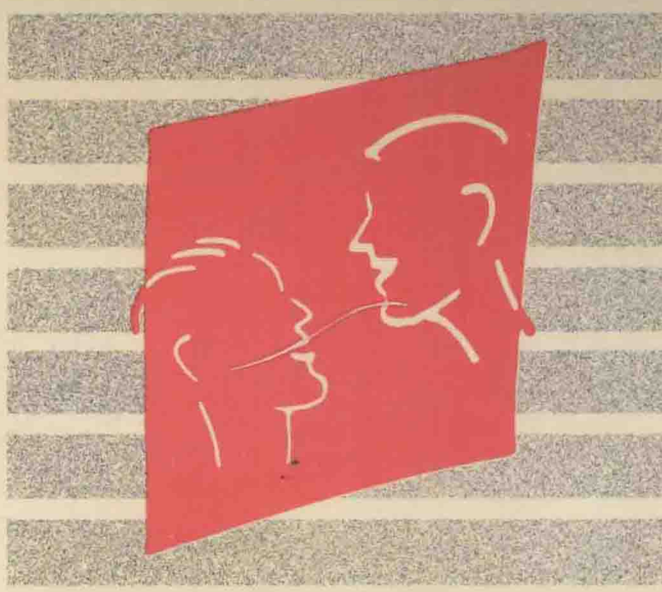
PROCEEDINGS OF THE CONFERENCE
HELD IN LONDON, OCTOBER 1988

COMPUTER



GRAPHICS 88

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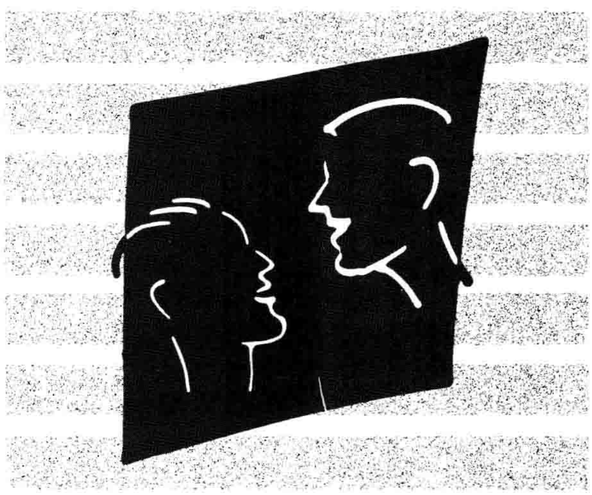

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Introduction

Computer graphic techniques are now widely and effectively employed in a wide range of activities from presentation graphics and slide production to computer-aided design and animation. The advances in this technology have been more than matched by developments in techniques and the rapidly falling cost of employing computer graphics which, in turn, has led to an explosion of interest in the field.

Computer Graphics 88 examines the latest developments in graphics technology and applications. The book starts with a thorough review of the latest technology including visualisation environments, graphics processing, multi and variable resolution, and computer architectures. Next there is a substantial chapter on computer animation which explores the latest work on improving the realism of synthetic images through texture and illumination. There are also chapters on graphics design, low-cost CAD systems and presentation and information systems to make this a thorough treatment of the field.

Written by the leading specialists from hardware and software houses, the universities and the graphics users themselves, this latest review of computer graphics provides an up-to-date and authoritative appraisal of the latest significant developments in the field.

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Computer Graphics Technology

An ador(é)able computer

David G Howes
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Ardent Computer Limited
UK

The opportunities for greater insight into complex engineering and scientific computations processed by supercomputers can only be released by a new paradigm embracing both hardware and software. General purpose computational and graphics hardware, coupled with a toolkit that takes the burden of visualisation from the applications developer is seen as the most appropriate route for progress in interactive supercomputer visualization. Such a toolkit, Doré, and the Ardent Titan graphics supercomputer is described in this context, together with the availability of an open supercomputer bus with many times the throughput of today's workstation buses.

David Howes has been involved in scientific computation and visualization throughout his career, as a civil engineer, and then in sales, marketing and management roles with IBM, Scicon and Prime. He established Apollo Computer in Europe in 1981, and was a founder member of the Computer Graphics Suppliers Association. As vice president, European Operations for Ardent Computer, he is responsible for that company's activities in the "old world".

Supercomputer Visualization

The burgeoning scale and complexity of calculations performed by users in fields such as computational fluid dynamics, molecular modelling, seismic studies, mechanical computer aided engineering and medical imaging has assured the future of that class of machine that we may define as supercomputers. However, comprehension of the many multi-dimensioned numeric arrays that typically represent the output of such computers is in no way aided by the extra computational power that we manage to engineer into them. Computer graphics, increasingly, provides the *only* route to understanding in this domain; the quest for new levels of sophistication in visualization is on.

Scientists and engineers are demanding more than just the ability to see the graphical results of their analysis. Their ideal is to watch a solution *evolve*, by causing the analysis to be displayed in "real time" as it is computed. As an example, computational fluid dynamics researchers want flow simulation - the results of the calculations from their particular solver algorithm - to be integrated with grid generation - the definition of the 3-dimensional granularity of the computation and the various boundary conditions. Biochemists want molecular modelling and molecular dynamics coupled in the same package. Geophysicists need seismic interpretation linked with seismic data processing. They *all* require the ability to modify, interactively, the parameters of their problem and to observe the computational effects in 3D, full colour graphics - and in real time! They are demanding *interactive supercomputer visualization*.

But existing architectural paradigms - both on a hardware and a software level - are unequal to these demands.

Here we discover the essence of the "visualization/computation paradox" since, as yet, no single platform has had the capability to provide both the supercomputer processing speed *and* the 3D full colour real time graphics needed for interactive visualization. It has taken two machines in concert to fulfill the joint requirements for high speed computation and for high level visual representation of the computational results. Supercomputers (or mini supercomputers) which provide high computational ability with no visualization, are teamed with graphics terminals or workstations which provide visualization with little computational ability.

On inspection, the shortcomings of such an arrangement become obvious, both for graphics and computation. With a "thin-wire" connection between the computational and graphics components of the combination, users fail to achieve prompt feedback as they change problem parameters. They are forced to re-submit a batch-process job to the supercomputer or computational server, wait for network-based data transfers and then direct the revised model of the process back to the graphics component. Even when an interactive program is run on a supercomputer - a processing mode that doesn't necessarily bring out the best of this type of computational resource - the link to the terminal or workstation remains a bottleneck. (In this context, even solutions based on Hyperchannel™ provide a relatively slender path.)

When considering visualization, the basic difficulty presented by this style of supercomputer/workstation solution evolves from the fact that the majority of graphics workstations achieve their (relatively) high graphics performance with custom hardware. Whilst useful for some fixed functions like transformations and clipping, custom hardware is generally constrained to perform only those specific algorithms for which it was built. So an inflexibility may exist for advanced features such as light source shading and texture mapping. The custom approach lacks a smooth transition between the graphics functions which it can do well, and those that are not cast in silicon.

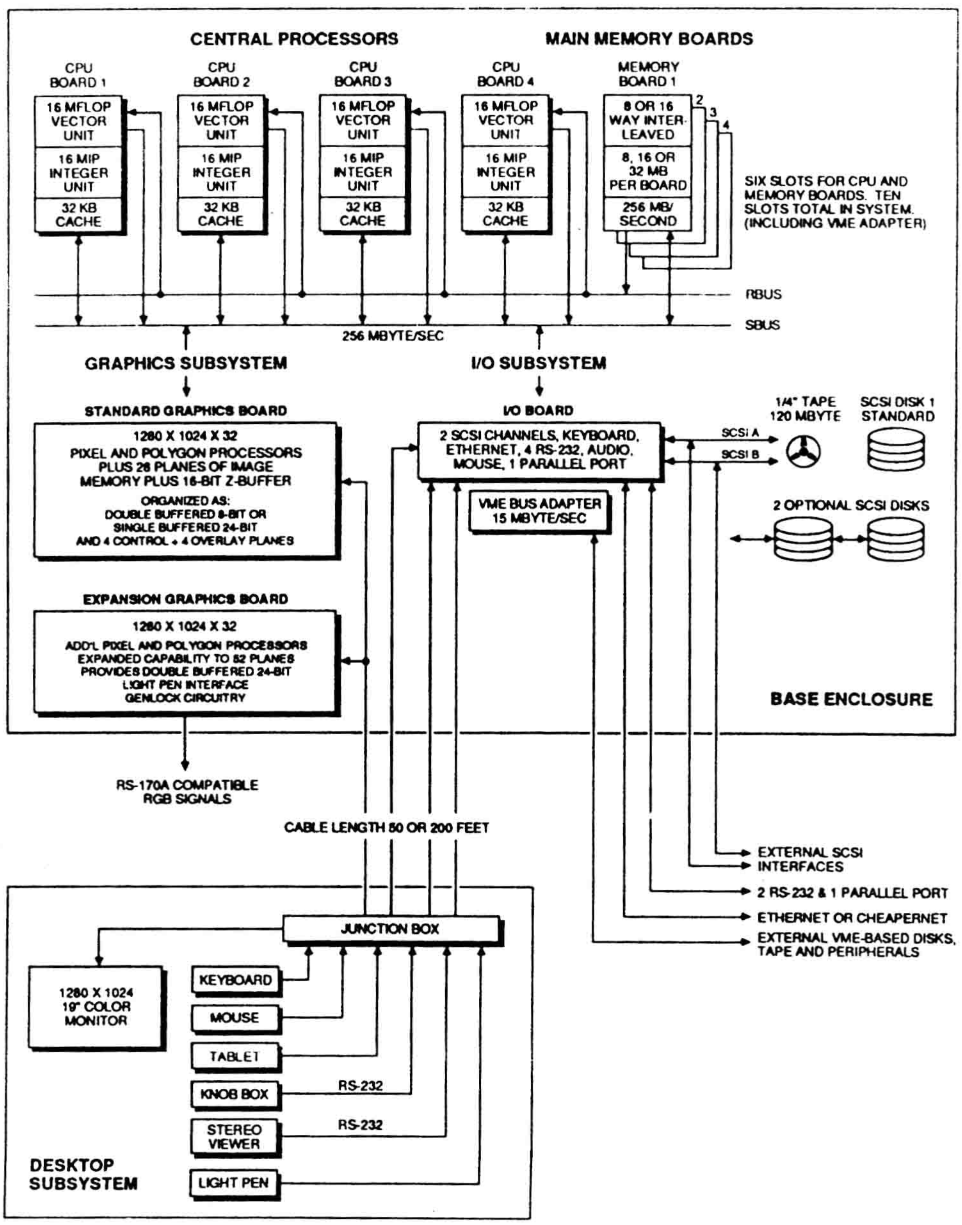
Also, from the software viewpoint, this approach fails to deliver against the needs of interactive visualization, since the practice of putting fixed-functionality graphics standards in a workstation is equally constraining. Users again encounter a communications bottleneck - the "thin-wire" link between graphics and adequate computational power - whenever they need to visualise beyond the capabilities of workstation-level, fixed functionality, non-extensible interfaces. And doesn't this approach pre-suppose that graphics interface standards are adequate to the demands of high-end visualization? In reality, the standards are effectively outmoded by the time they come into use. Indeed, the visualization requirements of some application areas such as computational fluid dynamics and computational chemistry may well be too young, too dynamic, for standards.

To take an example; a computational fluid dynamics researcher using a remote supercomputer, a workstation and applications with standard graphics interfaces faces several constraints. The scientist here could not compute a flow field and view it interactively. He could not develop a large zonal grid scheme, compute the grid points, display them and optimise the whole in real time. A desire (not unreasonable!) to display a 3D flow field would force him to devise and compute volumetric primitives himself, since graphics standards interfaces lack support for the complex primitives specifically needed in such diverse areas of scientific research.

To answer the frustrations of scientists and engineers trapped by the visualization/computation paradox, Ardent has developed a computer system and software which, in combination, address the demand for interactive visualization. The company believes there *is* a paradigm for achieving a better balance of computing and graphics: one platform that closely couples graphics to a supercomputer class processor.

Closely Coupled Graphics Processing

The Ardent Titan™ is not merely two traditional-style compute and graphics engines wired together, but defines a new class of machine: the graphics supercomputer.



Titan System Block Diagram

Titan is a 64-bit symmetric parallel, vector processor.

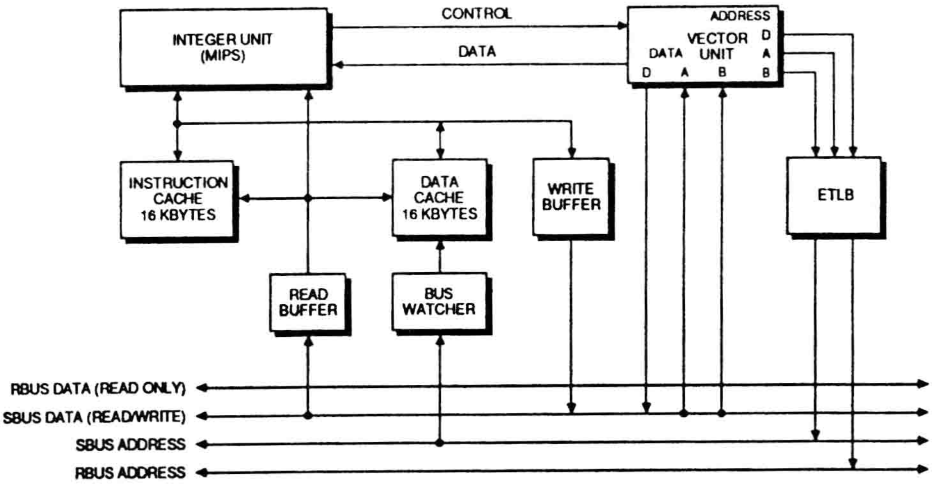
Up to four processors can be configured in a single system. Each processor comprises a pipelined integer unit ***and*** a pipelined and chained vector unit. The integer unit is a RISC processor. The vector unit is a vector register machine that operates on floating point vectors, integer vectors and floating point scalars. Multiple processor configurations make parallel processing possible. This includes:-

(i) Multiprocessing - the parallel execution of multiple processes on multiple processors.

(ii) Microtasking - the division of a process into multiple threads (microtasks) that can be executed in parallel on multiple processors.

(iii) The parallel execution of ***integer*** operations (address calculations, bitwise operations) and floating point operations within each processor.

Titan's vectorising and parallelising compilers accept "standard" C and FORTRAN code (F.77 with Vax™ extensions and Cray™ directives) and automatically compile for vector and parallel processing. The operating system is based on the standard AT&T System V.3 UNIX operating system with Berkeley 4.3 operating system extensions.



Titan Processor Subsystem Data Flow