SPARCstation 10SX System Performance

Technical Brief
version 1.1

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Introduction

Selecting the right graphics platform is critical to deliver the best application performance for the task at hand. But measuring performance, and just as important, evaluating that performance, is often an uncertain endeavor fraught with compromise.

As standard system and graphics benchmarks have emerged over the last few years, workstation vendors have found new cause for agreement in developing common, broadly defined measures of system performance. This technical brief explores the performance metrics associated with Sun's SPARCstation 10SX graphics workstation.

Product Highlights

The SPARCstation™ 10SX™ represents an revolutionary approach to the requirements of graphics applications, providing balanced acceleration for both imaging and geometry. Residing directly on the CPU-memory bus, the SPARCstation 10SX memory controller and rendering engine, called the SMC, can perform extremely fast transfer of data from physical memory (DRAM) to the frame buffer. This architecture serves to increase the image transfer rate by more that ten times the equivalent processor technology residing on an I/O bus. The close-coupling of the SMC to the SPARCstation 10 CPU further enables floating point-based graphics computation to utilize the high-performance transformation capabilities on the SPARC processor.

The SMC acts as a *vector integer coprocessor* working in a balanced fashion with the host processor. The SMC provides pixel and vector manipulation logic, which complements the floating-point computational capability of the CPU. The SMC's direct access to physical and display memory additionally provides flexible and powerful capabilities for the management, manipulation, and display of large image sets.

The SPARCstation 10SX system was designed to leverage significant advances in multiprocessor bus design, high-performance RISC technology, and graphics integration. The development of the SPARCstation 10SX system represents a new standard in integrated graphics, delivering the broadest graphics computation and rendering capabilities of any system to date.

The SMC processor extends the functionality of the standard memory control found on MBus-based systems by incorporating logic for arithmetic and logical operations, vector (multiple) instruction support, multipurpose registers, and a variety of other high-level computational features.

Graphics Interfaces

The SPARCstation 10SX system is supported by all Solaris graphics and window systems APIs, including the XGL, XIL libraries, Display PostScript (DPS), and the OpenWindows Version 3.3 (X11 R5) window system. Industry-standard X-extension libraries, such as Xlib and PEXlib, are also available and are accelerated via the XGL and XIL foundation graphics libraries. Emerging standards such as the X Imaging Extension (XIE), together with its related API, will be supported in the future.

The SPARCstation 10SX processor delivers broad performance to a large range of graphics and imaging functions. These functions represent common operations for both geometry and raster-based graphics rendering, which are accelerated through Sun's low-level APIs such as the XGL, XIL, and Direct Xlib libraries. Additional, 3rd-Party APIs layered above the XGL, XIL, and Direct Xlib libraries, will provide performance corresponding to the level of optimization at which they were ported. In general, most layered APIs experience substantial performance boosts using the SPARCstation 10SX system over common unaccelerated frame buffers.

General Imaging Performance

To address the independent requirements of many market segments, the SPARCstation 10SX graphics technology was designed to employ features that allow it to accelerate the low-level rendering operations common to all graphics accelerator devices. In addition, the unique coupling within the SPARCstation 10SX system between the SX Memory Controller (SMC) and SPARC CPU enable direct access to system and display memory in such a way as to also provide acceleration for image manipulation.

Table 1 shows the approximate performance metrics for the SPARCstation 10SX Model 40 with 8 MBytes of video memory. Common imaging operations, such as pan, zoom, blend and convolution are supported directly on the SPARCstation 10SX directly through the Solaris XIL Imaging Library.

Operation	Pixel Rate[1] (32-bit)
Zoom 200% (3 Bands[2])	19.32 MPixel/sec
Fill (3 Bands)	48.65 MPixel/sec
Pan (3 Bands)	19.69 MPixel/sec
Pan (1 Band)	65.62 MPixel/sec
Rotate 45 deg (3 Bands)	2.42 MPixel/sec
Monadics (3 Bands)	6.85 MPixel/sec
Monadics (1 Band)	23.39 Mpixel/sec
Dyadics (3 Bands)	4.83 MPixel/sec
Dyadics (1 Band)	16.90 MPixel/sec
Blend (3 Bands)	1.86 MPixel/sec
Convolve (3x3 8-bit Separable)	4.66 MPixel/sec
Convolve (5x5 Separable)	2.58 MPixel/sec
Lookup (16-bit to 8-bit)	6.31 MPixel/sec
Lookup (8-bit to 8-bit)	7.84 MPixel/sec

[1] 32-bit, except where otherwise specified
[2] Bands refer to individual color segments of an image (e.g., RGB images have 3 bands)

Table 1 SPARCstation 10SX Imaging Performance

Geometry Graphics Performance

Graphics images are built from pixel representations of vectors and polygons. Graphics systems are designed to maximize the speed at which these elements are created. Since they are the building blocks of images, they are sometimes referred to as graphics primitives. Primitive operations include creation of 2-D and 3-D vectors and 3-D polygons, strips, and meshes. Various properties are attached to primitive objects such as color, spatial orientation, number of pixels, shading, and light source. Use of properties varies with the application. For example, solids modeling requires more properties than wire frame. The more properties required, the more processing power is required to generate an image.

The rate at which these primitive operations can be completed underlies the rate at which images are created. Thus primitive operation benchmarks can help to characterize the performance that can be expected from a graphics system. Although all graphics vendors recognize the utility of primitive operation benchmarks in product positioning, there is no accepted convention for running these benchmarks. Thus the rate reported by one vendor for a type of operation may have a different meaning than that reported by a second vendor because the definition of properties may not be the same. In order to facilitate comparison with competing products, SPARCstation 10SX results conform, wherever possible, to the conditions used in other vendor's tests. Reporting conditions vary widely among manufacturers. *The results included below are for general guidance only.*

To eliminate any effect that orientation might have on performance, both vector and triangle primitive operations are rotated through many different angles to arrive at an average value. Similarly, the primitive objects are translated across the display screens x-axis to smooth out any performance peaks that might result from a given locale in the frame buffer. Primitive operations for 3-D geometry are run through the XGL graphics library. A primitive is drawn repeatedly for two seconds and the result is reported in primitive operations/second.

To achieve optimum geometry performance, the SPARCstation 10SX SMC processor supports 'vector' instructions, that is, ones that perform a sequence of operations. This allows the SMC's instruction bandwidth across the MBus to be relatively low compared to the SPARC CPU — usually on the order of 20-25%. Many functions can be trivially vectorized, while others may possibly be recast into vector form with some analysis.

On a SPARCstation 10SX system, the video memory (VRAM) and dynamic memory (DRAM) are in the same physical address space, so the SMC processor can accelerate pixel operations on both of them. When the SMC has physically contiguous blocks of memory to operate on, it can avoid the overhead of page boundary checking. This provides further performance optimization. Certain classes of rendering, in particular, rendering vectors to an off-screen image, or maintaining a Z-buffer, benefit by reserving some system memory for the exclusive use of the SMC at boot time.

Performance at a Glance

The primitive performance results in the following tables reflect a summary of the standard benchmarks for the SPARCstation 10SX. These values represent common tests defined by the X11perf, GPC and other standards for graphics and related tasks.

GBench

GBench is a Sun-specific benchmark designed to indicate geometry graphics performance. It uses the XGL graphics library, and provides an effective comparison to raw performance numbers from other graphics workstation vendors.

Gbench uses 10 pixel vectors for 2-D and 3-D measurements. 3-D polygons employ 50 pixel Gouraud-shaded, Z-buffered, unlit triangle strips. Table 2 lists the GBench benchmark results for the SPARCstation 10SX Model 40 and 51.

Test	SPARCstation 10SX Model 40 (0 MByte)[1]	SPARCstation 10SX Model 40 (8 MByte)[1]	SPARCstation 10SX Model 51 (0 MByte)[1]	SPARCstation 10SX Model 51 (8 MByte)[1]
GBench (XGL)				
2-D Vectors	545,000	545,000	495,000	495,000
3-D Vectors	289,000	289,000	330,000	330,000
3-D Polygons	30,500	30,5000	20,500	20,500

[1] SPARCstation 10SX memory allocated to graphics operations

Table 2 GBench Benchmark Results

Standard Benchmarks

The following sections describe industry-standard systems and graphics benchmarks for UNIX workstations running the X Windows environment. Each benchmark possesses specific constraints or limitations that define its applicability to a system and how the benchmark should be used in evaluation.

X11perf

X11perf, developed in 1987, provides a balanced measure of X-based systems performance than previous benchmarks (such as Xstones) in that it tests four general categories of operations including basic graphics, window management, terminal emulation, and X-specific operations. For example, X11perf measures common requests such as line draw, copy area, map window, and scroll, as well as uncommon requests such as XOR-mode 100-pixel wide double-dashed ellipse drawing.

This benchmark is also designed to produce repeatable results. Each test is short and is run over 200,000 times. The benchmark software runs the test, averages, and calibrates the results, and then determines a fixed amount of time during which it will rerun the test to produce the final results.

Although X11perf is a more balanced and repeatable measure of X systems performance, it generates large amounts of data that are very difficult to interpret. In addition, each result carries the same relative importance, which may not reflect the actual importance of the operation to the user. Thus, the X Windows community created a consortium to define a benchmark that is balanced, repeatable, considers the relative importance among tests, and produces a single result.

The X Performance Characterization (XPC) group is a project of the Graphics Performance Characterization (GPC) committee of the National Computer Graphics Association (NCGA). It is a nonprofit organization comprised of vendors, users, and consultants that establishes, maintains, and endorses standardized benchmarks for measuring X-terminal performance. The group's goal has been to provide an unambiguous test for comparing the performance of hardware operating in X Windows environments. On June 8th, 1993 the XPC announced the Xmarks benchmark.

The X11perf Geometric Mean test is the geometric mean of the results from the five categories of X11perf v1.2 tests. Table 3 lists the X11perf benchmark results for the SPARCstation 10SX Model 40. Each category in this test represents a particular component of X11 performance:

- General Graphics
  Dot, rectangle, line, circle, ellipse, and polygon
- Terminal Emulation
  Text and scrolling
- Window Management
  Copyarea, copyplane, getimage, and putimage
- X-Specific Operations
  Noop, getatom, getproperty, changeGC, and all window manipulation measurements
- 500-Pixel Operations
  All operations involving manipulation of 500-pixel elements

SPARCstation[1] System/ Benchmark Test	**SPARCstation 10SX (8 bit mode)**	**SPARCstation 10SX (24 bit mode)**
Dot	3,170,000	2,930,000
10x10 Rectangle	83,200	138,000
500x500 Rectangle	258	198
10-pixel Line	489,000	547,000
Scroll 500x500	96.9	78.2
Copy 500x500 Window	72.8	78.4
PutImage 500x500	88.6	5.0
80 Character (Text)	197,000	195,000
X11perf 1.3 Xmark	3.704	3.704

Table 3 X11perf Benchmark Results

GPC Picture Level Benchmarks

The Picture Level Benchmarks (PLB) are a set of six graphics display performance metrics for use in testing graphics hardware platforms. Rather than measuring primitive performance such as triangle and vector creation rate, the PLB extracts tasks from several different graphics disciplines and specifies the conditions for executing these tasks on a given platform. Each task is chosen to measure a different aspect of graphics performance such as 2-D design, 3-D wireframe performance, and solids modeling. A summary of the six PLB scenarios is presented below.

For each of the six tests, two results are reported: PLB_{lit} (literal) and PLB_{opt} (optimized). The literal results represent performance of unoptimized applications. Due to design constraints, some graphics hardware may perform better than others on certain aspects of the tests. For the literal result, these platforms will be shown at an advantage. In addition applications providers may not be interested in optimizing for many different designs. The literal results apply best to this group. The optimized results reflect changes that have been made to get higher performance from a platform and its interface.

Where ever possible, both literal and optimized results have been included. For those systems whose optimized results are not published in the GPC Quarterly Report, only literal results are shown.

Not all graphics systems have the components needed to run all of the tests. For instance, graphics hardware designed for use in 2-D design has no need for solids modeling features. This does not imply a limitation; only that choices can be made to target a system for a specific type of application. For this reason, vendors may choose not to publish results for all six tests on a given platform.

pc_board The pc_board benchmark is representation of an application in the electrical computer aided design (ECAD) market. The test pans and zooms a printed circuit board layout for 560 frames. The average number of two dimensional vectors per frame is 5655.3 This benchmark also has an average of 6923.8 2-D markers and 882.7 characters per frame.

sys_chassis The sys_chassis benchmark is a wireframe model of a computer chassis. It is representative of the type of data required for 3-D wireframe applications, which are typical applications in the mechanical computer aided design (MCAD) market. The test rotates, pans, zooms and views the model from different perspectives. The chassis model consists of 6107 3-D solid polylines and 158 3-D dashed polylines. The number vertices per polyline ranges from two to 11 with a total of 19064 vectors. The test displays 500 frames total.

cyl_head The cyl_head benchmark is a 3-D solid model of an automobile engine's cylinder head. It is composed of 3621 3-D polygons and 32 3-D fill-areas. There is an average of 4.8 vertices per polygon. The fill-areas have an average of 55.7 vertices per and 2.7 contours per frame. A total of 225 frames are displayed in the test. The head, which is rotated, translated, and zoomed during the test, is displayed in true color RGB. All of the polygons are Gouraud shaded. This benchmark uses three light sources with ambient, diffuse and specular components.

head The head benchmark is a 3-D human head modeled with data generated by a laser scanner. This type of data is typical for such application areas as animation and biomedical. The data set has nearly 60,000 triangles rendered using multiple T-mesh strips. There are four directional light sources. This benchmark generates 240 frames in four rotations around the head's Y-axis.

shuttle The shuttle benchmark depicts the rendezvous of a space shuttle and a satellite. The shuttle and satellite are modeled using quadrilateral meshes, triangle strips, and polygons. There are a total of 3355 facets. The planet model consists of quadrilateral meshes, totaling 5632 facets. Constellation data was derived from the BOSS star catalog and is modeled using 2283 3-D markers. Ambient, directional, and point light sources are used. This benchmark provides an example of low end simulation.

studio The studio benchmark is an architectural walkthrough consisting of 300 frames. The viewer is given a tour of a photo-realistic design studio illuminated with light from a variety of sources. Lighting conditions are generated using precomputed radiosity methods. The file contains 7518 quadrilaterals in eight MULTI-POLYGON3's; the first seven MULTI-POLYGON3's have 1000 quads, the last has 518 quads. There are no light sources; shading is accomplished with the vertex colors present on every quad. No facet data is present in the file.

floor_plan The floor_plan benchmark is typical of data from a 2-D architectural drafting application. It is the floor plan of one story from an office building and contains multiple layers of information such as room layout, furniture, electrical, duct work and safety information. The test pans and zooms over the floor plan for 383 frames with an average of 960.5 2-D multipolygons per frame, seven polygons per multipolygon, and four vertices per polygon. The file also contains 1,481.6 2-D multipolylines with 119,620.9 vectors per frame.

site_plan The site_plan file depicts a 2-D site plan drawing. It pans and zooms for 260 frames over the tracts and roads for a housing development. There are 1,271 2-D multipolylines comprised of 206,593 vectors drawn each frame.

racecar The race_car benchmark is a data set representing a 3-D wireframe model of a race car as seen from different views. Unigraphics 3-D modeling software was used to create the car model which is displayed and animated in four different simultaneous views on the screen. There is an average of 17,917 3-D solid polylines containing 141,934 vectors with 129 color attribute changes per frame. The animation sequence contains 600 frames.

Table 4 lists the PLB benchmark results for the SPARCstation 10SX Model 40 and 51.

Test	SPARCstation 10SX Model 40 (0 MByte)[1]	SPARCstation 10SX Model 40 (8 MByte)[1]	SPARCstation 10SX Model 51 (0 MByte)[1]	SPARCstation 10SX Model 51 (8 MByte)[1]
GPC Benchmark				
pc_board	27.77/31.52	27.77/31.54	33.67/37.57	32.91/37.57
floor_plan	15.84/17.30	15.86/17.14	22.56/33.15	33.18/36.03
site_plan	27.28/29.41	27.30/29.44	33.15/35.83	33.18/36.03
PLB2D	24.03	24.01	29.47	29.80
sys_chassis	12.78/23.63	12.78/23.63	15.10/27.70	15.13/27.74
racecar	17.62/23.32	17.80/22.41	20.64/26.97	20.52/27.04
cyl_head	5.70/10.42	6.36/12.45	6.50/10.83	7.30/11.03
head	16.74/17.34	18.73/19.47	17.05/17.51	17.23/17.61
shuttle	11.25/12.37	11.78/12.96	13.34/14.24	13.56/14.55
studio	15.61/16.99	18.02/19.89	17.32/18.45	17.60/18.81
PLBsurf3D	12.6	14.12	13.75	14.14

[1] SPARCstation 10SX memory allocated to graphics operations

Table 4 GPC Benchmark Results

Comparative Performance of SPARCstation Graphics Systems

The SPARCstation 10SX addresses a wide range of graphics requirements, from technical imaging and prepress to geometry-based electronic design and 3-D computer-aided design. As with any system, the best way to determine applicability and performance for a given set of requirements is to evaluate the applications running on that platform.

Table 3 lists the comparative performance values of the SPARCstation 10SX versus the spectrum of Sun graphics workstations, including the SPARCstation GX, SPARCstation TurboGXplus, and SPARCstation ZX. Benchmark data provided in the table should be considered in the context of the individual benchmark tests which define them. For example, the X11perf benchmark suite represents graphics rendering performance related to the X Windows server, while the GPC and GBench tests measure geometry performance.

SPARCstation[1] System/ Benchmark Test	SPARCstation GX	SPARCstation TGXplus	SPARCstation ZX	SPARCstation 10SX (4 MByte VSIMM) (24 bit mode)
GBench (XGL)				
2-D Vectors	479,000	1,160,000	750,000	545,000
3-D Vectors	344,000	440,000	750,000	289,000
3-D Polygons	—	—	125,000	30,500
X11perf with DXlib				
Dot	1,460,000	1,450,000	330,000	2,930,000
10x10 Rectangle	292,000	542,000	123,000	138,000
500x500 Rectangle	450	4,880	118	198
10-pixel Line	398,000	1,070,000	151,000	547,000
Scroll 500x500	134	423	63.3	78.2
Copy 500x500 Window	83.8	370	63.2	78.4
PutImage 500x500	43.1	42.8	25.5	5.0
80 Character (Text)	464,000	323,000	81,100	195,000
GPC				
GPC - pc_board	25.4/29.6	31.6/37.3	30.0/33.4	27.77/31.54
GPC - floor_plan	26.3/31.9	31.3/38.5	9.8/10.8	15.86/17.14
GPC - site_plan	21.6/22.2	28.1/29.2	28.3/41.7	27.30/29.44
GPC - sys_chassis	15.7/21.7	20.3/30.2	11.5/27.2	12.78/23.63
GPC - racecar	20.2/23.9	20.3/30.2	11.5/27.2	17.80/22.41
GPC - cyl_head	—	—	5.7/39.4	6.36/12.45
GPC - head	—	—	71.2/NA	18.73/19.47
GPC - shuttle	—	—	32.3/36.0	11.78/12.96
GPC - studio	—	—	88.3/NA	18.02/19.98
PLBsurf3D	—	—	51.3	14.12

[1] SPARCstation 10 Model 40

Table 3 SPARCstation Graphics System Comparative Performance

For Further Information

Solaris XGL Reference Manual, SunSoft Inc.

Solaris XGL Programmer's Manual, SunSoft Inc.

Solaris XIL Imaging Library Reference Manual, SunSoft Inc.

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