

Autodesk Systems Platform Evolution The Implications of High Performance Linux Workstations

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Abstract

New Linux[®]-based workstations offer faster performance, lower ownership costs, and a future-proof investment. This white paper examines the implications and benefits of Linux workstations as the next generation hardware platform for Autodesk's real-time visual effects and editing systems Autodesk[®] Inferno[®], Autodesk[®] Flame[®], Autodesk[®] Flint[®], and Autodesk[®] Smoke[®].

By selecting the industry's highest performing Linux components and specifically tuning its software for these configurations, Autodesk is able to offer artists and editors significantly enhanced interactivity and productivity.

Autodesk[®]

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Introduction to Autodesk Systems

Autodesk advanced visual effects and editing systems are designed specifically to provide artists and editors with the best creative experience in tools, interactivity, and performance. With the launch of Flame in the early 1990s, a radical new approach to high-performance post-production systems helped redefine an industry: to create highly interactive, performance-tuned software solutions that were hardware independent and could therefore be migrated from one workstation to another as computer technology advanced. The advantage of this approach is threefold:

1. Better creative tools: Autodesk Research and Development resources are focused on developing advanced creative tools rather than constantly having to re-engineer new hardware components to keep up with Moore's Law.

2. Superior overall performance: Autodesk systems are designed to leverage the latest in computing, storage and networking technologies. Software performance-tuning enables its solutions to deliver significantly higher levels of real-time performance and interactivity.

3. Future-proofing: Autodesk systems are software-based and can therefore take advantage of next-generation hardware platforms while maintaining flexibility so that you can take advantage of our solutions' improved creative capabilities with every release.

These advantages are underscored with the new Linux workstations. This platform transition, while in many ways no different to past transitions¹ (such as the SGI® Octane® to Tezro® transition) offers some unique advantages. In particular, today's multi-core workstations provide compelling productivity gains for Autodesk solutions – in many cases more than quadrupling the performance. These are discussed further in this white paper.

¹ Autodesk supports previous platforms with new software version releases enabling you to better choose exactly when will be the right time to switch platforms and to do so without losing creative capability.

NARNIA™ © DisneyWalden
*The Chronicles of Narnia, The Lion, the
Witch, and the Wardrobe.*
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of Sony Pictures Imageworks.



*“While working on *The Chronicles of Narnia: The Lion, the Witch and the Wardrobe*, there were many artistic challenges in creating just the right look for magical elements. The White Witch’s stone victims, the luminescent ice castle, talking animals, and a vast fly-over shot of Narnia; they all needed to stir up a sense of wonder. The talent of our artists, combined with the capabilities of the Flame system, helped bring this classic to life.”*

David Smith

Digital Effects Supervisor, Sony Pictures Imageworks.

Creative Imperative

Post-production is above all a creative service – a creative service that is becoming more complex with each new project and where there is constant pressure from clients to deliver with tighter schedules and budgets, often against aggressive competition. In this environment creative power has never been more important, and it flows from the facility’s most important resource: its artists and editors.

Autodesk solutions are designed to empower artists and editors. They are designed to provide them with tools that will enable them to realize their most imaginative ideas better than ever before, and to do so with greater speed and precision. Autodesk’s mission is to build the industry’s best creative tools, and to do so we focus our research and development resources in three key areas:

- 1. Image science and creative tools** – From precision keying and color correction to 3D compositing, Autodesk continues to invest heavily in developing new creative tools for artists.
- 2. Application interactivity and performance** – Autodesk does significant research in software optimization, interface design, and ergonomics as well as hardware tuning to help ensure that your experience is as interactive as possible.
- 3. Facility workflow and resource management** – Given the complexity of modern post-production workflows, a new area of focus has been developing new solutions to improve the overall effectiveness of the creative workflow from better resource sharing (e.g., Autodesk® Burn™ software) to data management (e.g., Autodesk® Wiretap™ functionality) and richer meta-data exchange (e.g., with Apple® Final Cut Pro® XML).

Transitioning to Linux

An Autodesk hallmark has always been to offer compelling software tools that have been tuned to run on the industry's highest performing computers. Computer technology jumps forward every year and few technologies have moved as fast as general purpose computing. In this environment, making the right decision as to when and how to transition software to the next platform is not always an easy choice. As discussed below, there are many compelling reasons to migrate to a Linux solution² including exceptional gains in performance and reduced cost of ownership.

Faster Performance, Greater Productivity

The performance characteristics of today's multi-core workstations provide compelling productivity gains for Autodesk solutions when compared to previous generation SGI computers, with performance more than doubling in many cases. High end Linux workstations from companies like IBM and HP now offer levels of performance and flexibility that match or exceed specialized hardware³.

Virtually all of the Autodesk creative functions—including 3D particles, blurs, color correction, keying, tracking—are accelerated on these new platforms, and are faster than ever before. The speed is noticeable whether creating a composite, finessing a frame, playing back media, or even scrubbing a sequence. Brainstorming ideas is therefore easier, and rendering out complex visual effects shots executes much more quickly.

Significant performance improvements mean that artists have more time to make creative decisions enabling them to either try more versions or simply finish projects faster. In turn, your clients will be happier because they can get better results, faster. With faster project turnaround times, facilities become much more productive overall. They can bid on more projects over time, or complete larger, more lucrative, projects that involve more creative shots.

*“While working on *The Chronicles of Narnia*: “The real breakthrough with the effects work was that we were able to complete over 600 effects shots in just eight months. The flexibility and power of Autodesk’s tools made it possible for us to meet this remarkably fast turnaround.”*

David Schaub

Animation Director, Sony Pictures Imageworks.

2. Autodesk will continue to provide software updates for older SGI platforms extending the lifetime of your investment whatever choice you decide to make.

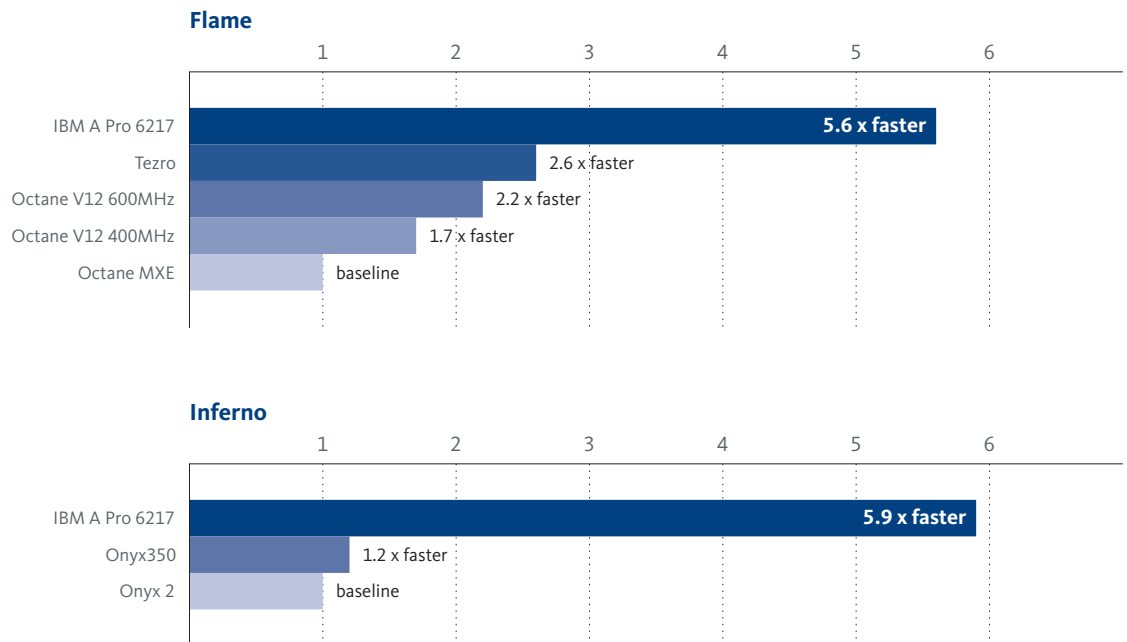
3. Proprietary hardware may have some short-term benefits for simple tasks such as resizing, however overall performance and productivity, especially for complex creative tasks, is compromised and these simple tasks quickly become feasible using standard components (GPUs or CPUs) increasing their risk of obsolescence.

The charts below show examples of how Flame and Inferno products' performance increases based on hardware platform⁴. While performance will vary depending on the type and complexity of task being performed, internal benchmarking of our systems has shown consistent performance improvements in our solutions of the order shown below. However, exact performance will vary depending on exactly what the user is doing.

Until recently, only SGI computers were capable of delivering the sustained performance required for 10-bit and 12-bit RGB data transfers between all component subsystems. More general purpose workstations were only capable of doing so between certain components. Today, the general computer market has caught up. Newer dual core systems with faster front side busses, faster PCI busses and new high performance graphics cards are now available. For the first time, Autodesk is able to offer not only Flint but also Flame and Inferno on Linux workstations without performance regression.

Autodesk also does specific Linux optimizations to enable our applications to run as efficiently as possible on these configurations and deliver real-time frame-locked performance for functions like video I/O and playback.

Figure 3– System Render Performance Improvements for Batch and Action



4. Overall IBM® A Pro 6217s performed 1.5 to 5 times faster than the SGI Tezro in over 80% of our test cases. The IBM system tested was a dual core system with 2.2GHz processors. The SGI Tezro tested was a 4 processor configuration running 1 GHz MIPS R16000 processors. In a few tests performance increased as much as 10 fold.

Linux Workstations – Lower Cost of Ownership

Historically, the demands of processing non-compressed video and film data in real time required very expensive proprietary hardware or supercomputing platforms – this is no longer the case. The rapid advances in general purpose computing have eliminated the need for customized components that are complex to design, slow to iterate, and expensive to build. As a result, the cost of purchasing computer hardware for real-time media applications is continually decreasing.

Proprietary hardware solutions offer little flexibility in when and how you can upgrade. When new hardware-dependent features are introduced, you must upgrade your hardware; there is no flexibility to enable you to install new software on your existing platform. In addition, the costs of the upgrades, as well as just maintaining the system, are generally higher. You face a significant hurdle in that switching to a next generation platform typically involves throwing out the entire system and having to learn an entirely new application.

The cost of hardware support⁵ for specialized or proprietary hardware systems can be significant – often well over \$10,000 US per year⁶. Hardware maintenance costs for Linux workstations are much lower and can offer substantial support cost savings, ranging from 40% less for a typical Flame configuration to as much as 80% less for certain Inferno configurations. Today, the cost of Autodesk hardware support with software subscription, which includes all major software version upgrades, on a Linux-based Flame or Inferno configuration is well under \$15,000 US and less than 3% of the overall system cost.

Image Courtesy of Absolute, UK



“The Autodesk Flame system has been a big part of our business. The Flame system running Linux is a turning point for the industry. Autodesk’s use of high-performance, dual-core Linux workstations provides us with more flexible and cost-effective platform choices going forward. The system’s new tools, such as layer-based paint in batch, are great too because they increase our design flexibility.”

Dave Smith

Managing Director – Absolute, UK

Autodesk® Burn™

As fast as applications are, performance can be further enhanced with Autodesk Burn remote processing solution. With Burn, processing is distributed over shared render nodes so that shots can be completed more quickly – reducing production costs and time.

Burn nodes process Batch and timeline clips in the background, simultaneously freeing the system for more creative tasks. By offering fast, cost-effective processing power, Burn can significantly increase the productivity of the facility. Since Burn acts as a render farm, the nodes can be shared among all your systems.

An added advantage of Linux workstations is the ability to independently upgrade hardware components such as graphics cards, which are increasingly affordable. This allows you to take early advantage of new capabilities such as increased graphics texture memory, often with a significant improvement in the performance of the creative application.

As a result, your facility now has more flexibility in how to upgrade. Instead of spending large amounts every year just maintaining your hardware system, you can invest the same money to upgrade your facility's capabilities: you can maintain your software up-to-date while choosing not to upgrade your hardware, you can upgrade particular hardware components or subsystems therefore extending the life of your workstation while increasing its performance, or you can upgrade your complete workstation to the latest and most capable technology. With these options, the long-term cost of maintaining your facility current is significantly decreased.

4. Proprietary hardware may have some short-term benefits for simple tasks such as resizing, however overall performance and productivity, especially for complex creative tasks, is compromised and these simple tasks quickly become feasible using standard components (GPUs or CPUs) increasing their risk of obsolescence.

5. With Advanced Parts Exchange, replacement part is shipped to you prior to return of the faulty component

6. For SGI Onyx platforms this can exceed \$40,000 a year. Support for older generation systems from custom hardware manufacturers tends also to be significantly higher.

Investing in the Future

New Linux workstations provide compelling computing power. When you combine them with modern 64-bit, highly threaded applications such as Inferno, Flame, Flint, and Smoke, you will see outstanding performance gains as compared to running the same software on older generation workstations. But it is not only the gains of today that are significant – there are also the gains of tomorrow. Any investment in a high-end system becomes the basis a long-term relationship, so it is important to understand where that relationship is headed.

As mentioned at the beginning of this white paper, an investment in an Autodesk system is an investment in:

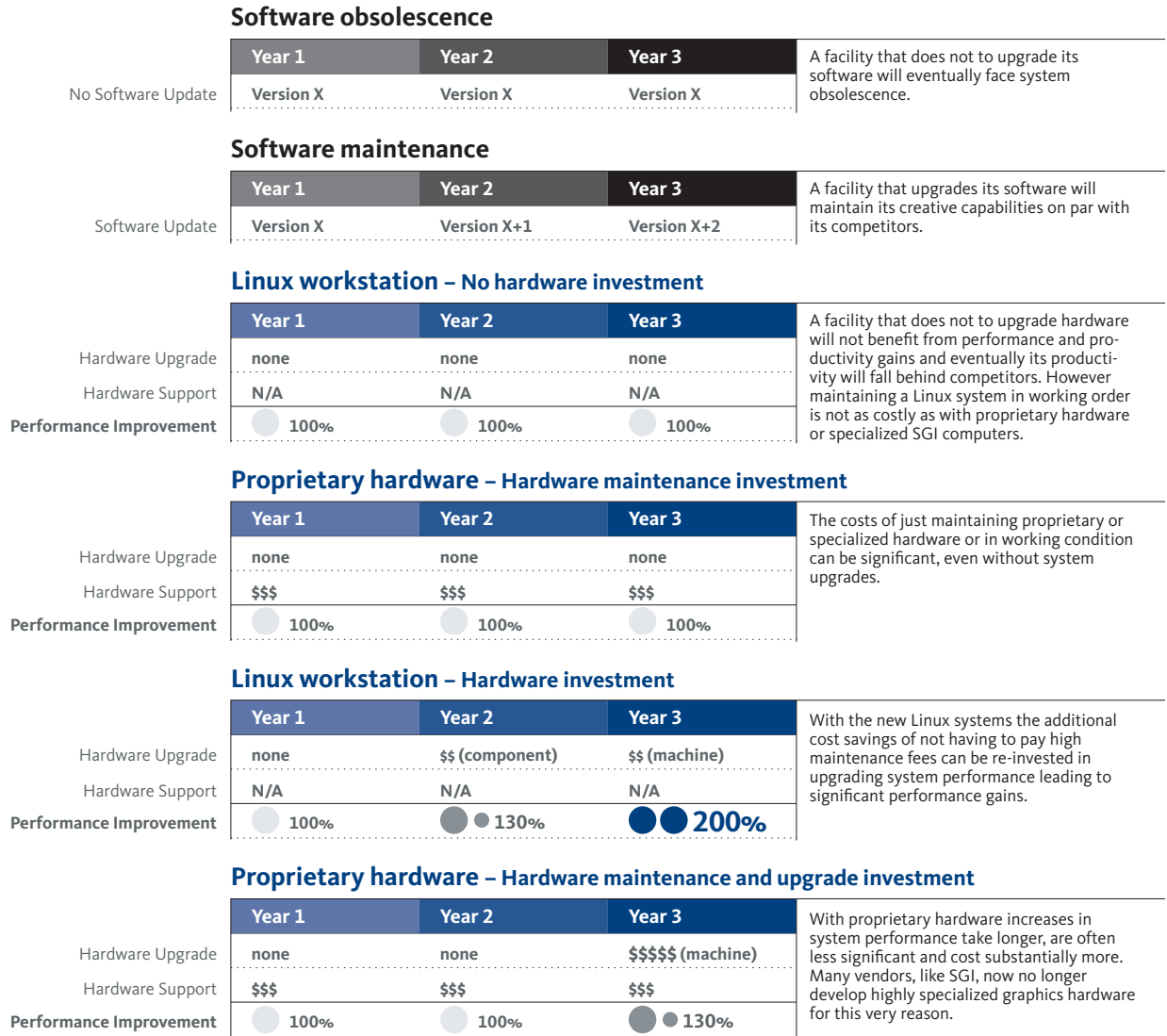
- **Better Creative Tools**
- **Superior Long-Term Performance**
- **Reduced Hardware Obsolescence**

Software innovation means better creative tools and is the real enabler to artistic talent. Autodesk continues to invest in advanced image processing research through its Image Science Group. The Image Science Group develops 2D and 3D technologies that enable creative problems to be solved in new ways and is responsible for such new tools as the Master Keyer and the new motion estimation technology recently added to our software as well as developing new software tools for advanced visual effects creation. This team has been further expanded with the addition of (the former) Alias team of research scientists.

For more than a decade, Autodesk has developed industry-leading talent and expertise in high-performance computing, including advanced multi-threading techniques, software optimization, 64-bit processing, graphics acceleration, and high-bandwidth networking. In recent years, Autodesk has been investing in harnessing the power and capabilities of the Graphics Processing Unit (GPU) for advanced image-processing applications. This is an area of emerging technology that will be a critical component of long-term system performance as it is highly scalable. The biggest performance driver in the post-production industry will no longer be processor clock speed but increasing core density and increasing GPU performance.

Software solutions increase the longevity of your hardware investment by enabling new versions to run on older configurations. Even those users who choose to upgrade their hardware can easily find ways to reuse their old hardware. For instance, a Linux workstation can be transformed into a desktop graphics workstation, an administrative system, or even a render server for Burn. The useful lifetime of an Autodesk-Linux workstation can extend well beyond its time powering Flame or Smoke software.

Figure 7– Cost-performance comparison of commodity and proprietary hardware.



Note:
 The chart above is a figurative guide to the three-year cost performance relationship between software systems running on high-end Linux workstations and proprietary or specialized hardware solutions. The performance gains are illustrative only and based on trends in workstation technology over the last three years. Although in many cases the performance gains have been higher, we use a conservative approximation in creating the chart.

Make the switch

With the Autodesk family of effects and editing systems on more powerful, and more affordable, Linux workstations, now is the perfect time to reap the benefits of our transition. You can strengthen your business both today and into the future with the new Autodesk advanced systems platforms for high-speed compositing, creative editorial, visually arresting graphics, and interactive client-driven design.

It is our plan that the new hardware configurations will support our applications for years to come, and future upgrades will become easier than ever. So supercharge your studio, lower your costs, and boost productivity.

To get started, contact your nearest Autodesk Authorized Reseller for more information, or visit us at www.autodesk.com/me.

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Appendix – Autodesk System Tuning and Performance

One of the unique advantages of the Autodesk Discreet Inferno, Flame, Flint, and Smoke systems is the performance tuning that Autodesk provides to ensure that the artist or editor's experience is a highly interactive one. This involves building applications that integrate core functions, such as video I/O, and conform and broadcast monitoring, into a single efficient workflow while taking full advantage of the most advanced technology on the market.

- **Multi-core Processing**
- **High Performance Bus Architectures**
- **High Performance Networks**
- **High Performance Storage**
- **High Quality RGB 4:4:4 Video I/O**
- **High Performance Graphics Processing**

In order to deliver guaranteed and sustainable real-time performance as well as superior levels of interactivity, Autodesk rigorously tests all the components of the system as an integrated solution. Prior to evaluating new hardware, we establish a rigorous set of benchmark tests that the system must pass before we certify it. This is done to prevent regressions in the performance, quality or reliability of our software as we move from one platform to another.

Because Autodesk is an industry leader in real-time application design, our requirements are some of the most demanding in the industry. We work extensively with new technology leaders to help them bring their hardware and device drivers up to the specifications we require and only choose those that can meet our exact requirements. Often, many commodity and general purpose workstations and components fail to deliver real-time capabilities due to issues such as internal bandwidth limits.

Although processor performance is a popular benchmark, it is rarely the best indicator of system performance for real-time media systems. One of the biggest challenges today is not processing speed but moving vast amounts of image data between system components in real time.

Table 1 shows how much data needs to be transferred between components to provide a real-time stream of non-compressed media (not including audio). Should the system be unable to deliver these data rates, it will fail, either by dropping frames during video I/O,

Table 1– Minimum bandwidth requirements for HD and Film (single stream)

HD – 1920x1080@29.94i			
	HD-8 bit	HD-10 bit	HD-12 bit
Disk	186.3 MB/sec	248.8	372.5
Video	186.3	248.8	N/A
Graphics	186.3	248.8	372.5

2K – 2058x1556@24p			
	2K-8 bit	2K-10 bit	2K-12 bit
Disk	229.5 MB/sec	306.0	459.05
Video	149.4	199.1	N/A
Graphics	229.5	306.0	459.0

4K – 4096x3192@24p			
	4K-8 bit	4K-10 bit	4K-12 bit
Disk	941.4 MB/sec	1225.1	1882.7
Video	N/A	N/A	N/A
Graphics	941.5	1255.1	1882.7

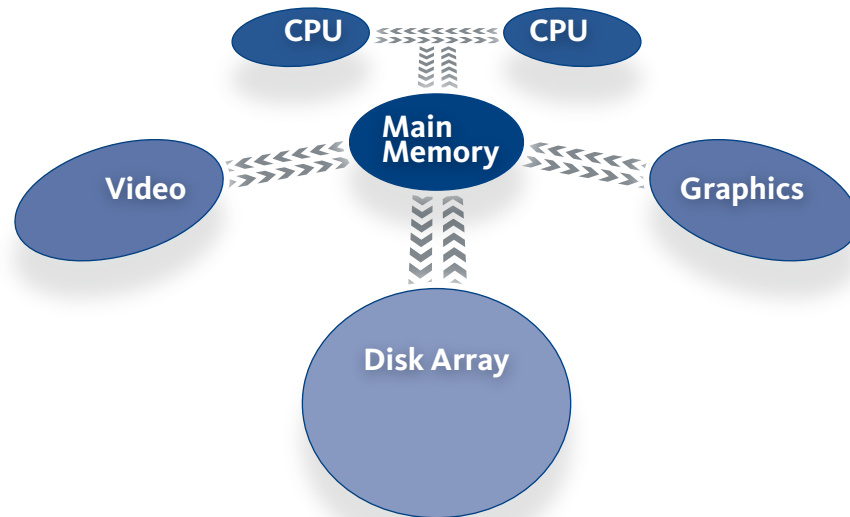
faltering during playback, losing synch between graphics and the video monitor, and more. The selection of the right platform to maximize performance for all aspects of the creative application is therefore critical.

It is also essential that all the system components deliver these minimum bandwidth requirements in a sustained manner. There is often a significant difference between the theoretical maximum bandwidth publicized by the manufacturer and the actual sustainable bandwidth, or the bandwidth that can be maintained for an indefinite period for the purposes of the application.

In choosing its systems, Autodesk tests all aspects of the system, including:

- **Read and write transfer speeds between the video I/O subsystem and the disk array - (with graphics monitoring);**
- **Read and write transfer speeds between the disk array and the CPUs - (with graphics monitoring);**
- **Read and write transfer speeds between the disk array and the graphics card;**
- **Read and write transfer speeds between the disk array and the network subsystem;**
- **Performance of graphics to video output;**

Figure 4– Real-time data transfer requirements between system components



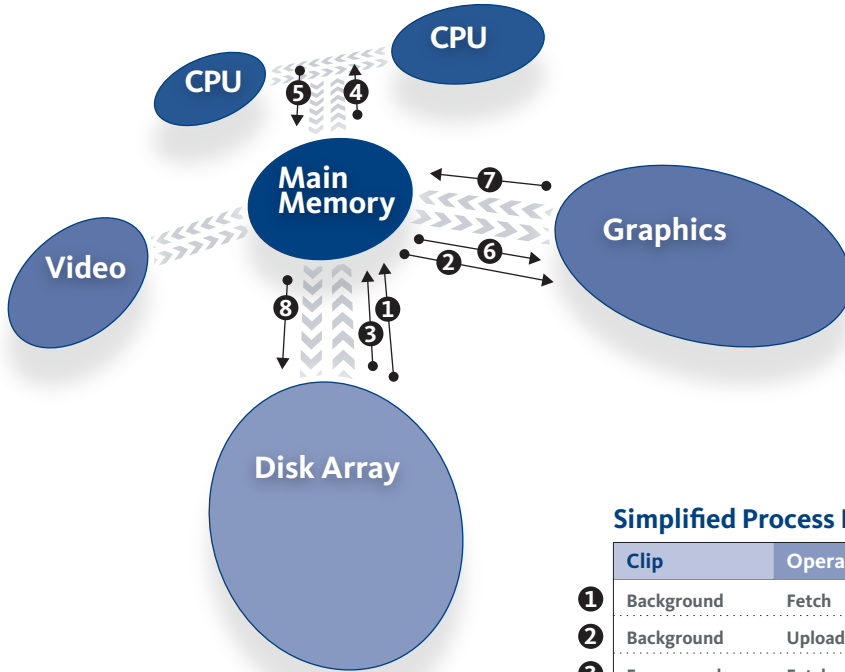
As Figure 4 shows, the biggest bottleneck in the workstation is often main memory bandwidth as it acts as the central hub for most data transfers. The speed of the front side bus is also critical in determining how fast data can be transferred to the CPUs. High-speed graphics pipes (both read and write) are critical for real-time graphics processing. Multiple high-speed PCI I/O busses are essential to transfer data to and from storage devices, video I/O cards or across high-speed networks such as Infiniband or 10 Gigabit Ethernet. Professional systems require multiple PCI busses as well as large amounts of slot space. Slot space is often a critical issue in determining whether a workstation will scale to handle a professional data-centric post-production pipeline. Only higher-end workstations provide this capability.

Multiple core CPUs increase the computational power of the system. Efficient processor caching, low latency between transfers, and high-processor bandwidth are all critical components, especially when rendering media sequences with many layers and at large resolutions. Technology trends show that the core density is set to increase faster than processor speed and applications. This provides unique advantages to Autodesk applications which have been designed to run on multi-processor systems since initial conception. As a result, Autodesk systems show close to linear performance scaling across the entire application (including user interaction) with respect to core density.

The example below shows how many data transfers are required to process a very simple effect. Two images are loaded into main memory. One is sent to graphics the other is sent to the CPU and from there to the graphics card where they are combined and saved back to disk. Each time another element or layer is added the amount of bandwidth to produce the final image result goes up. As computational complexity increases so does the bandwidth required.

Today, the demand is for increasingly complex and sophisticated visual effects work involving sometimes hundreds of layers. No hardware can do this in real time today or is likely to be able to in the foreseeable future. To be able to work efficiently requires solutions

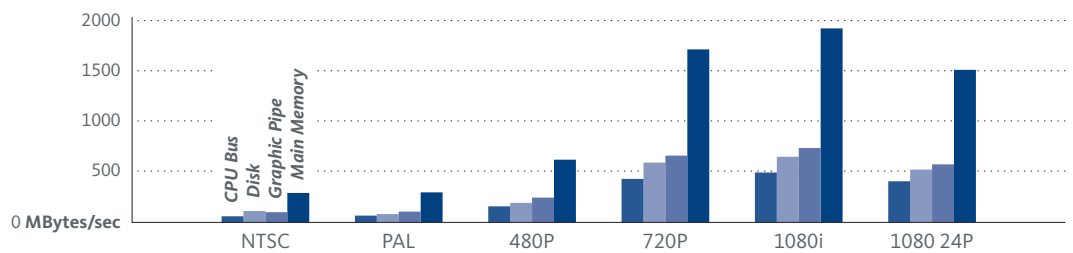
Figure 5– Bandwidth requirements for real-time CPU and Graphics capabilities



Simplified Process Flow Diagram

Clip	Operation	Format	Source	Destination
1	Background Fetch	RGB	Disk	Memory
2	Background Upload	RGB	Memory	Graphics
3	Foreground Fetch	RGB	Disk	Memory
4	Foreground Key	RGB	Memory	CPU
5	Foreground Key	RGB	CPU	Memory
6	Foreground Upload	RGBA	Memory	Graphics
7	Result FB Read-back	RGBA	Graphics	Memory
8	Result Write-back	RGB	Memory	Disk

Bandwidth Per Component



that offer more sophisticated capabilities including advanced caching, rendering and proxy handling. Absence of these capabilities will ultimately limit the ability of the artist to do complex tasks efficiently.

While many solutions can execute simple tasks in full resolution with real-time feedback, it is the ability to work on more complex creative tasks interactively that sets Autodesk solutions apart.◀