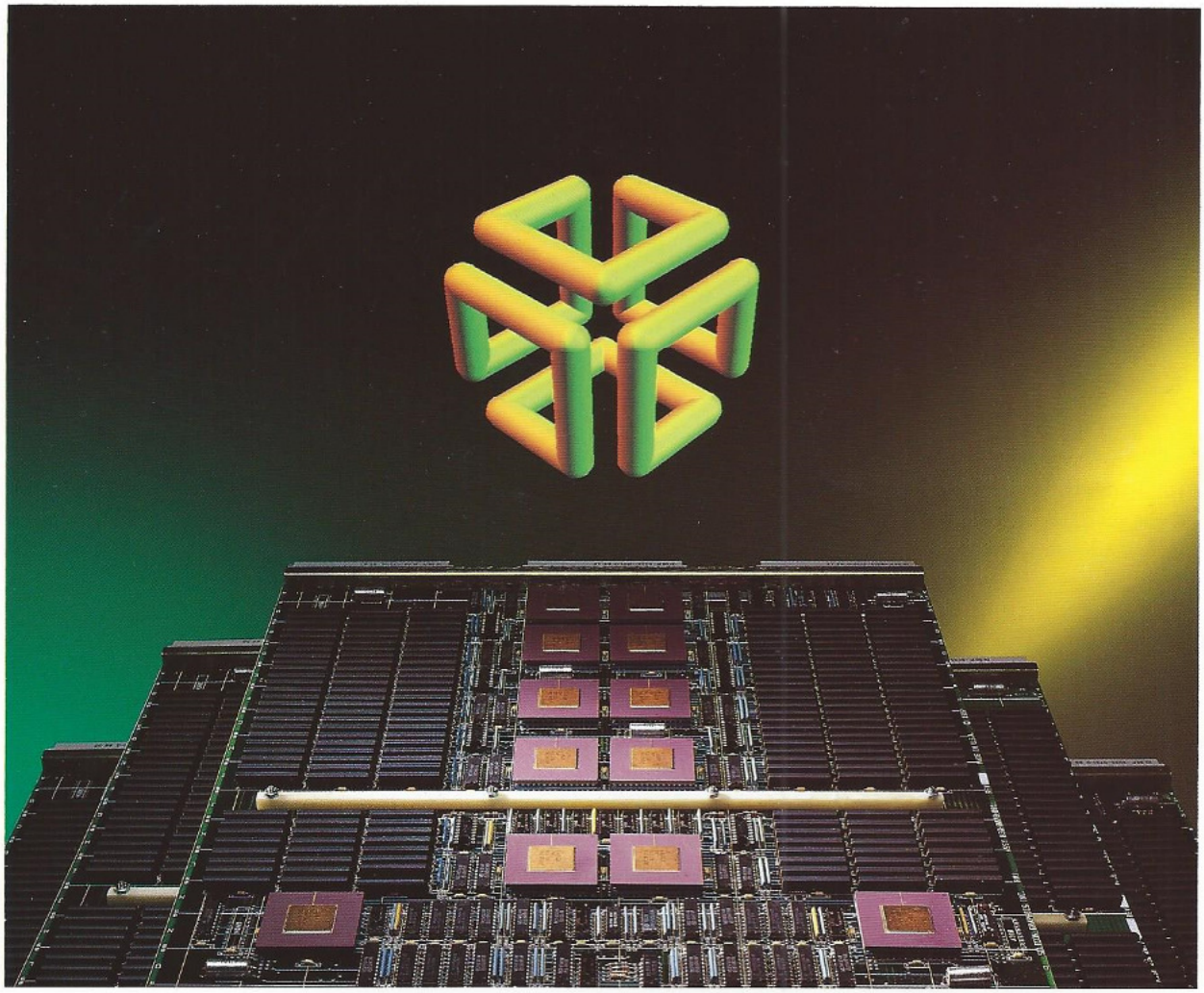


With the IRIS GT, users can render objects like this Silicon Graphics logo and rotate them faster than the eye can register.

The IRIS GT is a set of five printed circuit boards used to upgrade the graphics performance and functionality of Silicon Graphics IRIS-4D Series Superworkstations. With this upgrade, users can experience the benefits of graphics applications never before available on a workstation. The IRIS GT provides an incredible ten-fold increase in the polygon processing rate over rates currently available on the industry-leading IRIS-4D Series Superworkstations.

The IRIS GT combines the latest advances in silicon technology with a new, proprietary frame buffer architecture that incorporates seven new VLSI graphics processors designed by Silicon Graphics. This architecture incorporates 50 of these graphics processors simultaneously, enabling the IRIS GT to render smooth shaded 3D objects in real time with hidden surface removal, lighting and alpha blending.

The architecture provides users with 16.7 million displayable colors in double buffered RGB color mode. Or the user can use double buffered color index mode, with 4096 colors from 16.7 million color palette. A separate Z-buffer allows hidden surface removal to be used in both color modes.

IRIS GT

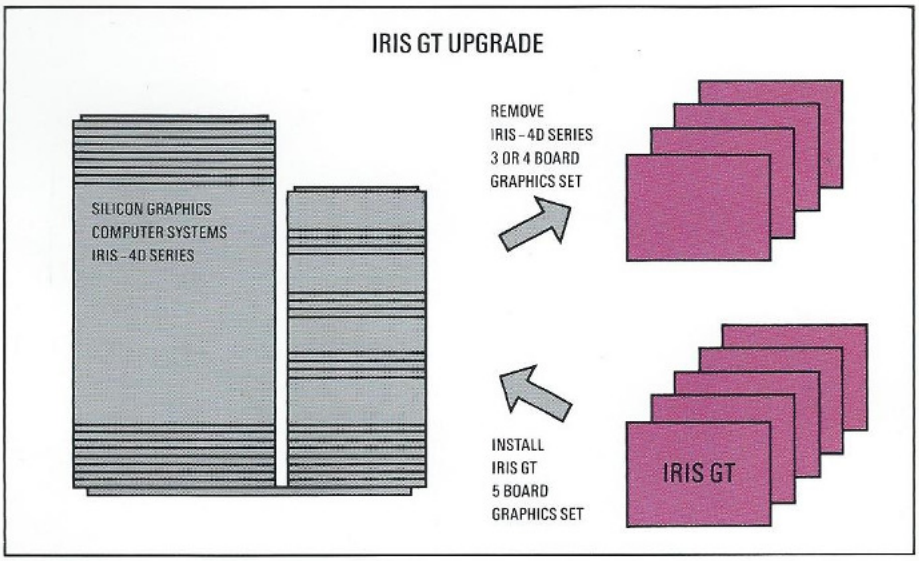
The IRIS GT represents a major breakthrough in display system quality and graphics performance. If you feel that you have been held back by slow drawing rates or inaccurate looking 3D models, the IRIS GT and Silicon Graphics Superworkstations have the graphics power you need.

The IRIS GT includes the following features:

- 64 image bit-planes (including 24 image bit-planes, double buffered and 8 alpha bit-planes, double buffered)
- 24 Z-buffer bit-planes
- 4 bit-planes for overlay or underlay
- 1280 x 1024 screen resolution
- Windowing environment support for multi-mode graphics (single or double buffered; RGB or color map)
- Hardware support for arbitrarily shaped windows
- Hardware support for multiple, colored, local and infinite lights
- Hardware support for diffuse, ambient and specular (Phong) lighting models
- Hardware support for flat and smooth (Gouraud) shading
- Hardware support for anti-aliased lines
- Hardware support for backface polygon removal
- Hardware support for 6-axis clipping
- Hardware support for depth cuing
- Hardware support for pan and zoom of images
- Optional hardware support for Genlock and NTSC/PAL encoding

Advanced Graphics Pipeline

The graphics pipeline of the IRIS GT concurrently performs transformation of points and normals with clipping and perspective division. The pipeline also performs complex calculations for advanced lighting and surface generation. By performing these calculations in hardware, with our proprietary integrated circuits, the graphics pipeline delivers tremendous processing speed when compared to general purpose CPU's. Calculations are carried out using IEEE 32-bit floating point arithmetic for accuracy and precision at a maximum rate of 100 MFLOPS and a sustained rate of 40 MFLOPS for 3D graphics applications. On IRIS 4D/70 with IRIS GT graphics, the graphics pipeline transforms 400,000 3D 32-bit coordinates per second with clipping and perspective division.



The IRIS GT five board graphics set can be installed in the field or factory by removing the three or four board set from the IRIS-4D Series Superworkstations.

The graphics pipeline incorporates five floating point processors and twenty special purpose graphics processors of four types designed by Silicon Graphics.

The pipeline was designed with rendering quality and speed as the most important design criteria. In addition to the geometry calculations performed by the graphics pipeline in the IRIS-4D Series, the IRIS GT's graphics pipeline performs advanced lighting calculations with support for multiple colored light sources and a variety of reflectance models. The graphics pipeline provides users with much more realistically rendered displays in addition to significantly increased performance.

Image Engines and Parallel Frame Buffer Architecture

To keep up with the graphics pipeline, Silicon Graphics designed a frame buffer which utilizes a massively paralleled array of Image Engines, VLSI circuits designed by Silicon Graphics for high speed processing of pixel data. The

Image Engines process pixels at a sustained rate of 80 million pixels per second including Z-buffering and alpha blending of the data. An additional five proprietary VLSI components are used as preprocessors for the Image Engines. Five more proprietary chips manage multimode windowing.

With this highly parallel architecture, the IRIS GT renders over 60,000 independent four sided polygons per second, including Gouraud shading and Z-buffer for hidden surface removal. This innovative technology and performance clearly reinforces Silicon Graphics' undisputed leadership in the superworkstation market.

Accurate Hidden Surface Removal

The principal method of performing hidden surface removal on the IRIS-4D Series is via a 24-bit Z-buffer. A full 24-bits of Z-buffer insures that intersecting surfaces can be resolved to far greater accuracy than possible with the 16-bit Z-buffer implementations used by much of the industry. Custom multipliers also insure a high degree of accuracy allowing complex 3D objects to be rendered with greater realism.

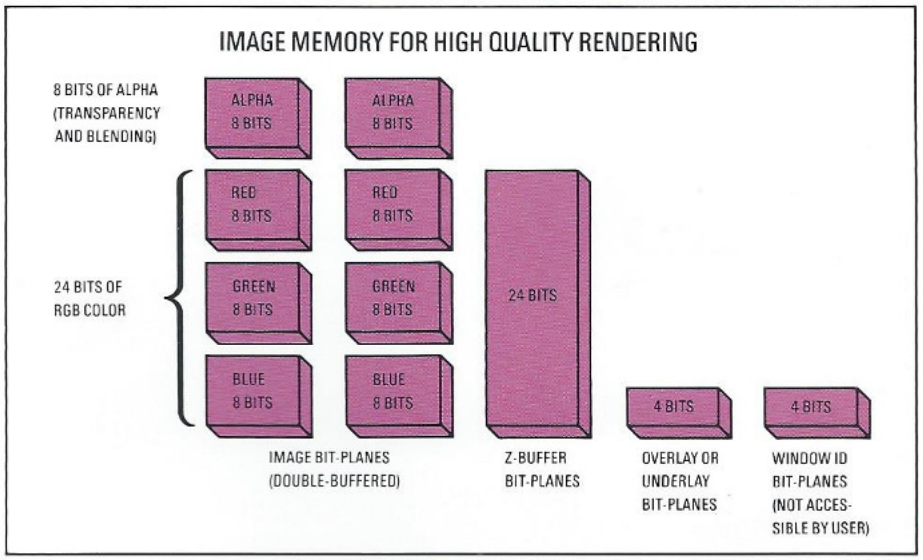
Shading

As in all IRIS-4D Series Superworkstations, flat and smooth (Gouraud) shading are supported in hardware. However, with the new technology and parallel architecture of the IRIS GT, rendering calculations are performed at over ten times the speed of the current IRIS-4D Series architecture. With the IRIS GT, users benefit by being able to manipulate fully shaded objects at rates faster than other workstations manipulate wireframe models.

Advanced Lighting Models

Several advanced lighting models which were supported in software on the IRIS-4D Series are now supported in hardware, in the graphics pipeline. These include:

- *Colored light sources.* Users can define the color and position of up to eight light sources.
- *Infinite light sources.* Light sources modeled so that all the rays from the light source enter the scene in parallel.



- *Local light sources.* Light sources modeled as if the rays radiate out in all directions from a single point. In addition, the light from a local source may fade as it grows distant (lighting attenuation).
- *Ambient reflectance.* Reflectance modeled as if light was coming from all directions at once.
- *Diffuse reflectance.* Reflectance modeled taking into account the direction of the light source(s), but independent of the viewer's position in the scene.
- *Specular reflectance.* Reflectance modeled by taking into account both the direction of the light source(s) and the viewer's position. The intensity of the reflected light can be made extremely bright where the reflected light heads directly toward the viewer. By increasing the specularity value, these highlights make the object seem shinier.
- *Depth cuing.* A useful "special case" modeled as attenuating parallel rays coming from "over the shoulder" of the viewer. The effect indicates depth by making closer portions of the object brighter.

Alpha Blending

The IRIS GT's alpha blending capabilities allow the user to model the transparency of an object and blend it into other objects on the screen. For example, imagine a window of a car set to be 90% transparent so that background images are still visible. The Image Engine array blends the pixel color data of the nearly transparent car window with the pixel color data of background opaque objects already in the frame buffer. As a result, 90% of the opaque objects show through the car window. The degree of transparency or blending is completely user-definable.

The alpha blending capability is a standard feature of the IRIS GT. There are 8-bits of alpha for each pixel, which are double buffered for real time applications. In addition, the alpha buffer contents are available as a video output signal used in applications where composite video techniques are required.

Anti-aliasing

The process of creating a straight line on a raster display often results in the line appearing to be jagged. The IRIS GT uses subpixel positioning and fractional pixel coverage information to draw smoothed lines at real-time rates.

Multimode Windowing

Multimode windowing is a unique feature provided by Silicon Graphics. This means that a variety of different windows, operating in different modes, can be run concurrently on the screen. For example, there could be four different windows, each running single or double buffered RGB mode or single or double buffered color index mode. Furthermore, the color map is available as a shared resource to all of the active windows.

Overlays/Underlays

In addition to all of the other bit-planes used for imaging in the system, each IRIS GT comes with four bit-planes which may be used to overlay graphics or text on top of what is already in the frame buffer. The graphics in the primary frame buffer are not disturbed by what is written into the overlay planes. Application programs can take advantage of these planes to annotate drawings or create pull down or pop up menus and icons.

Alternatively, these planes may be configured as underlay planes, enabling them to be the display *background* for whatever graphics exist in the primary frame buffer.

Software Compatibility

The IRIS GT is upward compatible with the IRIS-4D Series Superworkstations and uses the IRIS Graphics Library to provide high-level support for graphics programming.

Specifications

Image Memory:

- 64 1280 x 1024 image bit-planes (8 bits each for red, green, blue and alpha; double buffered)
- 24-bit Z-buffer
- Four 1280 x 1024 overlay or underlay bit-planes
- Four window ID bit-planes (not accessible to user)

Video Interface:

- RGB and Alpha levels 0.7Vp-p into 75 ohms
- 60 Hz non-interlaced refresh rate
- Interlaced refresh rates available:
  30 Hz 1280 x 1024
  30 Hz 636 x 485 (NTSC)
  25 Hz 768 x 575 (PAL)

Color Range:

- Color index mode: 4096 colors from a palette of 16.7 million
- 24-bit RGB mode: 16.7 million displayable colors mapped into frame buffer as 8 bits red, 8 green, 8 blue
- Both single and double buffered modes supported.

Physical Description:

- Five printed circuit boards, designed to fit into IRIS 4D/60 with Turbo Option or 4D/70 chassis. Software and documentation included. Field or factory installation available.

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Corporate Office
2011 Stierlin Road
Mountain View, California 94043
Telephone (415) 960-1980

Federal Sales Division
601 Democracy Blvd.
Suite 220
Bethesda, Maryland 20897
Telephone (301) 564-1980

Western Region
2105 Landings Drive
Suite 2105
Mountain View, California 94043
Telephone (415) 960-1940

Midwestern Region
34700 Grand River Avenue
Suite 300
Farmington, Michigan 48024
Telephone (313) 478-5446

Southern Region
15280 Addison Road
Suite 130
Dallas, Texas 75248
Telephone (214) 788-4122

Eastern Region
128 Technology Park
Waltham, Massachusetts 02254
Telephone (617) 891-8100

Canadian Office
2 Berkeley Street
Suite 500
Toronto, Ontario
Canada M5A-2W5
Telephone (416) 365-7444

International Division:
Headquarters, Geneva:
(41-22) 987525
UK, Newbury:
(44-635) 37425
Germany, Cologne:
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