transtec technology compass

Graphics Workstations

Applications and their hardware requirements

transtec

What components do I need for my applications?

Before procuring new hardware for graphics applications it is usually necessary to give consideration to the criteria relevant for selecting new system components.

This brochure deals with the three principal fields of application of Graphics Workstations: **CAD/CAE, photo-realistic rendering** and **animation** as well as **image processing**. The technical requirements for each of these areas are dealt with and practical advice for the selection of the appropriate components is given.

Careful attention should be given to the selection of the graphics card, the amount of RAM and the type of processor as they apply to the application at hand. The transtec technology compass is intended to aid you in reaching a decision.

CAD and CAE

Computer-aided design (CAD) and computer-aided engineering (CAE) are indispensable tools in modern engineering and architecture. CAD assists engineers and architects in their work by providing a powerful computer-based design tool.

CAD can be subsumed under computer-aided engineering. In CAE the design is carried out using predefined procedures for evaluating the suitability of the design for practical use. CAE makes use of numerous numerical models.

Today's CAD applications reach well beyond aiding in design. During the 1990s CAD programs were restricted to 2D designs corresponding to hand-made drawings made on a conventional drawing board. 3D visualisation is an integral part of the design process in current CAD programs, an enormous benefit for designers. The 2D workshop drawing that can be created with CAD programs can be considered as a mere by-product of the overall 3D design process.

The design time using modern 3D CAD programs is several times shorter than with their 2D predecessors. A 3D CAD program is indispensable for most of today's engineering design tasks.

CAD applications offer designers a variety of useful features, including:

- 3D visualisation
- Creation of components lists
- Exploded views
- 2D projected view for creating workshop drawings
- Plug-ins for numerical simulations (FEM)

Techniques used in applications

Every 3D CAD program is based on solid modelling (also known as Constructive Solid Geometry, CSG for short) techniques. In solid modelling the design is represented by so-called primitives. The design is constructed by creating complex objects through the operations of Boolean algebra done on the primitive objects. Due to its limitations, this technique is now supplemented with topological methods involving so-called boundary representations of objects. Combining this topological method with solid modelling results in the hybrid technique that forms the basis of modern 3D CAD programs. The 3D model of a design describes a complete shape.

Further division of the hybrid model into smaller shapes constitutes the basis for the finite element method (FEM), hence its name. The decomposition of design into finite elements is the basis for computer-aided engineering.

Among the numerous applications of FEM techniques are:

Mechanical stress and pressure
Selecting the proper materials used in structural components

Fluid dynamics
Simulation of flow in fluids and gases, for example, as found in turbines

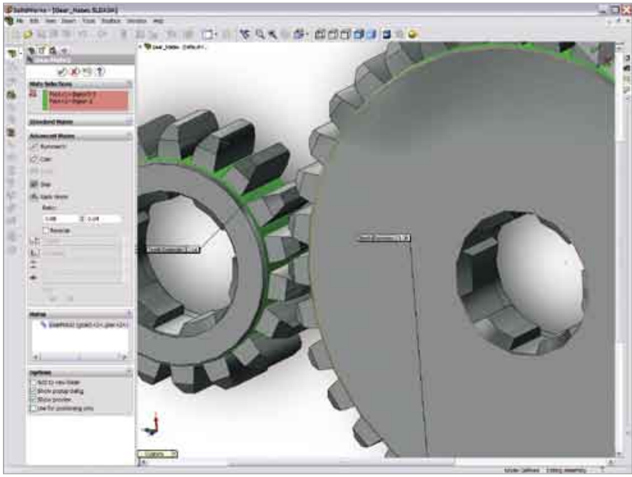
Thermal analysis
Simulation of heat transfer, for example, in mechanical parts

Vibration analysis
This plays an important role in characterising resonance, which may lead to material fatigue

In addition, there are many special applications of FEM, of which the most important are:

- Molecular Modelling: Modelling of chemical bonds
- Circuit simulation and chip design
- Geophysical modelling: Spread of ground-water

The results of an FEM analysis can be graphically processed with a 3D CAD program and overlaid on the design. This allows the physical in addition to the geometrical aspects of a design to be represented. FEM plug-ins are available for all leading CAD programs.



CAD design created with SolidWorks® 2007

System recommendations

Graphics cards
For purposes of display the design is decomposed into discrete polygons. For a complex design it is not at all uncommon that there are 10,000 to 100,000 such polygons. The polygons are displayed using OpenGL® or DirectX®. OpenGL®, the industry standard, has a clear edge over DirectX® here. An additional level of complexity arises from the fact that the design image is often rotated during the design process. In addition, portions of the design may be cut or made transparent so that details are easier to recognise. For a smooth workflow, hardware that can deliver 15 to 20 images per second is required.

From the above it can be seen that CAD places high demands on a graphics card. Manufacturers of CAD applications explicitly specify that for proper results and to be eligible for support only certified drivers should be used with their programs (See the overview on pages 10-11). For this reason it is advised that consumer-grade and onboard graphics should not be employed.

transtec recommends NVIDIA® Quadro®- and ATI FireGL™-series graphics cards. These graphics cards offer very high OpenGL® performance. A dual head interface, a standard feature of NVIDIA® Quadro® graphics cards, allows the video output to be viewed on two monitors. In a typical CAD application, the secondary monitor is used for a full-screen preview of a complex assembly. For CAD applications, monitors capable of delivering a resolution of at least 1600 x 1200 pixels are recommended.

Processors
Most current CAD programs still have little to offer in the way of multithreading[1] capability, the reason for this being that they represent 3D objects internally, using solid modeling, a technique which is difficult to achieve from multithreading. Since multi-threading capability is lacking, one cannot expect dual-core CPUs[2] to deliver noticeably higher performance. However, it can be expected that multithreading will play an increased role in future CAD software.

The situation changes when FEM techniques are employed; here dual-core CPUs do bring significant performance benefits. A realistic FEM simulation requires that the design object is decomposed into a large number of finite elements. This results in up to a million simultaneous linear differential equations. Since the algorithms for their solution have been programmed for multi-threading, code execution can be shared more or less equally between the two processor cores.

Main memory
The demands placed on system memory in the case of pure CAD applications are modest. However, if FEM modelling is done on a workstation, at least 8 GB RAM is required. In this case transtec recommends that a 64-bit operating system should be used so that all of system memory can be addressed.

[1] Parallel execution of multiple tasks (threads)
[2] CPU with two cores, each of which is a complete processor

Component recommendations

Graphics card
NVIDIA® Quadro®

CPU
1-2 dual-core CPUs:

CAD: Intel® Xeon® 5100-series (Woodcrest) processors

CAE: Intel® Xeon® 5100-series (Woodcrest) processors
or
AMD Opteron™
Dual-Core processors

Main memory
At least 4 GB

Photo-realistic rendering and animation

Photo-realistic rendering strives to create, through computing techniques, images that are closer to true-life scenes. Such applications have progressed from still images to animation. One example of this would be to enhance an architectural model with a more life-like atmosphere.

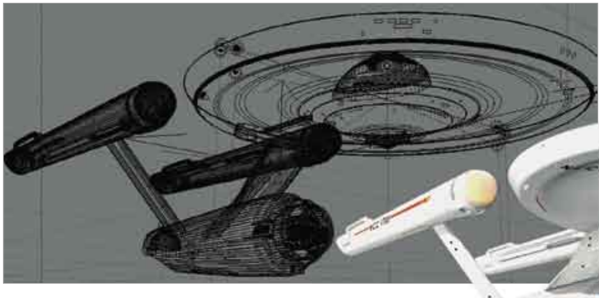
Applications of photo-realistic rendering are becoming increasingly important and especially so in the CAD environment where more and more leading manufacturers now offer the appropriate plug-ins. These allow for illustrated brochures and handbooks to be created without the need for the purchase of additional software.

Techniques used in applications

3D models used in photo-realistic rendering are normaly represented using polygonal meshes. To obtain a high degree of realism the meshes are successively made finer and finer. This allows a high degree of suppression of annoying polygonal artefacts.
Programs offering advanced features, allow for the possibility of adapting a mesh to a desired form. For example, the preview function represents a mesh as a wire frame model in order to give the designer a rough impression of the design. This is followed by a rendering using shaded polygons, which also permits the employment of textures.

When the intricacies of the design phase have been completed, a scene is ripe for the photo-realistic rendering. Rendering is based on ray tracing algorithms that permit reflection, shadow and refraction effects to be portrayed in a way true to the laws of physics.
Recent ray tracing enhancements allow the modelling of indirect light, as found, for example, in interior architecture applications. These enhancements are based on the photon mapping techniques, which allow for the modelling of spatial energy distribution of light.

The design phase of an animation compared to that of a single image, is often complicated and requires some careful thought. The movement of the camera must be planned-ahead if a scene is to be portrayed in the correct manner.



Mesh representation of an object

Completely rendered representation of an object

Examples of textures:

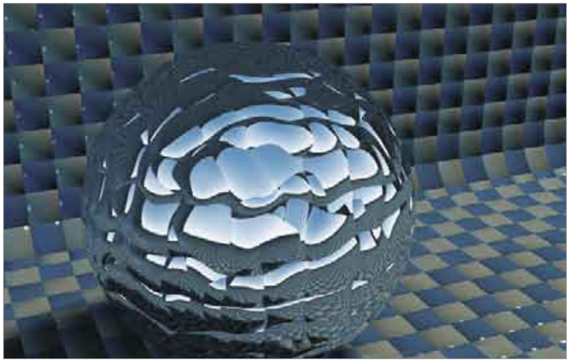
Stone and glass textures
Used in architectural modelling

Metallic textures
Used to achieve a lifelike representation of components used in mechanical engineering

Satellite and landscape photos
Used in geophysical modelling

There are numerous parameters whose time-dependency must be taken into account and specified, including:

- The path over which the camera moves
- The line of sight of the camera
- The camera’s intrinsic rotation
- Zoom and aperture settings needed to create more dynamic camera movement



Physically correct reflections created with Povray

System recommendations

Graphics cards
For a smooth display of objects during the design phase, a graphics card which is capable of delivering a high OpenGL® performance is required. Unlike CAD applications, in the case of photo-realistic rendering, manufacturers do not prescribe stringent certification requirements for drivers, thus expanding the variety of graphics cards which can be used, including those from the NVIDIA® GeForce®-series. Numerous 3D rendering programs use Microsoft®'s DirectX® API for previewing.

Even in preview mode, a wide range of textures can be used, necessitating a generously dimensioned video memory. In certain applications, for example, geophysical modelling and the representation of satellite-acquired images, a display of textures can require up to 1 GB of video memory and for this reason, we recommend the use of a graphics card with at least 256 MB of video memory.
transtec recommends the use of graphics cards with at least 256 MB of video memory.

Processors
Ray tracing algorithms, the core of photo-realistic rendering, allow extremely realistic representations. They are very CPU-intensive – typically 80-percent of their instructions are floating points which are fed to the Floating Point Unit (FPU). For this reason a CPU with good FPU performance should be selected. FPU performance is usually specified as Whetstones in GFLOPS. Since virtually all ray tracing programs are multithreaded, transtec recommends that multi-core CPUs be used for such applications.

Certain applications even permit ray tracing to be implemented on the GPU of a graphics card. The ability of the GPU to use rendering pipelines for parallel execution results in appreciable performance increases over calculations done on the CPU. In the case of extremely computational-intensive applications a second graphics card, whose function is restricted to serving as a booster for the primary card, is recommended.

Main memory
The representation of an image as a high-resolution mesh places severe demands on main memory. Realistic model meshes can typically consist of more than 100,000 polygons therefore it is suggested that the system memory be scalable from 8 GB to 16 GB.

As in the case of CAD the employment of a second monitor brings benefits. The secondary monitor can be used for a full-screen view of the completed rendering, with the primary monitor employed exclusively for previewing and designing.

A smooth animation consists of approximately 30 frames per second. The resulting computational load is very high, even for a few seconds of film. Such problems can be overcome through the use of a rendering farm in which the tasks of computational-intensive animation are divided over several computers.

Component recommendations

Graphics card
NVIDIA® Quadro® or GeForce®

CPU
1-2 dual-core CPUs:

Intel® Core™2 Duo processors
or
Intel® Xeon® 5100-series (Woodcrest) processors
or
AMD Opteron™ Dual-Core processors

Main memory
8-16 GB

Image processing

Modern computer-aided image processing is done after the image-acquisition procedure has been completed. This is true for home applications as well as in scientific and technical areas.
In the case of private users editing is limited to changing the contrast, brightness and colour saturation of images acquired from digital cameras or scanners.

In the scientific and technical arena, there are numerous applications whereby complex image processing is needed, such as in the following areas:

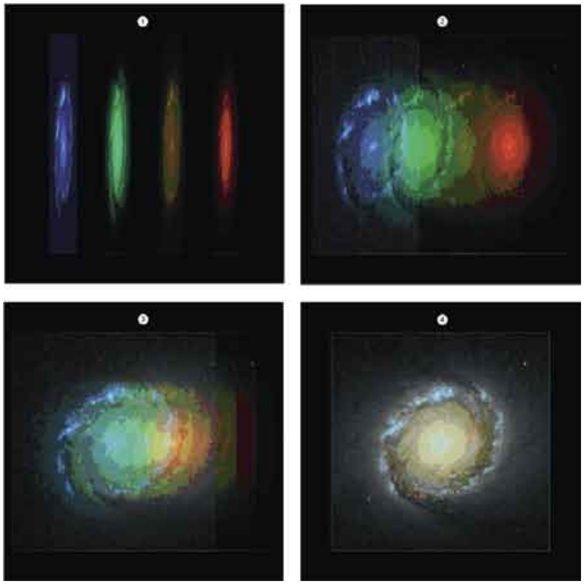
Synthesis and processing of astronomic images acquired by terrestrial and satellite-based telescopes.
This technique is used to remove, or at least reduce, the effects of artefacts created during the image-acquisition phase.

Analysis of images acquired by electron microscopes
Electron microscopes are divided into transmission and scanning types. Scanning electron microscopes scan the sample using a raster technique. Images generally require processing in order to deliver meaningful information.

Materials testing
Materials are tested to determine their durability and resistance to stress. Testing can reveal, for example, defects in crystals.

Synthesis and processing in medical image-acquisition
Computer tomographs and magnetic resonance tomographs create large amounts of data. In order that this data be interpretable by the physician, processing using a voxel model and subsequent editing is required.

Preparation of images from a microscope for use in error-checking of integrated circuits
The evaluation is done entirely with a computer and for this reason it can be considered as a high-end image processing application.



Picture left:
Overlaying four individual images of different wavelengths to create the final image – a common procedure in astronomy

Techniques used in applications

Scientific and technical image processing uses techniques based primarily on three complex numerical methods:

Fourier analysis: The input image, located in the so-called spatial domain, is transformed into the so-called frequency domain. It is possible to carry out transformations in the frequency domain to achieve changes in the original image, for example, to affect sharpness and wealth of details. For example, noise caused by CCD sensors can be reduced.

Wavelet analysis: Wavelet analysis is a very recent technique that is a partial substitute for Fourier analysis. It represents image content as a linear combination of elementary functions, so-called wavelets.

Geometric correction: Because a perfect lens is impossible to construct, the lenses of microscopes and telescopes cause image distortions, usually of the geometric type. For example, the so-called pincushion distortion exhibited by wide angle lenses is difficult to avoid. However, using modern image processing techniques such distortion can be corrected, allowing the image to be rendered without angular or linear distortion.

System recommendations

Graphics cards

For real-time applications special graphics cards with integrated video inputs are recommended. These permit the direct connection of CCD cameras as well as real-time signal processing. Such techniques find application in electron microscopy.
The 3D performance of a graphics card has no relevance in image processing since only 2D information is represented. The graphics card should be capable of displaying high resolution images.

transtec recommends the use of dual or quad displays. The first monitor is used for working with the application. A second monitor displays the original image and a third and possibly fourth monitor is used for viewing the processed image.

Processors

Since all image processing applications are FPU-intensive and offer good hyperthreading support, dual-core CPUs are recommended. Even higher performance can be achieved through the use of multiple CPUs, especially to achieve a smooth representation in FPU-intensive real-time applications.

Today's graphics cards offer up to ten times higher FPU performance than current CPUs. Special routines permit the use of the graphics card as a FPU in order to take the burden off the CPU. Here the shader units of the graphics card are employed as pure FPUs. Since current graphics cards have up to 32 shader units in parallel, a corresponding increase in performance is achievable.

In the case of long-term use the employment of two graphics cards with high 3D performance is justified. One graphics card is restricted to serving as a booster for the primary card. This should not be confused with the familiar SLI tandem operation of graphics cards used in gaming.

Main memory

Image processing applications are extremely memory intensive. For the high-end range transtec recommends that a 64-bit operating system be used so that system memory above 4 GB can be addressed. This allows annoying delays caused by hard-drive access to be minimised.

Component recommendations

Graphics card
NVIDIA® Quadro® NVS
(multi-monitor interface)

CPU
2 dual-core CPUs:

Intel® Core™2 Duo processors
or
Intel® Xeon® 5100-series
(Woodcrest) processors
or
AMD Opteron™
Dual-Core processors

Main memory
4-16 GB
(depending on the
image material)

What is the right graphics card for my application?

Choosing the right graphics card is a major challenge for many users. In making available this guide, transtec's aim is to provide a non-binding point of reference that will assist you in selecting the graphics card best suited to your application.

In the list below we have put particular stress on an unbiased selection of applications. No claim to completeness is made.

Graphics cards are classified, depending to the applications used and user requirements, as entry-level, midrange and high-end:

Entry-level
Occasional use of a program for small objects or components
- Approx. 10-percent of all users

Midrange
Regular use of a program for medium- to large-sized objects and components and with all application features used.
- Approx. 80-percent of all users

High-end
Regular use of a program for extremely large objects and components and with all application features used.
- Approx. 10-percent of all users

Manufacturer	Application	Type of use		
		Entry-level	**Midrange**	**High-end**
ANSYS	ANSYS	Quadro FX 550	Quadro FX 1500	-
	Design Space	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
Autodesk	AutoSketch	Quadro FX 350	Quadro FX 550	-
	AutoCAD LT	Quadro FX 350	Quadro FX 550	-
	AutoCAD MAP	Quadro FX 350	Quadro FX 550	Quadro FX 1500
	AutoCAD Mechanical	Quadro FX 350	Quadro FX 550	Quadro FX 1500
	AutoCAD	Quadro FX 350	Quadro FX 550	Quadro FX 1500
	Architectural Desktop	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
	Architectural Studio	Quadro FX 560	Quadro FX 1500	Quadro FX 3500
	Land Desktop	Quadro FX 350	Quadro FX 550	Quadro FX 1500
	Mechanical Desktop	Quadro FX 350	Quadro FX 560	Quadro FX 1500
	Inventor	Quadro FX 560	Quadro FX 1500	Quadro FX 3500
	VIZ	-	Quadro FX 1500	Quadro FX 3500
	3ds Max	Quadro FX 1500	Quadro FX 3500	Quadro FX 4500
	Combustion	Quadro NVS 285	Quadro FX 560	2x Quadro FX 560
	Cleaner	Quadro NVS 285	Quadro FX 560	2x Quadro FX 560
	Maya	Quadro FX 1500	Quadro FX 3500	Quadro FX 4500
	Studio Tools	Quadro FX 1500	Quadro FX 3500	Quadro FX 4500
Avid	Softimage|XSI	Quadro FX 1500	Quadro FX 3500	Quadro FX 4500
	Xpress	Quadro NVS 280	Quadro FX 560	2x Quadro FX 560
BENTLEY	Microstation	Quadro FX 350	Quadro FX 550	Quadro FX 1500
Co|Create	OneSpace Designer	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
DASSAULT SYSTEMES	CATIA	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
	SolidWorks	Quadro FX 550	Quadro FX 1500	Quadro FX 3500

Manufacturer	Application	Type of use		
		Entry-level	**Midrange**	**High-end**
UGS	I-deas	Quadro FX 350	Quadro FX 550	Quadro FX 1500
	Solid Edge	Quadro FX 350	Quadro FX 550	Quadro FX 1500
	Unigraphics	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
ePLAN	EPLAN	Quadro NVS 285	Quadro FX 550	-
	Logocad triga	Quadro FX 550	2x Quadro FX 550	2x Quadro FX 1500
ICEM	Icem Surf	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
MAXON	Cinema 4D	Quadro FX 560	Quadro FX 1500	Quadro FX 3500
NEMETSCHEK	Allplan LT	Quadro FX 350	Quadro FX 550	-
	Allplan	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
NewTek	LightWave 3D	Quadro FX 560	Quadro FX 1500	Quadro FX 3500
MEGATECH	MegaCAD	Quadro FX 350	Quadro FX 550	Quadro FX 1500
PTC	Pro/ENGINEER	Quadro FX 550	Quadro FX 1500	Quadro FX 3500
	Pro/Mechanica	Quadro FX 350	Quadro FX 550	Quadro FX 1500
SENSE 8	WorldToolKit	Quadro FX 4500	Quadro FX 5500	Quadro FX 5500G
	World Up	Quadro FX 4500	Quadro FX 5500	-
sgi	OpenGL|Performer	Quadro FX 4500	Quadro FX 5500	Quadro FX 5500G
VX	Varimetrix VX	Quadro FX 550	Quadro FX 1500	Quadro FX 3500

Graphics Workstation applications differ in their system requirements. The following overview is intended to aid in selecting the appropriate processor type for a given field of use. Because of the large variety of applications available it can serve only as rough guide. Detailed information on the system requirements for specific applications is available from the software vendor.

transtec Graphics Workstations

Area of application	Application properties	Intel® Core™2 Duo processors	Intel® Xeon® processors 5100-series (Woodcrest)	AMD Opteron™ Dual-Core processors
Computer-aided design (CAD)	The majority of today's CAD software is not programmed for multithreading. In addition, the performance of these applications is strongly dependent on system graphics speed. For many CAD applications it is advantageous to run several simulations simultaneously. Even if application software has not been programmed for multithreading, the employment of multiple processors can bring performance benefits due to the job mix.	Of limited suitability	Very well suited	Well suited
Computer-aided engineering (CAE)	CAE software applications, especially those involving finite-element methods (FEM), are FPU-intensive. In general, they are programmed for multi-processor use. Several of these applications are very memory-intensive and when multi-core processors are employed their performance is limited by the speed of the memory interface.	Well suited	Very well suited	Very well suited
Image processing, animation and photo-realistic rendering	Software applications of this type require high processor performance. The majority of these applications are programmed for multithreading. For example, rendering tasks are executed to a large extent in parallel and therefore profit from multi-core technology.	Very well suited	Very well suited	Very well suited

Very well suited ●
Well suited ◒
Of limited suitability ○

Recent developments in processor technology relating to Graphics Workstations applications

Until fairly recently, increases in processor performance were achieved by raising the clock speed. The limit was reached at 3.7 GHz. At this speed the processor is consuming over 100 Watts and further increases in clock speed would have required elaborate cooling techniques, something especially undesirable in an era of rapidly rising energy prices.

In searching for ways of increasing processor performance while at the same time reducing the extravagant power consumption of high-GHz CPUs, manufacturers have turned to a new processor architecture based on dual-cores, which is two processors or cores in a single chip.

A CPU core consists of:

- The Arithmetic Logic Unit (ALU), used for arithmetic computations
- The Floating Point Unit (FPU), used for decimal calculations
- The L1 cache, the primary cache which feeds the processor with data

In addition, both cores make use of a secondary cache, the L2 cache. In the case of AMD's Athlon™ 64 X2 processor there are two such caches, one for each core. On the other hand, Intel® Core™ technology uses a single L2 cache to feed both cores. Moreover, the cores share address and bus logic.

Dual-core processors have significant advantages over their single-core counterparts, including:

- Improved performance as expressed in MIPS[1]/Watt
- Growth potential for future multi-core processors
- Multi-core technology can also be used in graphics processing units and digital signal processors

Because of their unquestionable superiority, dual-core processors will largely supplant single-core CPUs in the workstation market during 2007.

The workstations with the highest performance today use mainboards with two CPU sockets. Dual-core processors allow the performance of such systems to be further increased through the implementation of a four-core design.

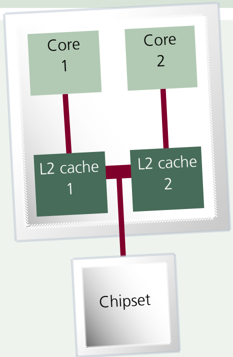
To take full advantage of multi-core technology the operating system and application software should be multi-threaded, that is they must be capable of executing code on more than one processor at a time. Since present-day software for photo-realistic rendering and image processing applications is multi-threaded, it allows the benefits of multi-cores to be realised. For example, in ray tracing applications performance is nearly proportional to the number of cores and the processor clock speed. CAD/CAE software lags somewhat behind in this regard – designers of CAD/CAE applications place more value on stability than performance. An exception is FEM applications, which are optimised for multi-threading.

Chip architectures:

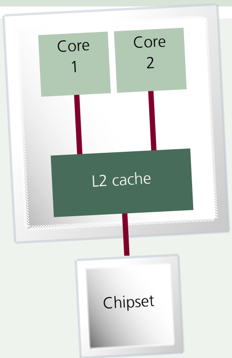
With conventional dual-core implementations each core has its own L2 cache, which requires that cache data be synchronised.

In Intel®'s new Core™2 Duo technology both cores share a common L2 cache. Since the processor is not burdened with cache synchronisation this results in additional performance increases.

AMD Athlon™ 64 X2



Intel® Core™2 Duo



[1]MIPS: Million Instructions per Second

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transtec = ttec in Belgium and Netherlands

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