THE TOLLY GROUP

No. 203124 September 2003

Intel® Corporation

Ultra Low Voltage Intel® Celeron® Processors at 650 MHz and 400 MHz

Competitive Performance Evaluation versus VIA Technologies Mini-ITX EPIA M10000 and EPIA ME6000 CPUs

Test Summary

***Premise**: Architects of PC and embedded products need to know the comparative CPU processing power and memory access characteristics of various "motherboards" that they are considering as base platforms for their value-added offerings in order to make an informed decision as to the relative value propositions of competing products and vendors.*

Intel Corporation commissioned The Tolly Group to benchmark the performance of its Ultra Low Voltage Intel® Celeron® processors operating at 400 MHz and 650 MHz alongside a pair of VIA Technologies, Inc. mainboard CPUs: the EPIA M10000 C3 Nehemiah and EPIA M6500 C3 Samuel 2.

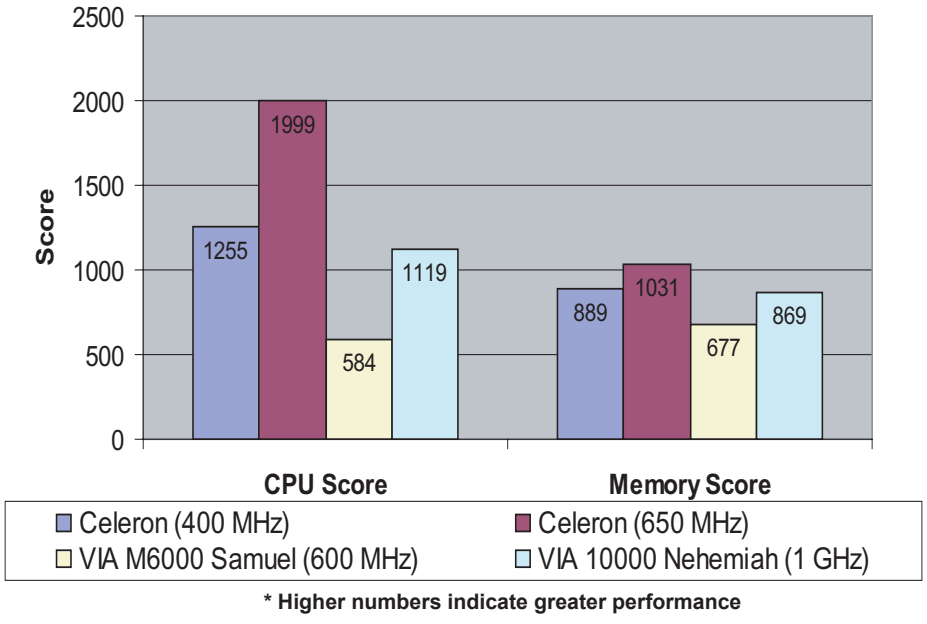
The Ultra Low Voltage Intel Celeron processors operating at 650 MHz and 400 MHz are designed for embedded systems applications that include storage devices, such as entry-level network attached storage, and industrial computing, such as ruggedized computer systems used in manufacturing environments.

Engineers subjected all four devices to a battery of benchmark tests exercising the full range of capabilities of the devices. Performance comparisons were drawn from the devices that were subjected to industry-standard tests utilizing the PCMark 2002 (Futuremark Corp.), SANDRA (SiSoftware Ltd.) and SPEC CPU2000 V1.2 (Standard Performance Evaluation Corp.) benchmarks.

Test Highlights

- Ultra Low Voltage Intel® Celeron® processors at 650 MHz and 400 MHz outperform 1-GHz VIA Technologies Nehemiah processor at significantly less cost during PCMark 2002 benchmark tests
- Ultra Low Voltage Intel Celeron processors at 650 MHz and 400 MHz respectively surpass the performance of the VIA Technologies processors during SANDRA arithmetic benchmark tests
- Significantly outperforms VIA Technologies products in SANDRA CPU multimedia benchmark tests, again with the Ultra Low Voltage Intel Celeron processor at 650 MHz delivering double the performance of 1-GHz VIA-1000 C3 Nehemiah CPU in floating point tests

Comparison of CPU Performance Benchmark
- PCMARK 2002* -



*** Higher numbers indicate greater performance**

Source: The Tolly Group, September 2003 *Figure 1*

Tests reveal that even with less CPU clock speed than the VIA Technologies devices, the Ultra Low Voltage Intel Celeron processors operating at 400 MHz and 650 MHz consistently outperform the competitive products tested, demonstrating that Intel delivers greater CPU bang for the buck.

Results

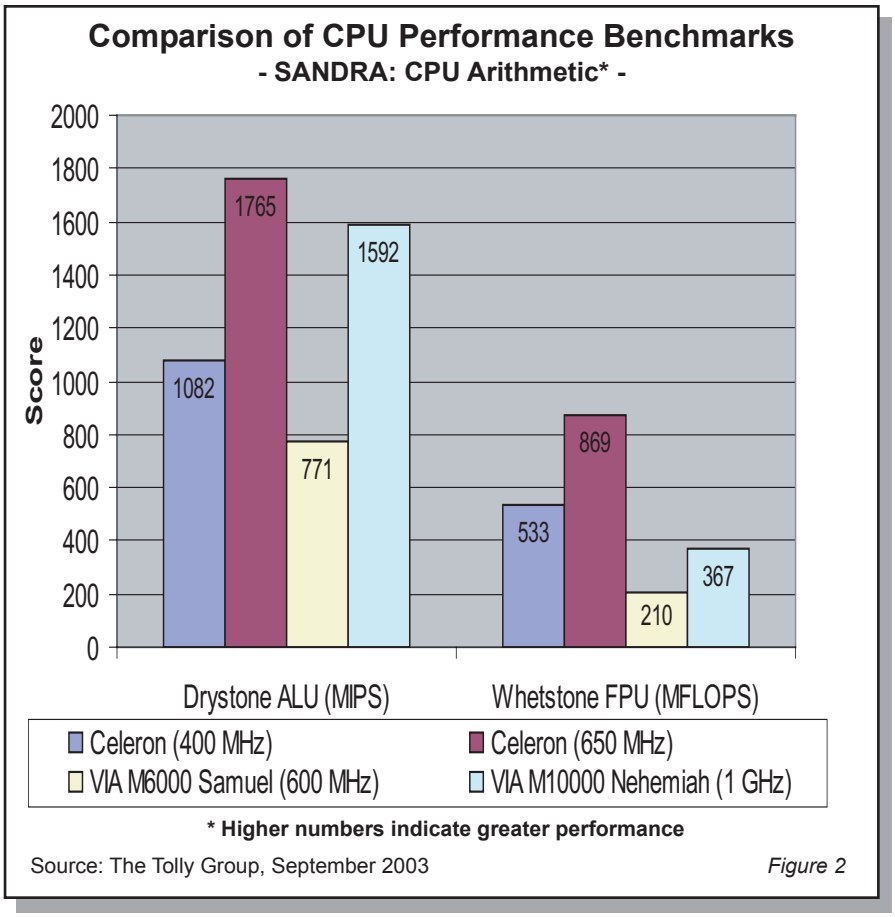
PCMark 2002 Tests

Engineers conducted six CPU and 25 memory tests each on the four devices. CPU performance scores clearly were in favor of the Ultra Low Voltage Intel® Celeron® processors as per the results generated by the CPU score and memory scores derived from PCMark 2002 tests. The 400-MHz version of the Ultra Low Voltage Intel Celeron processor yielded a CPU score of 1,255, outperforming the 1-GHz VIA Technologies' C3 Nehemiah by about 12%, which yielded a CPU score of 1,119. (see Figure 1.) Scores for the memory tests conducted on both devices show that the Ultra Low Voltage Intel Celeron processor at 400 MHz achieved a mark of 889 versus 869 for the 1-GHz VIA Technologies C3 Nehemiah. Meanwhile, the Ultra Low Voltage Intel Celeron processor at 650 MHz generated a CPU score of 1,999 and a memory score of 1,031, posting the best performance among the four devices under test.

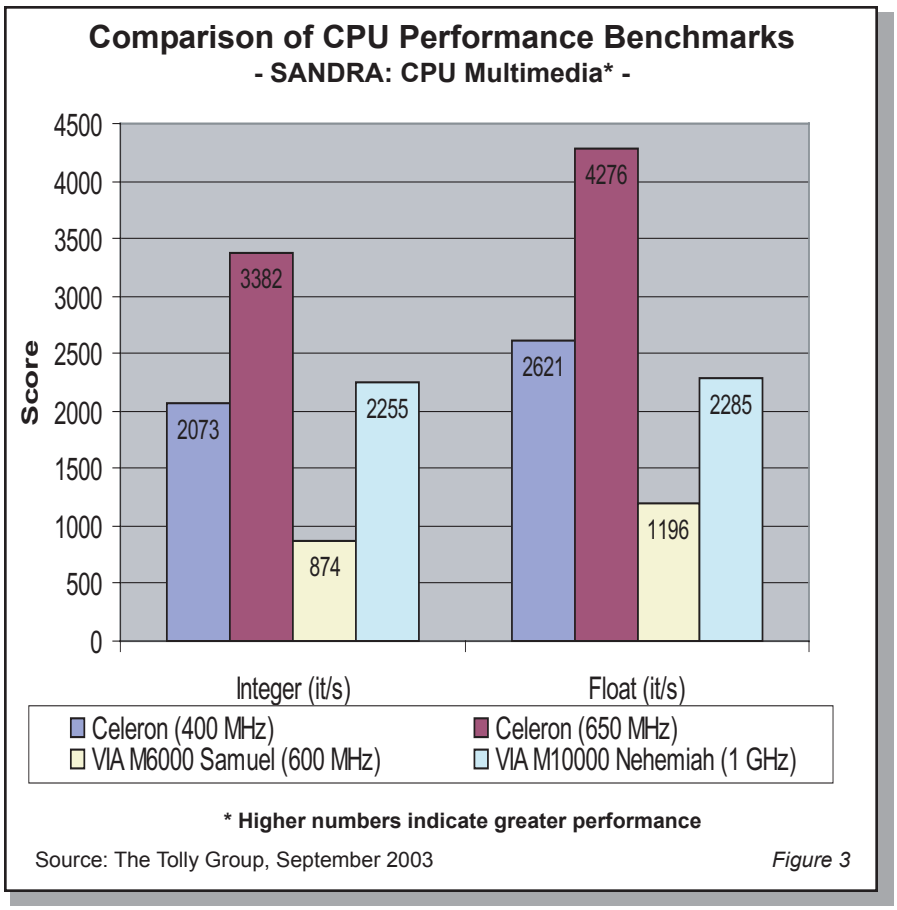
SANDRA Benchmarks

Engineers conducted tests in three areas: a CPU arithmetic benchmark, a CPU multimedia benchmark and a memory bandwidth benchmark.

For the integer-based arithmetic benchmark, Drystone ALU, the Ultra Low Voltage Intel Celeron processor at 650 MHz generated the highest score - 1,765 - followed by the VIA Technologies C3 Nehemiah, the



Source: The Tolly Group, September 2003 *Figure 2*



Source: The Tolly Group, September 2003 *Figure 3*

Ultra Low Voltage Intel Celeron processor at 400 MHz and the VIA Technologies Samuel 2 processor. For the floating point-based benchmark, Whetstone FPU, the Ultra Low Voltage Intel Celeron processors performed well compared to the VIA devices. (See Figure 2.)

For the CPU multimedia benchmarks provided by the SANDRA suite, the Ultra Low Voltage Intel Celeron processor at 650 MHz lead all devices again for both the integer-based and floating point-based benchmarks with scores of 3,382 and 4,276, respectively. (See Figure 3.) Tests scores on the multimedia benchmarks demonstrate better performance of the Ultra Low Voltage Intel Celeron processors compared to the VIA Technologies devices.

In the SANDRA memory bandwidth benchmarks, the VIA Technologies 1-GHz C3 Nehemiah generated a maximum score of 743 for the integer-based RAM bandwidth benchmark, while the Ultra Low Voltage Intel Celeron processor at 650 MHz generated a score of 551. (See Figure 4.) There was, however, a difference in RAM memory used in the Intel® platforms that used PC133 SDRAM and Via Technologies platforms that used DDR266.

SPEC CPU2000 Benchmarks

With respect to both the compute-intensive integer and floating-point performance, the Ultra Low Voltage Intel Celeron processor at 650 MHz generated the maximum scores with values of 276 and 198 respectively for both tests. (See Figure 5.) The VIA Technologies C3 Nehemiah performed slightly better than Ultra Low Voltage Intel Celeron processor at 400 MHz in the SPECint_base2000 test with a value of 217 versus 201 for the Ultra Low Voltage Intel Celeron processor at 400 MHz. But, for SPECfp_base2000 benchmarks, the Ultra Low Voltage Intel Celeron processor at 400 MHz delivered better performance with a score of 162 versus the VIA Technologies C3 Nehemiah's 129. The VIA Technologies C3 Samuel 2 demonstrated the lowest performance scores among all the devices tested.

Analysis

Test results show that processor clock speed, alone, is not a proven arbiter of overall performance. Operating at almost one-third less the clock speed of the VIA Technologies 1-GHz EPIA M10000, Intel's Ultra Low Voltage Intel® Celeron® processor at 650 MHz delivers greater performance consistently across the PCMark, SANDRA and SPEC CPU2000 tests.

In the PC Mark 2002 tests, both the Ultra Low Voltage Intel Celeron processors at 650 MHz and 400 MHz outperform the 1-GHz VIA Technologies C3 Nehemiah - in both CPU and memory score tests. Such extra performance headroom assures developers the processor can accommodate surges in load without jeopardizing system design.

Looking at the results of CPU Arithmetic and CPU Multimedia benchmarks from SANDRA, the Ultra Low Voltage Intel Celeron processor at 400 MHz scored lower compared to 1-GHz VIA Technologies C3 Nehemiah in integer-based benchmarks, but outperformed it in the case of floating point-based benchmarks. This could be attributed to the basic architectural differences of the two processors and thus the way the basic instructions are performed in these devices. With respect to the Memory Bandwidth integer-based benchmark, the Ultra Low Voltage Intel Celeron processors at 650 MHz and 400 MHz held their own against the VIA Technologies C3 Nehemiah, earning scores of 564 and 551, respectively, to the Nehemiah's 743. Meanwhile, the VIA Technologies C3 Samuel 2,

Intel® Corporation

Ultra Low Voltage Intel® Celeron® processor at 650 MHz and 400 MHz

CPU Performance Validation

TOLLY Up to Spec CERTIFIED

Intel® Corporation
Ultra Low Voltage Intel® Celeron® processor at 650 MHz and 400 MHz
Product Specifications*

The Ultra Low Voltage Intel Celeron processors provide an exceptional value for thermally sensitive and space-constrained embedded computing applications by combining the optimal balance of cost, performance, and low power. The processors are the ideal solution for communication appliances such as network attached storage, Web pads and other applications with lower power envelopes and BOM requirements.

Features

- Built on the Intel® 0.13 micron process
- 256K full-speed on-die Layer 2 Cache operating at core frequency
- Low-profile, surface-mount µFCBGA package
- µFCBGA package (35 x 35 mm)
- 479 balls in area array
- Tjunction: 0º to 100ºC
- MMX™ technology
- Floating Point Unit (FPU)
- Dynamic Execution Micro-Architecture
- On-Die L2 cache with Error Checking and Correcting (ECC)
- 100 MHz processor side bus
- 400 MHz has 4.2W TDP (max), 3.75W TDP (typ)
- 650MHz has 8.3W TDP (max), 7.0W TDP (typ)

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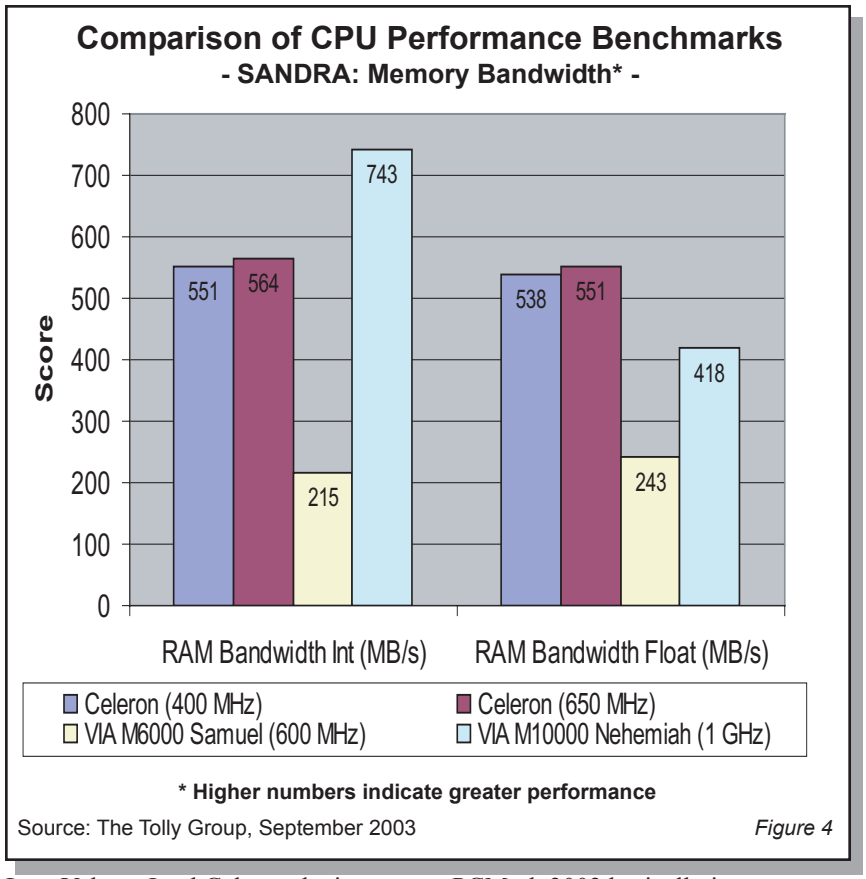
**Vendor-supplied information not verified by The Tolly Group*

with a speed of 600 MHz, scored just 215. All devices posted similar performance with respect to the float-based bandwidth benchmark, except in case of VIA C3 Nehemiah, which achieved a score of 418.

From the results of the SPEC CPU2000 suite benchmarks executed on the Ultra Low Voltage Intel Celeron processors and the VIA Technologies C3 processors, it is evident that the Ultra Low Voltage Intel Celeron devices performed better in integer-based and floating point-based benchmarks than the VIA Technologies devices. The VIA devices have comparable performance scores for most of the integer-based benchmarks, but are inferior in the case of floating-point-based benchmarks as reflected by the test scores.

The reason could be attributed to platform-based features of these devices, especially caching capabilities. Benchmark scores are always disputable, as they are based upon simulated workloads, never real workloads. Therefore, the actual performance of the processors should be assessed based on real applications and the benchmarks should be a guideline to make a performance comparison.



Source: The Tolly Group, September 2003 *Figure 4*

Test Configuration and Methodology

For performance tests, The Tolly Group tested Ultra Low Voltage Intel® Celeron® processor at 650 MHz and 400 MHz, model PEB-3632VL2A, a device outfitted with 512 MB of PC133 SDRAM memory and a 512 KB Layer 2 memory cache. The Ultra Low Voltage Intel Celeron devices were housed in a 5.25" EBX form factor with a Maxtor Fireball3 ATA 133 30-Mbyte hard drive, with the system running Windows XP Pro/XP1.

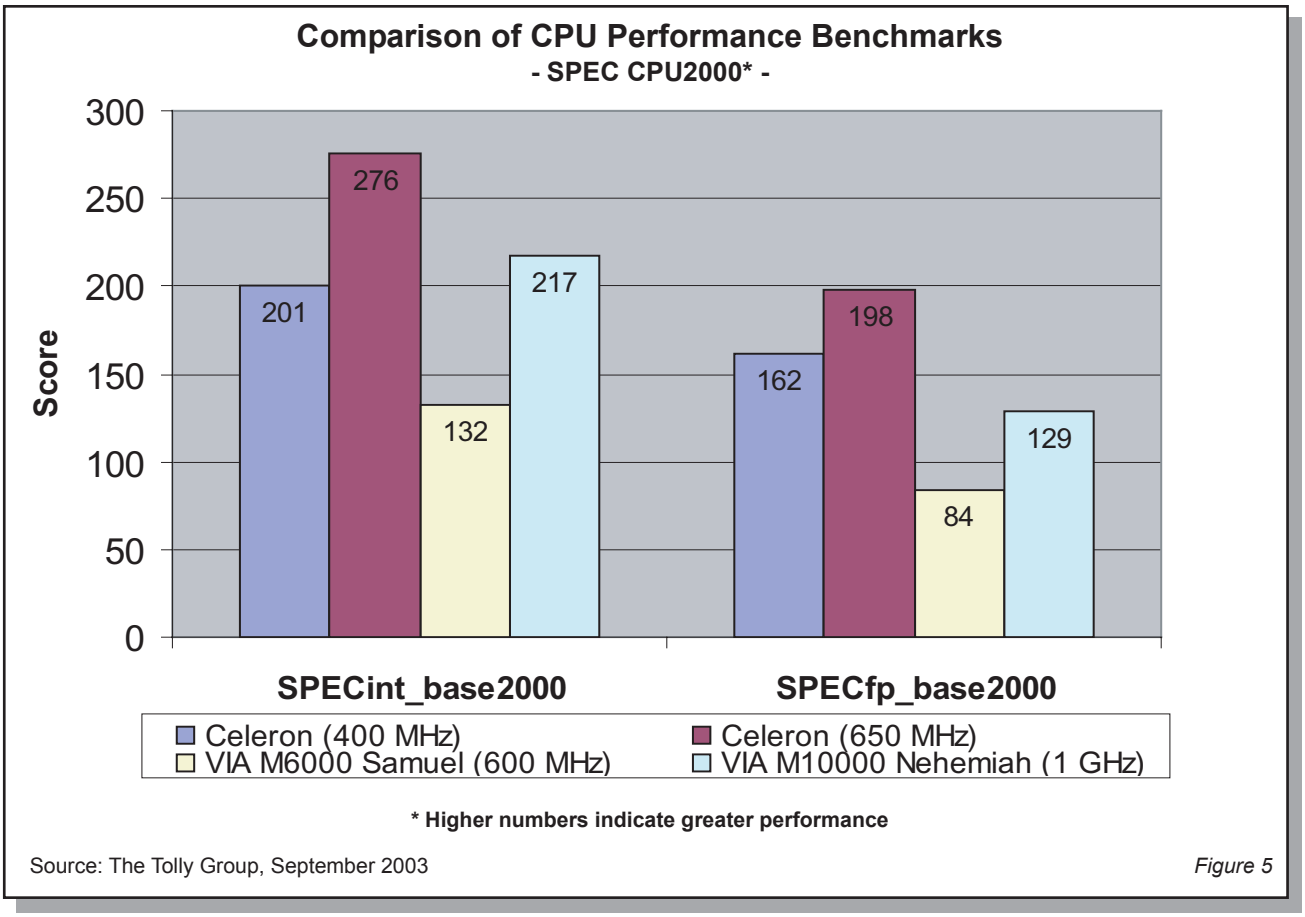
The Tolly Group tested the Ultra Low Voltage Intel Celeron devices against a pair of VIA Technologies VIA C3 processors - the ME10000 and ME6000. The ME10000 is a 1-GHz C3 Nehemiah processor outfitted with 512 MB of DDR266 RAM, a 128-KB Layer 1 cache and 64-KB Layer 2 cache. The ME10000 Nehemiah processor was housed in a 170mm by 170mm mini-ITX form factor. Like the Ultra Low Voltage Intel Celeron configuration, the VIA Technologies processors utilized a Maxtor Fireball3 ATA 133 30-Mbyte hard drive, with the system running Windows XP Pro/XP1. The ME6000 is a 600-MHz processor configured identically to the ME10000 described above.

Each device was subjected to the following tests independently using the exact same steps with the following industry standard benchmarks. Each test was run for three iterations in order to improve the accuracy of performance analysis.

PCMark 2002

PCMark 2002 basically is a component-level benchmark developed and distributed by Futuremark. It is designed to be a unified benchmark to test PCs on any platform, specifically geared towards home and office users (laptops, desktops and workstations). More information on PCMark 2002 is available at www.futuremark.com

In these tests, the algorithms used to measure six CPU-specific tests stressed both the integer and the floating-point unit and included some Intel® Streaming SIMD Extensions (SSE) and SSE2 optimizations. They are designed to test the performance of the processors where cache size is one of the major parameters affecting processor performance. In the 25 memory tests conducted, different operations were performed using several different block sizes in order to determine the speed of Layer 1 and Layer 2 cache as well as system memory. These operations were read, write, read-modify-write and random access.



Source: The Tolly Group, September 2003

Figure 5

The overall CPU and memory scores were calculated based on the performance of the processor with these individual benchmarks.

The tests were conducted as per the instructions provided by the test tool. The desired benchmarks were selected and executed.

Test results were recorded as the aggregate and individual scores generated by the test tool. Three test runs were executed and the average of the results was used for the analysis and comparison of different processors under consideration.

SANDRA

SiSoftware SANDRA (the System Analyzer, Diagnostic and Reporting Assistant) is an information and diagnostic utility. The SANDRA suite basically consists of three benchmark sets: CPU Arithmetic Benchmark, CPU Multimedia Benchmark and Memory Bandwidth Benchmark. This tool measures the processor performance scores based on both integer and floating point based measurements. More information on the SANDRA benchmark is available at www.sisoftware.co.uk

For the SANDRA benchmark, engineers employed the following tests: on the CPU arithmetic side, the Drystone ALU (MIPS) and the Whetstone FPU (MFLOPS) were used. For the CPU multimedia benchmark, engineers used Integer and Floating Point tests to measure the processors' instruction per second (it/s) rate.

Tests were conducted as per the instructions provided by the test tool. The desired benchmarks were selected and executed.

Test results were recorded as the aggregate and individual scores generated by the test tool. Three test runs were executed and the average of the results was used for the analysis and comparison of different processors under consideration.

SPEC CPU2000

The SPEC benchmarks are published by the Systems Performance Evaluation Cooperative and consist of a group of codes that are run on various computers by the hardware vendors to compare the speed of different computers. SPEC CPU2000 focuses on compute-intensive performance, which means these benchmarks emphasize the performance of the computer's processor (CPU), the memory architecture, and compilers. SPEC CPU2000 provides a comparative measure of integer and/or floating point compute intensive performance. The benchmark codes are selected so that they represent different types of calculations and they are an excellent indication of the cumulative performance of a computer. The source codes are written in FORTRAN, C, C++ and hence needed compilers should be installed in the device under test for compiling the codes. The ratio for each of the benchmarks is calculated using a

SPEC-determined reference time and the run time of the benchmark. For SPEC CPU2000, the reference machine is a Sun Ultra5_10 workstation with a 300-MHz SPARC processor and 256MB of memory, and this machine is given a SPECint2000 and SPECfp2000 score of 100. More information on this test tool is available at www.spec.org/cpu2000

Tests were performed to obtain benchmark scores for the four processors under consideration with identical test conditions. Intel provided the configuration files for the SPEC measurements with the same flag settings for both Intel and VIA Technologies devices.

Engineers generated measurement scores by executing all the benchmarks provided by the tool on all the devices under consideration. The scores of SPECint_base2000 and SPECfp_base2000 were used for performance comparison of the devices. The larger the SPECFP or SPECINT number the faster the computer.

Tests were conducted as per the instructions provided by the test tool. The desired benchmarks were selected and executed.

Test results were recorded as the aggregate and individual scores generated by the test tool. Three test runs were executed and the average of the results was used for the analysis and comparison of different processors under consideration.

The Tolly Group gratefully acknowledges the providers of test equipment used in this project.

Vendor	Product	Web address
Futuremark Corp	PCMark 2002	www.futuremark.com
SiSoftware Ltd.	SANDRA	http://www.sisoftware.net/
Standard Performance Evaluation Corp.	SPEC CPU2000 V1.2	http://www.specbench.org/

Tolly Group Services

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Project Profile

Sponsor: Intel® Corporation
Document number: 203124
Product Class: Processors for small form factor boards
Products under test:

- Intel Corporation Ultra Low Voltage Intel® Celeron® processors at 650 MHz and 400 MHz
- VIA Technologies 1-GHz C3 EPIA M10000 Nehemiah
- VIA Technologies 650-MHz C3 EPIA M6500 Samuel 2

Testing window: July/August 2003
Software status:

- Generally available

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