSPF (Version 2) | 3007 | 0% |
| IP Reassembly | 3315 | 62% |
| NAT | 3767 | 71% |
| TCP _{mark} ™ | 467.1 | |
| IP _{mark} ™ | 286.1 | |

With the combination of its Power Architecture instruction set, large level one and two caches and high clock speed, the 750GX does very well on all of the EEMBC benchmarks, but this newest release from EEMBC gives you a better idea of what it can do in a real networking application.



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EEMBC_NetV2_app.fm.00 September 16, 2004