6. Summary

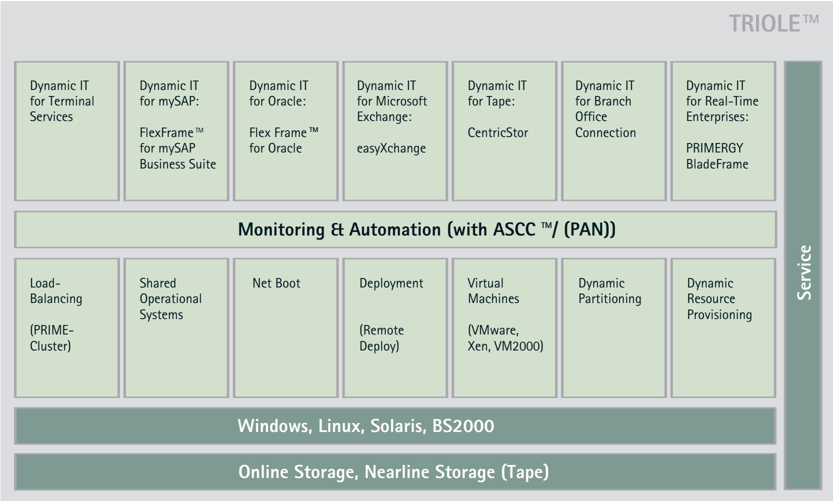
Numerous vendors are offering virtualization technologies as part of a broad range of products and services. Their aim is to help enterprises set up IT systems that are shared across customers, business units or applications.

Virtualization technologies are intended to serve as key components in end-to-end solutions aimed at enabling business policies and SLAs to drive dynamic and automatic optimization of the IT infrastructure, along the way reducing costs and increasing productivity. These architecture packages involve many technologies and a range of suppliers that manage and control various components of the infrastructure.

Industry standards for virtualization continue to mature, and some of the products currently on the market offer more in terms of future promise than in concrete ability to deliver right now. Fujitsu Siemens Computers, in contrast, is already implementing virtualization technology in its products with a very wide range of existing services.
Gartner, in a presentation at its Symposium ITxpo, pointed out that Fujitsu Siemens Computers provides strong integrated solutions as well as good partnerships including EMC, SAP and HP. ("Real-Time Enterprises Demand Real-Time Infrastructure," May 2005).

Fujitsu Siemens Computers is able to offer customers end-to-end solutions based on standard virtualization technologies that are ready to go today. Its experience and agility, moreover, allows it seamlessly to implement new virtualization technologies and standards as they develop, assuring customers of constant access to best of breed solutions.

Based on Virtualization, Automation and Integration the DDC delivers pragmatic Solutions and Services for optimized IT-operations



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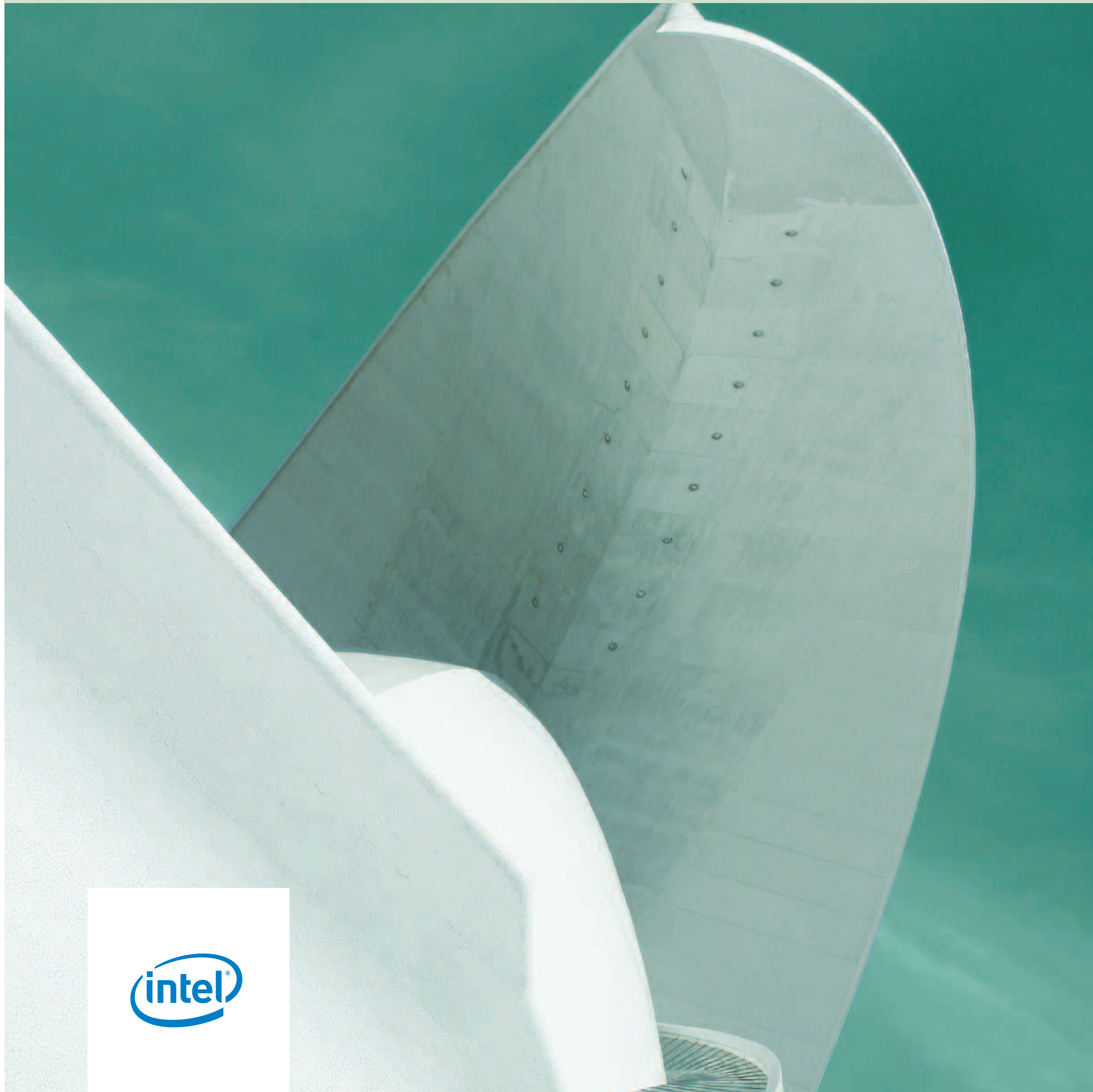
White Paper

We make sure

Dynamic Data Center™: Virtualization



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1. Introduction

CIOs and IT managers are working harder than ever to assure their boards that IT infrastructures can meet business requirements cost-effectively and give their organization a competitive edge in today's globalized world. Such efforts have put virtualization squarely in the spotlight, and interest in the various concepts and associated technologies is growing exponentially among corporate customers.

"Virtualization", "adaptive" computing and various flavors of "utility", "grid" and "on-demand" concepts are currently prominent buzzwords in IT circles. The precise meaning of these terms often remains somewhat muddled, with many meaning different things to different people. Whatever language we use – and clearly the basic definitions do need to be clarified before we can embark on a serious discussion of the issues – it is clear that a paradigm shift in the architecture and deployment concepts of corporate backend IT has been underway for the last three years or so. This shift is expected to continue and to bring about fundamental changes in the way IT is managed and the way it creates and delivers value and benefits.

This White Paper examines the different virtualization technologies in detail and explains to which IT infrastructure layers they apply. It also shows how Fujitsu Siemens Computers is incorporating these technologies into groundbreaking end-to-end solutions as an essential part of its Dynamic Data Center™ strategy.

2. Virtualization at a glance

Broadly speaking, virtualization is all about separating specific services or data from dedicated hardware resources. The concept now applies to all major layers of the IT infrastructure including

□ Storage □ Network □ Servers

The practical examples that follow, while by no means an exhaustive list, provide a useful illustration of how virtualization affects these different layers.

Storage virtualization

Virtualization of tape storage: Virtual tape technology for efficient data protection in heterogeneous data center environments is one of the key features of Fujitsu Siemens Computers' **CentricStor** solution. Please refer to the dedicated CentricStor section below for further information.

Continuous data protection – CDP: Multi-layer data redundancy is the key virtualization technology for CDP. The **Mendocino** product, for example, leverages an underlying infrastructure built on time- and event-addressable storage to return any application, database or file system to any previous point in time or process instantly and easily.

File/data level virtualization: This approach abstracts data at the file level. **Rainfinity** from EMC brings seamless file virtualization to the IT infrastructure to optimize NAS storage and file servers. This allows a single view across multiple devices to simplify storage management, and optimizes storage utilization through transparent, non-disruptive file movement between servers and NAS solutions.

Block level virtualization: Various products from different storage and switch vendors (such as EMC **Invista**) provide virtualization solutions that run on intelligent SAN switches. The main purpose of these solutions is to allow any storage to be allocated to any application, so they are also key enablers for information lifecycle management (ILM) strategies.

Network virtualization

VLAN: Abstracting a logical network on a physical LAN allows multiple LANs to be presented on a single switch. Every major switch vendor now supports VLAN.

Virtual routers: Abstracting a router to present several virtual routers on a single physical device

Virtual switches: Virtual switches provide switching technologies and features in software layers, and are typically realized using virtual machine monitors like VMware ESX. Like a physical switch, a virtual switch lets you connect networking components together. Virtual switches are created as needed by the VMware monitor and you can connect one or more virtual machines to such a switch.

Server virtualization

Chip virtualization: This approach creates a defined interface for communication between the virtual machine monitor and the associated guest machines. Provided by chip vendors, it makes hypervisors more efficient and robust. Intel VT (Vanderpool) is one of the industry leaders in this area. Please refer to the dedicated virtual machine section below for further information.

Hypervisors (virtual machine monitor): Abstracting a server makes it possible for a single server to appear as many. **VMware**, **Xen** and **Microsoft Virtual Server** are the most important products for industry standard servers today. Please refer to the dedicated virtual machine technologies section below for further information.

Application virtualization: This approach separates servers, applications and storage. It is supported by a mechanism for "just-in-time" dynamic allocation of server resources to applications. Fujitsu Siemens Computers' FlexFrame for mySAP and FlexFrame for Oracle 10g are the first real adaptive computing solutions in the industry. Please refer to the dedicated application virtualization section below for further information.

Data center virtualization: Creating virtual servers from pools of distributed components is the key technology behind the Fujitsu Siemens Computers PRIMERGY BladeFrame solution. This outstanding virtualization solution is based on industry standard servers connected in a high-speed switch fabric together with a very effective I/O virtualization method and the management capability of the PAN (Processing Area Network) manager. Please refer to the dedicated data center virtualization section below for further information.

3. The main driving forces for virtualization today

The virtualization approaches presented above have unquestionably unleashed a paradigm shift in the architecture and deployment concepts of corporate backend IT. This shift is expected to continue and to bring about fundamental changes in the way IT is managed and the way it creates and delivers value and benefits.

The new paradigm is driven by a series of striking economic arguments:

□ Immediate TCO advantage
- Significant reduction in hardware and software components
- Reduction in operating costs
- Automated administration
- Optimal utilization of IT infrastructure resources
- Long-term investment protection resulting primarily from standardization of infrastructure components

□ Radically improved agility
- Reduced time-to-operation for new business opportunities
- Flexible adaptation of resources for business processes according to current needs
- Abstraction of infrastructure details in virtual environments

□ Continuous satisfaction of SLAs defined by the end user
- Improved availability of business processes
- Guaranteed quality of service

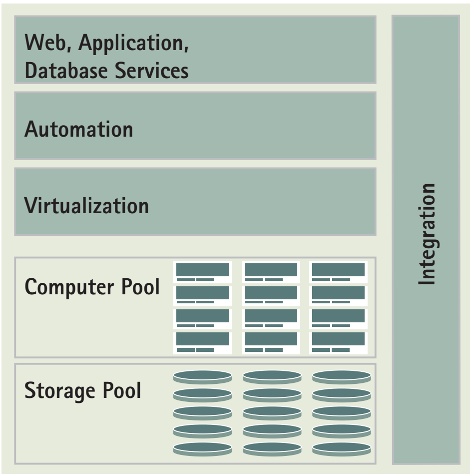
This paper outlines the basic principles of the new paradigm with particular reference to its incorporation into the Fujitsu Siemens Computers Dynamic Data Center™ (DDC) strategy.

4. Virtualization as part of the Fujitsu Siemens Computers Dynamic Data Center™ strategy

Virtualization is an essential layer in the Fujitsu Siemens Computers Dynamic Data Center™ (DDC). DDC is a strategy for a next-generation hardware and software architecture focusing on end-user services and SLAs. This combination makes on-demand computing a reality.

DDC uses virtualization, automation and integration technologies to move companies on to a service-oriented architecture in which computers and database resources can be assigned to applications dynamically. This yields increased flexibility and reliability as well as a considerable improvement in the cost-effectiveness of the IT infrastructure.

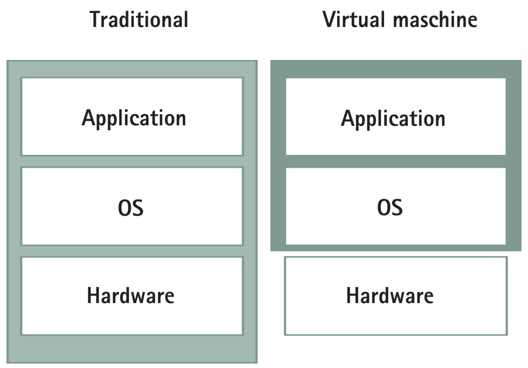
Virtualization of resources means that IT systems are pooled and shared for best usage. Automation ensures that IT resources are automatically allocated to services, while all of the building blocks are seamlessly integrated.



5. Virtualization solutions from Fujitsu Siemens Computers

How Fujitsu Siemens Computers supports virtual machine technology

CPU, memory and I/O devices are virtualized by a piece of software drawn from virtual machine technology that is now generally known as a hypervisor. The hypervisor is (typically) the only software that directly controls all real hardware resources in such a setup. Hypervisors are able to open large numbers of virtual machines running their own (guest) OS on a single physical server. This approach lends a more granular configuration to data center operations management while at the same time providing an abstraction of the underlying hardware. The software stack containing the OS and the application, in other words, becomes independent of the underlying hardware.



What problems are virtual machine monitors already able to solve?
The initial motivation behind virtual machine technology was the large number of only partially utilized servers operated by many companies. The importance of Intel-based servers in enterprise IT infrastructures has grown exponentially in recent years, and with the price/performance ratio of this server architecture being so good many companies have witnessed an uncontrolled proliferation of these systems. The operating systems for industry standard servers have a number of deficiencies that make effective coexistence of multiple applications on a single server difficult if not impossible, moreover, and the need to isolate individual applications totally from each other has only encouraged the uncontrolled server sprawl. It should also be mentioned in this context that today's operating system variants do not offer dynamic assignment of resources like memory, processor power and I/O bandwidth as is required for expedient balancing of peak loads.

Another factor behind the rise of virtual machine technology was the need to run legacy software ecosystems (OS + application) on the latest hardware. Legacy OS are not normally supported on the latest server hardware due to a lack of the necessary drivers, but in a virtualized environment all physical hardware is controlled by the hypervisor, which gives the legacy guest OS access to virtual hardware.

Virtual machine monitors have developed rapidly in recent years, and now offer functionalities making them suitable for use in applications far beyond the limited scope of the aforementioned consolidation scenarios. VMware ESX provides the best example of how customers can improve the flexibility and efficiency of their IT infrastructures using virtual machine technology.

VMware ESX – the enterprise virtual machine infrastructure

VMware, which was initially developed to address the consolidation issues discussed above, is currently the most successful virtual machine product. As a functional base, it provides excellent features for

- Optimal utilization and strategic management of a server's available resources
  - VMware ESX is ideal for consolidating server environments that are not used to full capacity, and can distribute the resources of a server very flexibly over the guest machines in use.
- Efficient provision of new services (OS + applications) and new servers
  - Once a basic infrastructure (VMware ESX itself plus typical operating systems on guest machines) has been created, these modules can be replicated very easily
- Total isolation of guest systems from each other
  - Every guest machine running is a self-contained unit. Any abnormal behavior of an application on a guest system thus has no effect on other guest machines.

These basic features alone significantly improve the IT infrastructure and lead to

- Reduced maintenance costs and unscheduled downtimes
  - The consolidation concept transforms a large number of smaller individual servers into a small number of large ones. The monthly cost of maintaining this small number of state-of-the-art servers is usually lower than that for the individual systems.
- Longer server infrastructure lifecycles
  - Customers frequently have stable server infrastructures that they do not wish to or cannot migrate to newer platforms (such as new operating system versions). The mutual independence of hardware and software in a virtualized infrastructure increases the lifecycle of a software ecosystem
- A much lower TCO and faster ROI
  - The arguments outlined above ultimately result in a far better TCO (total cost of ownership) and thus a faster ROI (return on investment). Other benefits include
    - Increased flexibility
    - More efficient server management
    - Reduced infrastructure complexity

VMware has continued to improve the ESX product since its introduction. Evolutionary steps such as adding support for the latest server technology (hyperthreading and dual core processors, etc.) and OS developments (64-bit OS, Windows and LINUX versions) were very important in demonstrating the continuity of the product, but the biggest leaps have come through revolutionary steps such as the introduction of VirtualCenter.

The VirtualCenter add-on management package significantly improves the management of VMware ESX infrastructures. The very first version of the product brought a dramatic change in platform management by concentrating not on individual ESX servers but on the entire ESX server farm, which can consist of several different industry standard servers running VMware ESX. Virtual Machines can be distributed across these servers very flexibly, and the VMotion feature of VirtualCenter even allows live migration of virtual machines, which means that a VM can be moved from one ESX sever to another while running with no loss of service. This critical technology laid the foundations for the outstanding new solutions coming with the next version of VMware ESX, which is called VMware Infrastructure 3 (previous versions were VMware ESX 3.0 and VirtualCenter 2.0).

DRS (Distributed Resource Scheduling) will provide a load-balancing service in an ESX server farm under which individual VMs are deployed or automatically migrated based on the actual utilization rate of the individual servers in the farm and the specified resource policies of the VM. This guarantees that the VM will always have access to committed resources and is a central requirement for meeting defined SLAs for specific services.

DAS (Distributed Availability Service) HA is a high availability solution for ESX servers. It controls the availability of the individual servers in the farm and automatically restarts dedicated VMs on other servers in the farm in line with user-defined policies and load-balancing considerations if an ESX server fails.

Given the aforementioned capabilities of virtual machine technology, this approach will also be used to improve deployment of IT services and as a foundation for efficient DR (disaster recovery) scenarios. VMware ESX is not yet in a position to virtualize all services, however, so the question for potential buyers must be: will I get sufficient performance out of an individual VM?

Current challenges for virtual machines

Depending on application profiles, the use of hypervisor technology without specific hardware assists can have a pronounced impact on performance. Performance can be limited in particular by simultaneous virtual address translation for multiple VMs and I/O emulation in some architectures, and the protection of real memory from access by unauthorized (guest) OSs can create issues that are difficult to handle in software.

Architecturally speaking, there is no standard interface for communication between the hypervisor and the guest OS, so each virtual machine monitor product has its own specially developed mechanism for virtualizing privileged instructions issued by the guest OS. This leads to incompatibilities between different hypervisor products and limits support for specific guest OSs in different environments. By way of example, Xen, an Open Source Community hypervisor concept, uses its own para-virtualization method in the communication between the Xen hypervisor and the guest OS. This involves modifying the guest OS, and Xen 2.0 consequently supports modified LINUX guests but not unmodified Windows. These problems are resolved in the new extensions to the IA instruction set (for example Intel VT).

Intel VT technology – improving virtual machine infrastructures

Intel Virtualization Technology makes it even easier to increase server utilization in your data center by consolidating more applications, improving data center reliability and adding robustness to virtualized systems. Intel's technology, which supports X-86 as well as IA64 processor architectures, provides specific functionality that helps simplify the implementation and deployment of a VMM and provides new capabilities for a better experience.

The first implementation is already available in the latest PRIMERGY 2-, 4- and 8-way servers and will be available in the IA64-based PRIMEQUEST server with the next generation of dual core processors (code name Montecito). With the first step in this development cycle, Intel Virtualization Technology gives both the VMM and the OS the authority each needs to run – without OS modification. With hardware-assisted virtualization, Intel Virtualization Technology greatly reduces critical barriers to consolidation, allowing you to move more software onto new Intel platforms.

Intel VT addresses the following areas with the following benefits:

VMM and OS level

- Greater OS and VMM independence.
- Higher levels of compatibility among unaltered heterogeneous operating systems

Benefits

- Can migrate more applications to platforms that offer hardware-assisted virtualization
- Fewer patches simplify system management
- Virtualize on standardized Intel®-processor-based platforms with the latest technologies

Business agility

- Support for mixed 32-bit and 64-bit operating systems and applications

Benefits

- Enables a more agile environment with new capabilities, increased headroom, and greater scalability

Reliability

- Hardware-assisted solution increases isolation of VMs and helps reduce possibility of propagation of attacks

Benefits

- More reliable platform
- Better business continuity

Robustness

- Simpler VMM
- Smaller software footprint; hardware-assisted VM management

Benefits

- More robust VMM
- Enhanced software reliability
- Helps reduce possible software-based conflicts

Virtualizes more environments

- Creates a more compatible environment for more software

Benefits

- Enables more vendors to offer virtualized data center solutions
- Provides greater choice for optimized virtual environments

Future versions of Intel processor families will have extended VT capabilities to give greater efficiency in handling the different virtual address spaces of hypervisor and the guest OS as well as significantly improved I/O handling in VMM environments.

Fujitsu Siemens Computers solution approaches for virtual machine environments

Fujitsu Siemens Computers has decades of experience in providing and managing virtual machine infrastructures. VM2000 for our BS2000 mainframe ecosystem is the perfect example of continuity and long-term investment protection in mission-critical data center environments.

Fujitsu Siemens Computers has set a clear focus on VMware Virtual Infrastructure in its support for virtual machine technology on industry standard servers. What does the choice of VMware Virtual Infrastructure as the enterprise product for VM-based DDC solutions mean for our customers?

Quality assurance

As described above, a hypervisor – in this case VMware – has exclusive control over a server's hardware, meaning that it assumes the role of an operating system. Fujitsu Siemens Computers treats VMware ESX as an operating system.

VMware ESX can now be obtained through a wide range of sales channels. It is usually offered as an IT solution or a sort of middleware, but this does not do justice to the complexity of the product. VMware ESX is an operating system. Would you buy a new operating system for business-critical applications from just any vendor? No! What does a customer planning to introduce a new operating system expect from a vendor such as Fujitsu Siemens Computers? In short, all of the care and responsibility that it has come to expect in connection with existing operating systems. Hand in hand with Fujitsu Siemens Computers' decision to introduce VMware as an operating system platform goes a clear commitment to adopt the same standards of quality applied to all other operating systems.

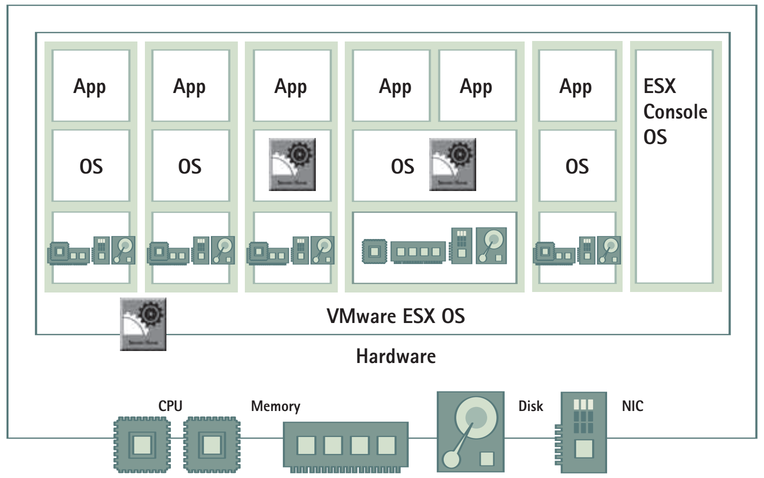
Qualification and certification of VMware ESX

As with other operating systems, Fujitsu Siemens Computers cooperates very closely with the vendor. Standardized testing procedures are followed at the laboratories to help ensure smooth interaction between the hardware and operating system. Fujitsu Siemens Computers has greatly restricted its portfolio of certified servers as part of the same effort in order to enhance quality even further, but VMware has so far still been released for all relevant 2-, 4- and 8-way PRIMERGY servers.

Installed components also play a central role in the interaction between the operating system and hardware. Here too, a very restrictive and conservative policy has been adopted in order to maintain a very high standard of quality. Components for testing and eventual release are selected very carefully in consultation with VMware. Please refer to the relevant Fujitsu Siemens Computers web pages for details of components currently released. Only these set configurations can ensure smooth running of the products and are covered by the necessary service agreements.

VMware ESX and Fujitsu Siemens Computers server management

The server management products from Fujitsu Siemens Computers are integral components of every PRIMERGY server and a not inconsiderable factor in this product's success in the market. ServerView now enables all PRIMERGY systems to be monitored fully in all phases, regardless of the operating system being used. Agents for the respective platforms are continuously being developed to permit this, for example for VMware ESX. Seamless integration of this platform in existing infrastructures was achieved in close collaboration with VMware. The interaction of the components and the degree of integration are shown in the diagram below.



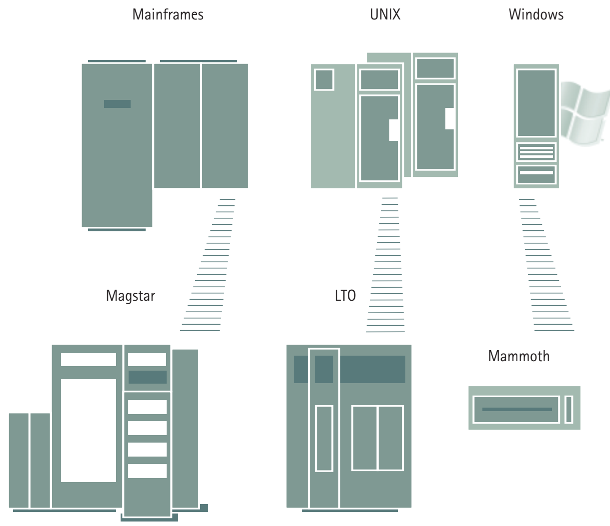
The agent for VMware ESX supplies information on the real hardware environment. The original agents of the operating system platform concerned run on the guest machines.

How Fujitsu Siemens Computers supports Virtual Tape Storage

Fujitsu Siemens Computers CentricStor solution

Challenges with physical tape

Organizations today are facing increasing pressure to do more with less, especially in the context of backing up critical enterprise data. Traditional backup methods have remained largely unchanged in the typical corporate environment over the last few years, with magnetic tape storage still usually the preferred option for backup and long-term archiving. Tapes are still popular and widely used because they provide high capacity and performance, are affordable and can store data for a very long time in a very competitive way. Now, however, multiple backup solutions in heterogeneous IT environments are starting to approach their limits: costs and complexity are increasing because each system needs its own backup process and tape technology, and IT organizations are finding it increasingly difficult to assure adequate data protection as a result. Tape cartridge capacity is often very poorly utilized in mainframe environments, while in open systems shortcomings in the transfer of data between servers and directly attached tape drives often lead to interrupted backup processes or even damaged tape drives. Shrinking backup windows, meanwhile, force users to run additional tape drives in parallel to achieve higher throughput, with the result that expensive tape resources are under-utilized most of the time.



Disk as tape

Other options such as backup to disk do not generally constitute an effective alternative. Their scalability for long-term archiving is limited, for example, and they are not particularly suitable for vaulting. The constant power consumption of rotating media devices is another drawback, as is the administrative overhead for new concepts and interfaces.

The advent of affordable disk storage stimulated the development of a variety of 'virtual tape' solutions, most of which combine disk with a kind of tape interface emulation. Despite strong competition from disk technology, however, tape cartridges are still the most economical storage media. The continuing rapid growth in user data generation (approx. 35% - 50% per annum) and new legal requirements such as long-term data vaulting make tape-based solutions almost unrivalled in the eyes of many customers, and IT managers are consequently evaluating integrated D2D2T virtual tape solutions to enhance system productivity and increase the return on investment over the years.

The market for virtual tape systems is growing steadily more diverse, and now offers software-only solutions as well as combinations of hardware and software components. There are in principle two different concepts for hardware-based systems. Disk libraries act like disk-to-disk systems (D2D) with virtual tape drive emulations, but D2D systems export data to physical magnetic tape in only very rudimentary fashion or through server-based arrangements, which obviously increases the load on the server. Integrated disk-to-disk-to-tape systems (D2D2T) provide automated and autonomous mechanisms for exporting data to physical magnetic tape without placing any demands on servers. There are also fundamental differences in the type and number of virtual tape drives and virtual tape library interfaces and in the methods of data compression used.

Comparison of virtual tape solutions

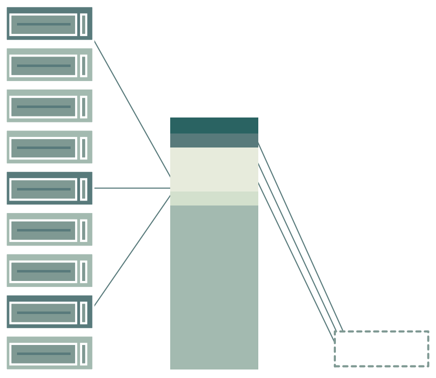
Virtualization is an intermediary layer that enables different hardware and software technologies to work together and utilize physical resources in a highly flexible and efficient manner. Without storage virtualization, each host has to manage its own specific storage; in a virtualized environment, the host and applications do not need to know on which physical device the data resides, as virtual devices with emulated interface characteristics replace the physical devices directly attached to the host. The virtualization layer manages the dynamic mapping of all virtual devices to the target physical devices, thereby increasing the flexibility and efficiency of resource assignment to the various hosts.

The actual degree of functional support and operational freedom achieved for IT operation depends on the detail of the virtualization solution used. There are several competing tape storage virtualization concepts, some of which offer only restricted functionality. Most kinds of virtual tape technology support mixing disk and tape, but only comprehensive integration with full virtualization of tape extracts the maximum benefit from both technologies.

Advantages of CentricStor Virtual Tape Appliance

Disk speed for tape backup

CentricStor Virtual Tape Appliance is several steps ahead of the other virtual tape solutions on the market. CentricStor integrates virtual tape with an automated tape library and offers information life-cycle management (ILM) functions for data backed up into the system to provide a highly integrated disk-to-disk-to-tape solution.



The integrated disk system acts as a tape volume cache (TVC) storing all logical volumes in a compressed format. CentricStor stacks these logical volumes and writes them together on physical tape cartridges. As a result, the full capacity of the cartridge and the streaming mode of physical tape drives are efficiently used. The software dynamically maps data written to the virtual devices onto physical storage and transparently manages usage of physical devices and media. This is the most efficient implementation of the disk-to-disk-to-tape (D2D2T) backup approach. Tape libraries from different vendors can be attached and controlled at the backend. CentricStor supports mixed tape library operation as well as mixed tape technology.

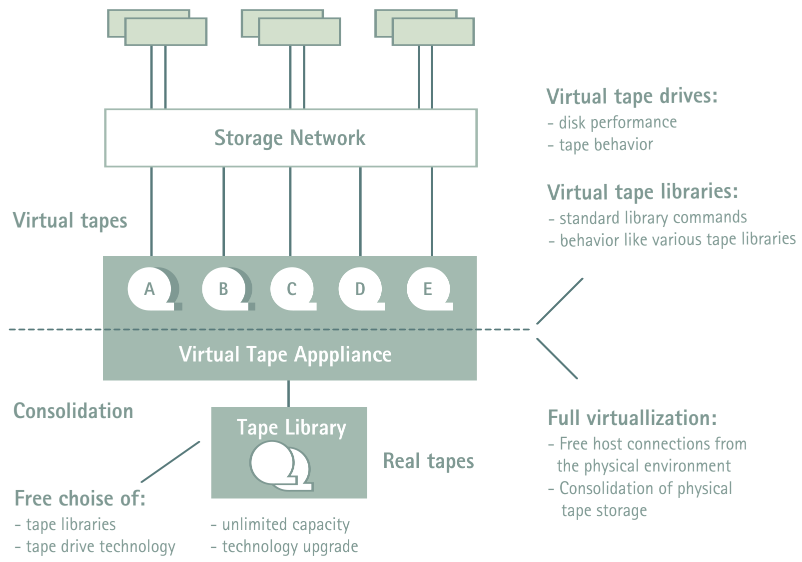
CentricStor consists essentially of three elements: device emulation (for tape drives and libraries), the internal tape volume cache (TVC) and control of physical library and drive attachment. It combines the performance characteristics of disks with the security characteristics of tapes without requiring changes at interfaces for the hosts, and it allows the IT department to separate investment decisions regarding hosts and applications from storage devices and the associated management tasks. Allocation and migration of the backup data to physical tape storage is managed automatically by means of policies.

CentricStor emulates various standard tape drive interfaces and library system controls for physical libraries. This virtualization solution with integrated tape volume cache makes it possible to provide high numbers of virtual drives at almost no cost. The performance potential of physical drives at the backend is leveraged by optimizing their operation, so high data transfer rates can be achieved with only low numbers of physical drives. CentricStor requires modifications neither to the host software nor to devices. Interfaces to hosts and interfaces to devices are completely separated and remain independent, so new physical devices from any future technology can be introduced without changing the interfaces for the hosts. Technical decoupling of host from peripheral devices is advantageous for

the overall IT operation too: efficient usage of resources no longer has any impact on operational issues such as the timing and frequency of backups or excluded read accesses to backup data.

CentricStor offers full virtualization of all the physical objects, which become completely invisible for the hosts with:

- virtual tape drive interfaces
- logical tape volumes
- virtual library interfaces



Protecting data in heterogeneous IT environments

CentricStor offers platform-independent data protection and integrates seamlessly into any data center. Its broad connectivity enables organizations to consolidate their entire range of magnetic tape systems in open systems and mainframe environments. A huge number of virtual tape drives are provided to all servers and backup applications as permanently available high-performance backup and archiving resources over the storage area network. This self-contained unit can be transparently integrated into existing IT environments without any additional software. The universal virtual tape appliance interfaces make it unnecessary to modify existing applications and tape backup scenarios. The extensive compatibility of CentricStor thus ensures seamless operation with leading backup applications while at the same time releasing them from the burden of managing physical tape systems.

Summary

CentricStor is the trade name for virtual tape solutions from Fujitsu Siemens Computers and is based on mature, patented concepts. It offers a common, centralized tape storage solution for mainframes, open systems and NAS storage devices and provides new degrees of operational flexibility. CentricStor is offered on various platforms (CentricStor VTA models, CentricStor VTC, CentricStor SBU solution packages) and supports the most widely used backup applications on the market-leading system platforms and the most important environments for tape automation.

CentricStor is able to meet a wide spectrum of requirements thanks to its unprecedented operational flexibility and its technical advantages in terms of tape operation. These strengths are the result of several years of development and a strong customer base: numerous satisfied customers in Europe are already using CentricStor for data protection in a consolidated Nearline environment, and the powerful CentricStor Virtual Tape Appliance is also being used successfully by large companies in Japan, the United States, and Southeast Asia.

How Fujitsu Siemens Computers supports application virtualization

A definition of application virtualization
Application virtualization is often described as application service virtualization. This type of virtualization is all about making available application services hosted in a framework of distributed computing power in accordance with defined business rules. The main objective is to be able to provide a specific service whenever it is needed without having to worry about which server provides the service or has to be started (this approach is very much related to the grid concept). Consequently, application virtualization helps to guarantee compliance with given SLAs.

FlexFrame™ for mySAP™ Business Suite
History
FlexFrame for mySAP Business Suite is a virtualized infrastructure concept in the sense of an enterprise grid based on application virtualization as described above. The initial concept and the first implementation were the result of a joint effort between Fujitsu Siemens Computers, Network Appliance and SAP started in the SAP Linux Lab in the summer of 2001. At this time, the enterprise grid concept and its advantages had not yet been realized, and there was no reference model that could have been followed. FlexFrame evolved in a direction nobody had considered before, its original target being to create a powerful method of operating and maintaining a standard SAP installation.

Once the prototype had been completed, Fujitsu Siemens Computers productized the collection of scripts that constituted the core of the effort in conjunction with additional software components to create FlexFrame. SAP recoded this functionality to make it a part of NetWeaver, SAP's integration and application server suite. SAP coined the name Adaptive Computing Infrastructure (ACI) and this new piece of software became the Adaptive Computing Controller (ACC). Fujitsu Siemens Computers received the SAP Pinnacle Award for Adaptive Computing 2003 and FlexFrame was used as the on-stage demo to introduce Adaptive Computing at SAPPHIRE in Orlando in 2003. Fujitsu Siemens Computers was also the first system vendor to be certified for the ACC.

The first application-server-related dynamic provisioning concept in the industry, FlexFrame/ACC enabled SAP to complement their ROI messages with a clear TCO message. Previously SAP had concentrated only on the return on investment for new SAP-enabled business processes, but now it was able to bring home the message that budgets for such innovations could only be generated by driving down the cost of existing processes by moving to the adaptive computing infrastructure (ACI). This message quickly came to dominate SAP events and executive keynotes. Initially, the ACC was more theoretical concept than usable technology, with FlexFrame the only serious option for implementing the ACI. The latest version of FlexFrame is able to use the ACC as a component.

What is FlexFrame for mySAP Business Suite?
FlexFrame for mySAP Business Suite is a joint development of SAP, Network Appliance and Fujitsu Siemens Computers. It is an Adaptive Computing Infrastructure for mySAP solutions integrating the new SAP NetWeaver™ technology platform and is designed to dramatically increase flexibility, simplify operations and reduce costs as compared with previous infrastructure concepts for SAP. FlexFrame offers software services on demand. This is achieved by complete virtualization of the software services and by clean separation of the key infrastructure resources:
☐ computing, ☐ networking, ☐ storage and ☐ control.

A modular architecture replaces rigid hardware and software configurations with virtual bridges. Computing power, storage resources, network components and mySAP™ ERP solutions can all be scaled independently and assigned dynamically. The result is a highly adaptable infrastructure that responds to changing service needs in real time. All resources are available on demand, giving you greater enterprise-wide agility.

Fujitsu Siemens Computers considers the following plus points to be particularly valuable in meeting the requirements for a virtualized application environment.

Shared operating system
- ☐ Rapid installation
- ☐ No need for time-consuming software distribution
- ☐ Single update for all servers

Virtualized SAP services
- ☐ Adaptive computing based on SAP NetWeaver™
- ☐ Flexible capacity allocation
- ☐ Optimized deployment of server resources
- ☐ Server changeover in minutes
- ☐ Simple grouping and pooling

Consolidated storage systems
- ☐ Innovative backup strategies
- ☐ Fail-safe data mirroring
- ☐ Expansion without migrating data
- ☐ High investment protection

Automated high availability
- ☐ No need for cluster technology
- ☐ Smart autonomous agents
- ☐ Easy system expansions
- ☐ Stable business processes

Virtualized resources, automated management
FlexFrame™ organizes all server and storage resources and handles variations in workload by reassigning available capacity in a matter of seconds. This ensures consistently high levels of performance and efficiency with fewer resources. Your investment levels and administration effort drop dramatically. FlexFrame™ is self-configuring, self-optimizing, self-healing and self-protecting.

Current status

FlexFrame™	Shared operating system	Virtualized SAP services	Consolidated storage systems	Automated high availability
Highlight	Automatic on-demand booting of OS on the various servers from a central source	SAP solution components no longer assigned to specific servers, grouping and pooling of components is possible	Flexible, on-demand allocation of resources	Automatic integration of new hardware using FlexFrame™ autonomous agents
Increased flexibility	Zero-downtime for update and patch testing, lower costs for software distribution and licenses, reduced workload	Standardized application virtualization with the Adaptive Computing Controller integrated in SAP NetWeaver™	Industry-leading Network Attached Storage (NAS) solutions	Minimum downtime for testing and low training costs
Future possibilities	Support for Linux, Solaris and mixed-OS environments	Improved ROI due to optimized deployment of server resources	Storage consolidation, rapid implementation of customized high availability and backup strategies	Stable business processes, costly cluster technology unnecessary

FlexFrame for mySAP Business Suite now runs on Linux in 32- and in 64-bit mode and on Solaris it supports mixed environments using NetApp NAS (EMC option on the way), and future versions will support EMC SAN. Since FlexFrame is a grid architecture based on application virtualization, it does not create virtualization-related performance issues and it does not require extra hardware support for non-standard features. It constitutes the best-in-class infrastructure for the NetWeaver environment. While other vendors have been able to gain ACC certification for their respective offerings, FlexFrame has always had a distinct set of features above and beyond ACC and we are maintaining a continuous dialog with SAP in order to retain our advantage in this area.

Currently, NetWeaver only runs SAP applications. It is not in the interests of SAP to give competitors a way in to its installed base, and it is therefore expected that only a small number of complementary/supporting applications will become available. This means that FlexFrame for mySAP Business Suite has a very clear positioning: it is the best-in-class infrastructure solution for supporting SAP-consolidated enterprise applications (EAS) environments based on NetWeaver and cannot serve any other purpose.

FlexFrame™ for Oracle 10g

History

Oracle announced the next version of their DBMS product under the name 10g in September 2003. This was the follow-up to 9i. The "g", which stands for grid, replaced the "i" for internet used in the previous two versions (older versions had no letter at all). Subsequently, Oracle named its application server 10g (AS) as well, in the process shifting its entire messaging focus from internet to grid.

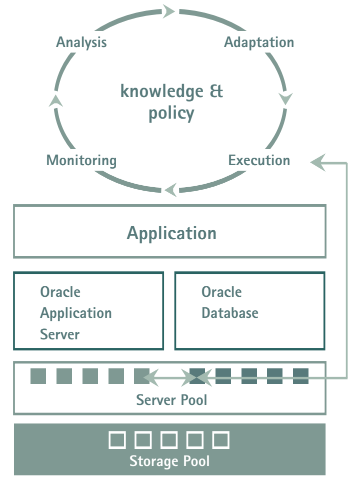
Oracle had talked about its concept of the (enterprise) grid before, essentially describing a scenario in which the database could be run on a big cluster of small machines (a much bigger cluster of much smaller machines than with its previous RAC (real application cluster) product) and in which the 10g AS would enable all applications running on top of it to run in a virtualized environment according to the grid concept described above. Overall this means that an enterprise application environment (composed of any suitable application components from ORACLE or other EAS vendors) could be run on a homogeneous grid of 2- or 4-way IA servers (as long as such configurations could satisfy the requirements defined by the set of applications).

Announced at VisIT'05, FlexFrame for Oracle 10g from Fujitsu Siemens Computers integrates Oracle's 10g platform with our ASCC (Adaptive Services Control Center) to produce an advanced grid infrastructure solution that can run any set of applications certified for the 10g AS. The entire range of J2EE-based applications qualifies for this certification. This solution currently supports Linux on x86 servers and NAS from Network Appliance. FlexFrame for Oracle 10g implements the provisioning mechanism in a slightly different way to FlexFrame for mySAP Business Suite and takes advantage of the policy-based control mechanisms of ASCC. Such differences aside, the two solutions are very similar. They share a common concept and feature set, and it is planned to pursue further convergence in future versions.

What is FlexFrame for Oracle 10g?

FlexFrame for Oracle (FF4O) is a dynamic infrastructure platform enabling data centers to consolidate business applications based on Oracle middleware and to step up to on-demand application and database services (grid computing).

Oracle 10g has been designed ready for enterprise grid computing, but so far Oracle has been restricted to defined servers preconfigured for an Oracle service. FF4O leverages the standard Oracle grid technologies here so that the Oracle middleware can be deployed together with its business-critical applications and underlying databases on a server farm. It automatically provides servers with the operating system and all necessary Oracle services, which allows fast setup of the server farm and dynamic adaptation of a running application to the needs of a changing workload. Finally, it is also very easy to enlarge an existing configuration in a growing environment: new servers can be added simply and after a few configuration steps the new resources can be used by all applications without long-lasting installation cycles.



FlexFrame for Oracle 10g – Overview

FlexFrame for Oracle delivers the following value added:

- Guarantees defined service levels by continuously monitoring health and performance indicators and automatically revitalizing failed services
- Minimizes TCO by consolidating server resources and using cost-effective servers based on industry standard architecture
- Automates administrative tasks and thus reduces human interactions
- Offers an attractive software licensing model
- Optimizes resource utilization by server and storage pooling and automatic, policy-based allocation of CPU power to application and database services

The underlying technological principles in FlexFrame for Oracle are the DDC principles of virtualization, automation and integration.

Virtualization: Unlike a traditional installation where a service is allocated on a dedicated server, the virtualization in FlexFrame for Oracle lets any Oracle service run on any server. This is achieved by storing the complete software stack (operating system, middleware and application) for each service on a central storage system and then provisioning any server in the farm with a Linux operating system and the required application server or database server with the aid of a special deployment tool.

Automation: FlexFrame for Oracle makes it possible to automate the entire server farm. It includes everything from the provisioning of the Oracle services at startup time to workload-dependent adaptation of the server farm to the current needs of the services. The automation solution relies on continuous monitoring of the health of the Oracle services and operating system and a control center that permits adaptation in accordance with a set of predefined policies in FlexFrame for Oracle.

Integration: FlexFrame for Oracle is a fully integrated infrastructure solution consisting of preconfigured hardware (servers and storage) and software (operating system, Oracle middleware and control center). This makes it easy to set up any business application based on the Oracle middleware that is ready to run as cluster. A completely preinstalled and preconfigured turnkey solution will be offered for some selected ISV applications.

A dedicated White Paper on this topic defines and describes several scenarios including:
- Provisioning of a server farm
- Policy-based workload management
- High availability (failover)
- Workload-controlled application management
- Time-controlled application management

Current status
In light of the above, Fujitsu Siemens Computers and Oracle have started a joint effort to migrate ISV- and end-user-specific applications to FlexFrame for Oracle 10g. The dedicated joint competence center opened for this purpose at Oracle's premises in Munich is the only one of its kind that Oracle supports in Europe and is run exclusively with Fujitsu Siemens Computers.

Summary – FlexFrame
The Oracle DBMS (10g or other) can be a part of both FlexFrames, and as already mentioned it is the only relevant option in the case of 10g AS. The Oracle database, which is far and away the most commonly used product of its type, particularly at the high-end, is also supported in the SAP-oriented FlexFrame. Indeed, SAP is now shipping the DBMS packaged with its own software and has thus become the most important channel for Oracle's DBMS in this area.

The two FlexFrames, in summary, are able to serve almost all relevant EAS environments and can both use the Oracle DBMS. Both solutions require a decision from the customer to consolidate EAS on either SAP applications or Oracle platform technology, which in practical terms means deciding to consolidate in either a NetWeaver or a 10g AS environment. The benefits are essentially the same in either case and arise largely from the flexible use of standard server hardware and advanced automation concepts.

How Fujitsu Siemens Computers supports data center virtualization

PRIMERGY BladeFrame
PRIMERGY BladeFrame implements a much more general and generic approach to delivering the Dynamic Data Center™ strategy. It does not depend on any ISV-related technology for application virtualization, but instead provides all the technology required to move large-scale heterogeneous enterprise application environments to a Dynamic Data Center™ framework irrespective of both strategic EAI vendor choice and the application scope beyond EAS.

BladeFrame's PAN (processor area network) manager technology provides a quick and easy way to set up virtual servers that are powered by real hardware when required and appear as real to the applications. The real server blades are stateless. They do not have any identity and, notably, do not contain any local I/O. Disk, network and control interfaces are virtualized and run over a high-speed rack-level interconnect fabric (switch). Ultimately, BladeFrame goes beyond application virtualization (in the sense of FlexFrame) by virtualizing the entire I/O while at the same time maintaining the one-to-one relationship between virtual and real servers (at runtime).

Due to this one-to-one real-to-virtual mapping, using BladeFrame has none of the adverse implications associated with the hypervisor concept. As explained above, BladeFrame provides server and data center virtualization, but does not virtualize CPUs and memory as with a hypervisor. It should be pointed out, however, that BladeFrame could be combined with such technology.

The application portfolio that can be consolidated and grid/utility-enabled on BladeFrame is all but unlimited (the only real limits are the number of 24 quad-CPU servers and the aggregate I/O rate in one system – and these limits are irrelevant for nearly all major application areas). There is no dependency on any specific EAI environment and no restriction regarding programming methodology (J2EE, .net, C++, etc.). Every application that runs in a standard Windows or Linux environment and on Intel CPUs, for example, is a candidate for integration into the grid/utility infrastructure powered by BladeFrame. This is a very strong proposition, particularly if home-grown/legacy applications are to be integrated. BladeFrame, in short, realizes the consolidated DDC environment in a completely universal manner, independent of any ISV-related enterprise application consolidation strategy and can even port existing, custom-developed applications to the new paradigm with minimal effort.

BladeFrame extends the advantages of the grid/utility concept beyond the scope of proven solutions as with FlexFrame, and creates similar customer benefits in a much more general – even heterogeneous – scenario. Significantly, it also provides an (n+1) high-availability concept for the entire application range that it covers. One server can act as the backup for a large number of servers and does not even have to be an idle spare system. The number of spares is thus minimized and the sizing to aggregate-application in contrast to single-application peak-performance becomes even more efficient if ISV-related application domains lose their limiting characteristics.

There is a big gap in the current debate about grid and utility computing between (marketing) vision and reality. Outside the areas of proven solutions, where FlexFrame is an immediately applicable infrastructure solution, BladeFrame provides the only existing technology that can smoothly and efficiently migrate an existing heterogeneous application scenario to a grid/utility infrastructure concept.

Architecture
The Storage Area Network (SAN) has emerged over the past decade as a popular option for centralizing, consolidating and virtualizing the deployment and management of storage resources. The SAN architecture was developed to address a set of complex problems that arose as storage moved from a central point (the mainframe-based data center) to a distributed model due to the growth of departmental systems and applications.

Processing resources have the same inherent problems as storage resources when a large number of discrete servers are deployed. Resolving the major data center pain points requires a new computing architecture. Known as a **Processing Area Network** or **PAN**, this architecture is intended to address the issues inherent in deploying and managing large numbers of servers and to leverage the increasing prevalence of SAN and Network Attached Storage (NAS).

PAN concept
The cost and difficulty of deploying computing power in enterprise data centers can be addressed through a collection of technologies referred to as a PAN. Just as the SAN paradigm has lowered total cost of ownership by simplifying storage deployment and maintenance, the PAN revolutionizes processing by simultaneously resolving multiple pain points. A PAN is characterized by ten fundamental concepts as described below.

Modular processing power
Physically speaking, the PAN lends itself to a form factor commonly referred to as a blade server – a system in which individual processing elements are on removable blades mounted within a larger chassis or frame. These platforms typically offer densities of 48 to 250 CPUs per rack with one to four CPUs per blade. To be considered a true PAN architecture, a blade server must provide hot insertion and removal, cable consolidation, integrated system management and integrated software deployment. The modular, hot-pluggable nature of PAN resources enables an administrator to increase or decrease processing capacity while the power is on and the system is running, facilitates rapid, cost-effective replacement of failed components, and permits processor and OS migrations without a forklift upgrade.

Software-based resource configuration
Managing large numbers of discrete servers is hard, resource-intensive work. With a PAN, on the other hand, integrated management software provides a logical layer for configuring and deploying virtual resources. An administrator can create the equivalent of a legacy server (known as a pServer), for example, by virtually associating a processing blade with external disk and network resources. In this scenario, components such as SCSI disks and Ethernet cards become virtualized. Meanwhile, applications think they are on traditional servers: they see conventional disk and Ethernet devices and are unaware that I/O is being virtualized and packets are being sent via routing tables.

Diskless processing resources
The processing blades in a PAN contain no disks or Ethernet ports, making them completely anonymous and stateless. This characteristic allows administrators to create pools of interchangeable virtual servers, supporting the ability to add capacity to a running application and enabling flexible configuration and failover since any processing blade can assume the identity of any pServer.

Centralized I/O
All interfaces to external networks and storage resources are centralized by redundant, hot-plug control blades within the chassis. Connections may be established via multiple Fiber Channel, Gigabit Ethernet and 10/100/1000 Ethernet links. Centralizing I/O minimizes cabling, simplifies configuration and failover and contributes to the stateless, interchangeable nature of the processing blades.

Built-in networking
A high-speed interconnect must be built into the chassis in order to connect system resources. This internal network is significantly faster than a typical enterprise backbone, achieving point-to-point data transfer of 2.5 Gigabits per second. This results in notable performance improvements over standard networking between discrete servers.

Redundant components
All physical and virtual components in a PAN are fully redundant with no single point of failure, so no single component or power failure can cause the overall system to become unavailable. This redundant, active/active architecture is leveraged not only for availability, but also for throughput, and yields exceptional speed and efficiency.

Virtual switches and interfaces
The PAN replaces error-prone physical components with virtual switches and interfaces that allow users to network processors without the restrictions of conventional hardware. With standard servers, network interface cards are physically present in the box and are connected to physical switches outside the box. With the PAN architecture, virtual NICs and virtual switches are configured and assigned through software. Virtual networks are then readily created from these virtual interfaces and switches. This provides both redundancy and high throughput.

Secure partitions
One of the most important attributes of a PAN is the ability to subdivide its resources into multiple, delegatable "containers" called Logical PANs or LPANs. An LPAN includes pServers and virtualized network components, in conjunction with external resources, that remain logically separated from the other resources of the PAN. Significantly, there is no connection whatsoever among LPANs – they are as isolated from each other as if they were different physical computers. Each LPAN is defined by the PAN administrator as resource needs dictate; administration can then be delegated to an LPAN administrator. Resources can be added on the fly by the PAN administrator at any time.

Built-in failover
A PAN delivers built-in monitoring of both hardware and applications supported by automatic failover. Integrated management software automatically detects failures, selects backup resources, restarts applications and remaps connections.

Summary – BladeFrame
Resolving the major data center pain points requires a new computing architecture. This architecture, called a Processing Area Network or PAN, is intended to address the issues inherent in deploying and managing large numbers of servers, and to leverage the increasing prevalence of SAN and NAS. The PAN is a distributed set of resources – including processors, memory, storage and network connections, and DVDs – that are logically assembled into virtual servers and clusters.

The PRIMERGY BladeFrame system's distributed-component hardware architecture enables a PAN by providing diskless processing resources interconnected by a high-speed switching fabric, access to NAS and SAN resources, and access to traditional or high-speed Ethernet networks. Computing power is packaged on blade servers that slide into a standard rack-sized chassis and require no individual cable connections. Increasing the amount of available computing power is as simple as sliding in new processing blades.

The PAN also introduces software-based virtual components to create the virtual servers that provide functionality traditionally housed in hardware. This architecture eliminates the physical scaling and provisioning restraints of networking individual servers, enabling administrators to create, modify and remove I/O communication channels in response to changing business conditions.

A PAN, finally, is provisioned and managed entirely through software. As a result, processing and I/O resources can be configured and deployed in minutes rather than days or weeks without physically moving or rewiring any components.