A HIGHLY-INTEGRATED WORKSTATION GRAPHICS SYSTEM

Hot Chips Symposium
August 9, 1993

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DESIRED FUNCTIONALITY

- Fast 2D Graphical User Interface (GUI)
- Digital video decompression support
- Efficient 3D graphics

PROJECT STRATEGY

- Cost/performance optimization through the use of system-level design (CPU hardware/Graphics hardware trade-offs)
- Performance optimization by pushing the limits of available technology
- Cost optimization through the use of a high level of integration

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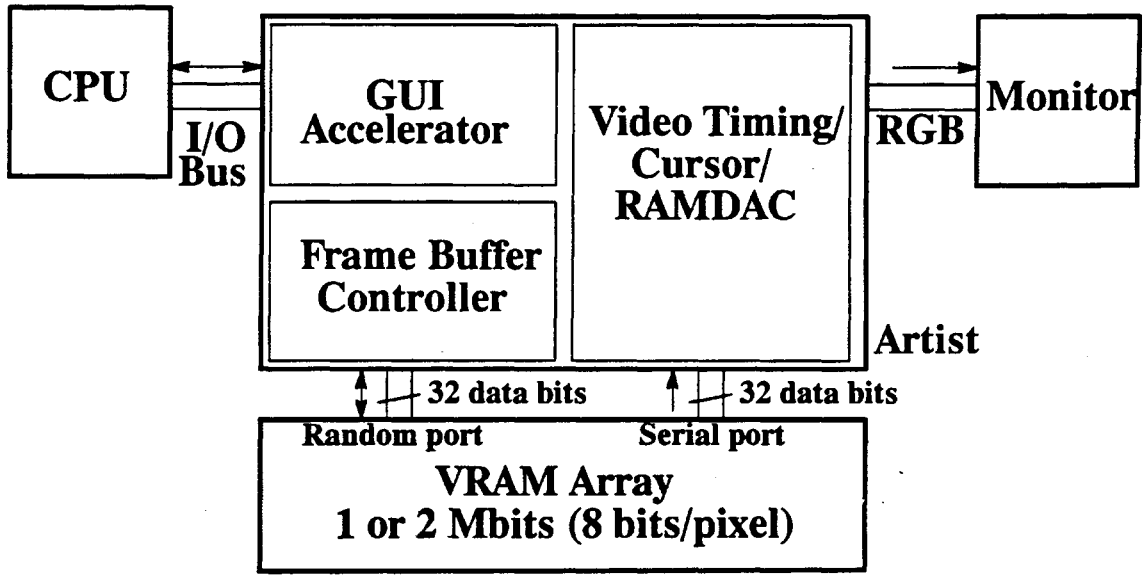
SYSTEM BLOCK DIAGRAM



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COST/PERFORMANCE OPTIMIZATION
(CPU/Graphics Trade-offs)

1. Can the function be performed more efficiently in the CPU?

2. Is the CPU enhancement inexpensive?

3. Is there a *significant* performance advantage by putting the function in the CPU?

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GUI FEATURES

CPU (Hummingbird):

- Fast memory → graphics path (block copy to I/O space)
- Fast register → graphics path (pipelined I/O store)

Graphics (Artist):

- Vector, rectangle, FB BitBlt, text, cursor HW
- Bit/pixel FB access mode, VRAM block write
- Boolean raster operations
- Two look-up tables

DIGITAL VIDEO DECOMPRESSION FEATURES

CPU (Hummingbird):

- Special image processing instructions
- Fast register → graphics path

Graphics (Artist):

- Color space conversion hardware
- Color compression into the frame buffer

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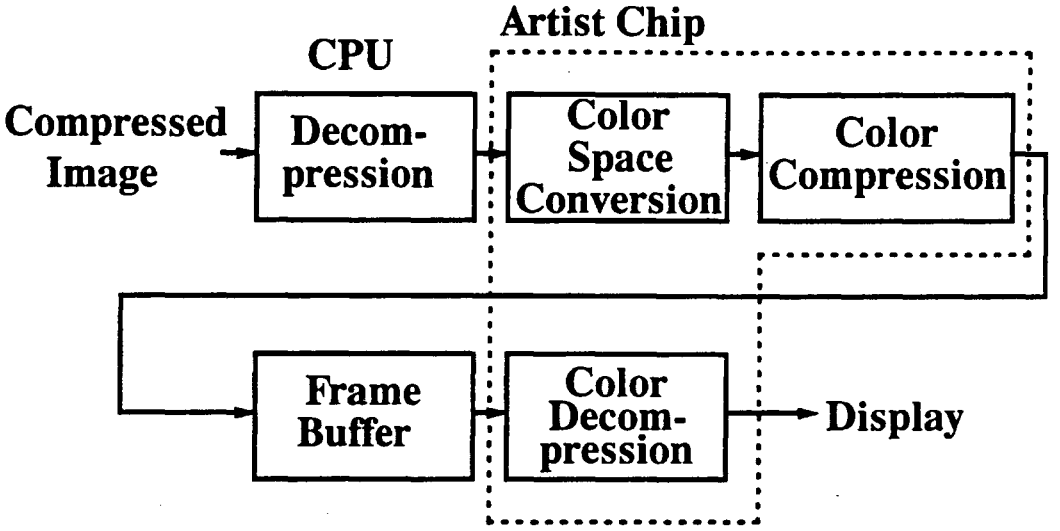
IMAGE DECOMPRESSION PIPELINE



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COLOR COMPRESSION/ DECOMPRESSION QUALITY

24 planes	8 planes dithered	8 planes with Color Compression

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3D GRAPHICS FEATURES

CPU (Hummingbird):

- Transformations, clipping (polygons and vectors)
- Lighting, Z buffering, pixel color interpolation (polygons)

Graphics (Artist):

- Vector rasterizer hardware
- Color compression into the frame buffer

MAXIMIZING PERFORMANCE

- Fast hyper page mode: 37.5 nsec
- Utilizing advanced VRAM features
- Pixel block write speed: 850 MPixels/sec (constant-color)

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GRAPHICS SYSTEM PERFORMANCE

Large rectangle fill (pixels/sec)	850 M
Vectors/sec (10-pixel random)	2.1 M
10×10 rectangles/sec	1.7 M
Text (6×13 characters/sec)	1 M
FB Bit BLT (unaligned pix/s)	47 M

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HIGH LEVELS OF INTEGRATION

- Built-in DAC connects directly to a monitor
- Built-in programmable PLL eliminates a crystal and allows flexibility to change resolutions
- JTAG port and multiple internal signature generators
- Mixed custom/standard cell design

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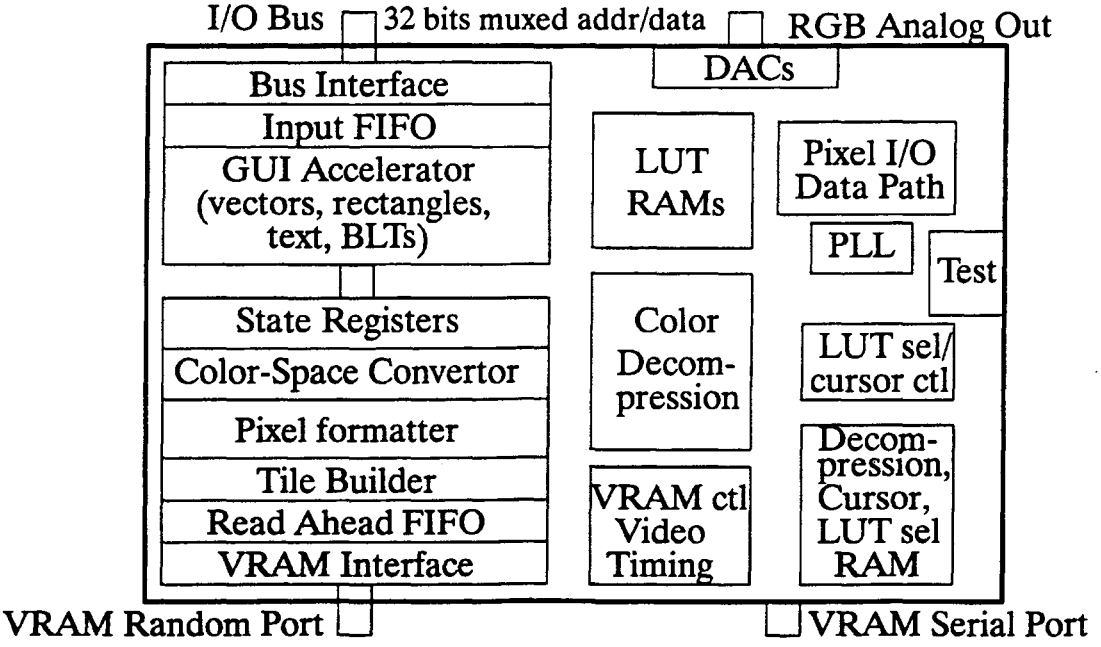
ARTIST FACTS

Number of Transistors	525,000
Equivalent gates	313,000 (108,000 without RAM)
Die size (Step size)	9.7 × 12.1 mm
Package	208-pin metal QFP, or 240 MQFP with flat panel out
Metal layers	3 (aluminum)
L_{eff}	0.61 μm (nFETs) 0.66 μm (pFETs)
Frequency of operation	40 – 80 MHz (GUI/RAM ctl) 25 – 135 MHz (video control)
Power	3.5 W (worst case)

ARTIST BLOCK DIAGRAM



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ARTIST DIE PHOTOGRAPH

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SUMMARY

By using a system-level design approach and high levels of integration, a powerful yet inexpensive workstation graphics system has been built. This system accelerates 2D GUI functions, digital image decompression, and 3D graphics.

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