Abstract

This white paper examines the performance considerations of placing SAP applications on FAST-enabled EMC® unified storage. It also discusses the best practices and total cost of ownership (TCO) benefits for deploying SAP applications using EMC FAST technology.

December 2010
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Executive summary
The business challenge that many SAP customers face today is reducing total cost of ownership (TCO) while improving service level delivery. Frequently, responsiveness to sensitive SAP applications has deteriorated over time due to increased data volumes, unbalanced data stores, and changed business requirements. By using EMC’s latest FAST technology on EMC® unified storage with block data, SAP deployments under performance pressure can often gain a significant responsiveness boost without the need to redesign the applications, adjust the data layouts, or reload significant amounts of data. FAST provides performance improvements by means of automated sub-LUN level tiering and allows a single LUN to leverage the advantages of Flash, Fibre Channel (FC), and SATA drives through the use of storage pools. Properly balancing data distribution over the tiers of storage optimizes both space utilization and the performance deliverable from the storage investment. The performance improvements and TCO benefits gained by using FAST technology in SAP deployments provide a tangible and quantifiable operational cost savings over time.

Introduction
This white paper provides insights into how using FAST technology in an SAP deployment with data stored on an EMC unified storage system can improve performance and TCO, based on an engineering case study conducted by EMC that used an SAP system on EMC CLARiiON® CX4 storage arrays using FAST technology. This white paper also documents the workload experiments that EMC has conducted with an SAP ECC 6.0 system using storage pools with FC drives only and with storage pools with Flash, FC, and SATA drives and the comparison between them. The goal is to verify that using FAST can boost performance and reduce TCO for certain kinds of SAP applications when compared to using traditional LUN-based technology. EMC tested these differences by comparing both in transaction rates per minute as well as transaction response times without requiring application-level changes and without changing the application design, code, and logic. The findings from these experiments serve as the basis of some of the deployment best practice recommendations for leveraging FAST technology in different SAP environments. You can skip the initial sections of this paper if you are already familiar with EMC storage, EMC FAST technology, and the SAP ERP Central Component (ECC) system.

Audience
This white paper is intended for SAP administrators, storage architects, customers, and EMC field personnel who want to understand the implementation of FAST technology in SAP environments to improve the performance of business applications.

Terminology
The following terminology is used in this paper.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAST</td>
<td>Fully Automated Storage Tiering</td>
</tr>
<tr>
<td>iSCSI</td>
<td>SCSI command over an IP network (Ethernet)</td>
</tr>
<tr>
<td>SAN</td>
<td>Storage Area Network</td>
</tr>
<tr>
<td>SATA</td>
<td>Serial ATA</td>
</tr>
<tr>
<td>SSD</td>
<td>Solid State Drive</td>
</tr>
<tr>
<td>Storage/disk array</td>
<td>A disk array is a disk storage system that contains multiple disk drives. It is differentiated from a disk enclosure in that an array has cache memory and advanced functionality, like RAID and virtualization</td>
</tr>
</tbody>
</table>

The following terminology is specific to SAP.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APO</td>
<td>Advanced Planner and Optimize</td>
</tr>
<tr>
<td>BW</td>
<td>Business Information Warehouse</td>
</tr>
<tr>
<td>CRM</td>
<td>Customer Relationship Management</td>
</tr>
<tr>
<td>ECC</td>
<td>ERP Central Component</td>
</tr>
<tr>
<td>FI</td>
<td>Financial Accounting</td>
</tr>
</tbody>
</table>
EMC and SAP technology

**EMC CLARiiON CX4**

The EMC CLARiiON CX4 series with UltraFlex™ technology is based on a breakthrough architecture and extensive technological innovation, providing a very competitive midrange storage solution. The CX4 is the fourth-generation CX series, and continues EMC’s commitment to maximizing customer’s investments in CLARiiON technology by ensuring that existing resources and capital assets are optimally utilized as customers adopt new technology.

CLARiiON CX4 systems support the latest generation of disk drive technologies like Flash drives, 4 Gb/s FC drives for high performance, and SATA II for high capacity. CLARiiON CX4 is the first midrange storage system to support all of these types of disk drive technologies. The CLARiiON CX4 with the latest FLARE® release 30 has been optimized for maximum performance and tiered storage functional flexibility. CLARiiON CX4 systems also benefit from the advanced capabilities that the EMC software provides, including local and remote replication, Unisphere™ Quality of Service Manager, and five 9s availability. A complete introduction to the CX4 series is beyond the scope of this paper, but you can obtain more details in the “References” section. A few major features of the CLARiiON CX4 series are listed below. All four models of the CLARiiON CX4 listed in the figure support FAST technology.

![Figure 1. EMC CLARiiON CX4 models](image)

<table>
<thead>
<tr>
<th>MM</th>
<th>Material Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW</td>
<td>NetWeaver</td>
</tr>
<tr>
<td>PLM</td>
<td>Product Life Cycle Management</td>
</tr>
<tr>
<td>PP</td>
<td>Production Planning</td>
</tr>
<tr>
<td>SCM</td>
<td>Supply Chain Management</td>
</tr>
<tr>
<td>SD</td>
<td>Sales &amp; Distribution</td>
</tr>
<tr>
<td>SEM</td>
<td>Strategic Enterprise Management</td>
</tr>
<tr>
<td>SRM</td>
<td>Supplier Relationship Management</td>
</tr>
</tbody>
</table>
EMC Celerra unified storage

EMC Celerra® unified storage platforms combine an IP storage enclosure and best-in-class, native CLARiiON storage providing NAS, iSCSI, and Fibre Channel in a single packaged solution. Having built on a robust platform like CLARiiON, the Celerra unified storage inherits all the high-availability (like five 9s) characteristics of a CLARiiON storage platform along with support for almost every latest technology available on a CLARiiON. The EMC unified storage platform also supports the latest generation of disk drive technologies including Flash drives, Fibre Channel drives, and SATA II.

Figure 2. EMC Celerra unified storage models

Most of the data points discussed in this paper are in the CLARiiON CX4 context but still apply to a native block implementation of any Celerra unified storage platform.

Both the CLARiiON and Celerra unified storage platform provide the new Unisphere management software for storage management and administration. This suite of tools allows centralized management of storage systems. Unisphere provides a centralized tool to monitor and configure CLARiiON storage. The Unisphere suite includes Unisphere Manager, which has a web-based UI, and Unisphere Secure CLI or Command Line Interface. The Unisphere management tool also provides functional capabilities like point-in-time local replicas and remote replication options for business continuity.

EMC FAST technology

EMC Fully Automated Storage Tiering (FAST) technology is storage-array-based software that provides a policy-based auto-tiering solution for enterprise applications transparently. FAST operates at a granularity of 1 GB, referred to as a “slice.” The goal of FAST technology is to leverage storage tiers to lower customers’ TCO and to increase performance by keeping hotter slices of data on higher tiers and colder slices of data on lower tiers. High locality of data is important to realize the benefits of the FAST technology. FAST has the ability to relocate sub-LUN level pieces of data from one storage tier to another, by relocating more active data to faster drives like Flash drives for performance and less active data to slower drives like SATA II drives for reduced storage costs. This occurs automatically and transparently to the host environment. FAST operates on the storage data by relocating the most active data up to the highest available tier (typically Flash) in the scheduled relocation window. To ensure that there is sufficient space in the higher tiers, FAST relocates less active data to lower tiers (FC or SATA). When FAST
relocates data, it will move the entire slice to the new storage tier. To successfully identify and move the correct slices, FAST performs statistics collection, analysis, and relocation. You can initiate the relocation of slices manually or automatically by using a user-configurable, automated scheduler.

FLARE release 30 also introduced the multi-tiered storage pool. The storage pool allows FAST to fully utilize all three storage tiers: Flash, FC, and SATA. The creation of a storage pool allows for the aggregation of multiple RAID groups, using different storage tiers, into one object. LUNs created out of the storage pool can be either thick or thin provisioned. These “pool LUNs” are no longer bound to a single storage tier. Instead, they can be spread across different storage tiers within the same storage pool. If you create a storage pool with one tier (Flash, FC, or SATA) then the FAST feature has no impact on the performance of the system. To operate FAST, you need at least two or three tiers. The following figure shows the storage pool with three tiers of storage layers.

You can enable FAST on all pools and pool LUNs (thin LUN/thickLUN). For the current study, we have used thick LUNs instead of thin LUNs. Specifically, FAST incorporates no limits on how many pools or pool LUNs can participate in auto-tiering. The Unisphere user interface provides the auto-tiering configuration tools.

Since CLARiiON supports three storage tiers, users must weigh the benefits of these choices and pick the appropriate tier for their environment.

The following steps outline the process to configure and leverage FAST in SAP deployments.

- Create heterogeneous storage pool(s) consisting of different types of disk drives (Flash, FC, and SATA).
- Create LUNs on the storage pool with an initial tier preference.

Figure 3. FAST storage pool with three tiers of storage

You can enable FAST on all pools and pool LUNs (thin LUN/thickLUN). For the current study, we have used thick LUNs instead of thin LUNs. Specifically, FAST incorporates no limits on how many pools or pool LUNs can participate in auto-tiering. The Unisphere user interface provides the auto-tiering configuration tools.

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- Create heterogeneous storage pool(s) consisting of different types of disk drives (Flash, FC, and SATA).
- Create LUNs on the storage pool with an initial tier preference.
• FAST keeps tracks of data I/O activity in the storage pools.
• The FAST module analyzes data I/O activity and decides which data to be relocated for better system performance.
• The FAST module automatically relocates the data during a relocation time window. Applying an array-wide relocation schedule allows the user to define the days and duration for relocations. You can also use the manual “relocate now” option for all pools.

**SAP**

SAP has helped customers automate their business processes through the use of its standard Enterprise Resource Planning (ERP) software solution, called SAP R/3. The ERP solution was upgraded and launched as SAP ECC 6.0 in 2005. The purpose of positioning it as ECC (or ERP Central Component) is to enable SAP to build and develop an environment of other products that can function upon the foundation of the central component. ECC has the components of the traditional R/3 finance, logistics, sales, material management, and human resources modules, and additional extension sets. Individually, each of these modules effectively serves to manage a business area or functional area for which a particular company department is responsible. SAP NetWeaver is SAP’s integrated technology platform and is the technical foundation for all SAP applications.

The standard NetWeaver 7.0 business suite includes many systems that perform different activities. Each system is a separate SAP instance. However, the technical architecture of each system uses the same kernel architecture. The data that is imported into each system’s database during installation is what makes it different. The difference between these NetWeaver products comes strictly from the type of data imported into these systems rather from the general architecture. This is also true with the rest of the NetWeaver Suite applications (CRM, SRM, and BI).

Typically SAP systems are deployed in two-tier or three-tier configurations. In a two-tier configuration, the application and database run on one physical server and the distributed presentation clients access the SAP system using client tools like SAP GUI. In a three-tier configuration, the database and central instance run on one powerful server, while multiple application servers run on different machines and distributed presentation clients access the SAP system using client tools.

**Importance of storage performance in SAP**

The production SAP system can generate quite large volumes of data that need to be accessed with low response times for the online users as well as background batch-processing jobs. The design of a database server’s storage system is one of the most important choices in the design of the SAP infrastructure. A properly designed disk storage system has a direct influence on the response times of the overall SAP landscape and instances. Typically, in the case of production SAP systems, the size of all the database files combined is significantly larger than the size of the physical memory (RAM) available, whether on the server or on the storage cache. Since most servers today do not support hundreds of gigabytes of physical memory, the data transfer to or from storage plays a crucial role in the overall performance of the SAP system.

**Disk I/O patterns from the business application perspective**

The number and type of hard disk drives have a considerable influence on the performance of disk I/O. In addition to the capacity requirements, an SAP system requires performance from the storage system in the form of high I/O throughput. Online Transaction Processing (OLTP) applications create millions of random disk accesses (usually an 8K block for SAP databases). For SAP R/3 systems, the database server has a typical OLTP disk I/O access profile of an 80/20% read/write (4:1) ratio. Depending on the components you use and the customizations you make to the SAP system, other ratios are also possible. For example if you want to import large amounts of data in batch mode, the read ratio is more when compared to the write ratio where the storage system may need to be configured differently.

Online Analytical Processing (OLAP) systems such as SAP Business Information Warehouse (BW) or SAP Advanced Planner and Optimizer (APO) usually transfer large data quantities. For instance, user-generated
BW queries and reports are extremely read-intensive and disk performance is key for these kinds of operations. So the 80/20% read/write ratio does not necessarily apply to the BW system.

You can characterize the disk I/O performance as the number of I/O (read/write) operations that a hard disk can perform per second (IOPS). Disk arrays are used for production systems to perform several I/O operations concurrently. For our study we have used storage pools with FC drives, Flash drives, and SATA II drives configured as RAID 5 in an EMC CLARiiON CX4-960. For better performance and the best failure protection, EMC recommends using RAID 1/0. In some cases, RAID 1/0 offers faster data reads and writes than RAID 5 because it does not need to manage parity.

SAP Application Performance Standard
The SAP Application Performance Standard (SAPS) is a hardware-independent unit that describes the performance of a system configuration in the SAP environment that is derived from an SAP Sales and Distribution (SD) benchmark. SAP standard benchmarks are geared more toward measuring the CPU and the memory of a hardware system based on a customer’s SAPS requirement. SAP standard application benchmarks are not I/O-intensive in nature and do not generate the required I/O load to compare and contrast SAP system performance using FAST at a storage layer. Therefore, EMC has internally developed custom SAP OLTP workloads that are based on real customer data and can generate the I/O load for our engineering study.

System hardware setup
To characterize FAST with SAP OLTP workloads, EMC used the following hardware setup. The performance study is done on an SAP ECC 6.0 system running on SUSE Linux Enterprise Server 10 using a single instance of an Oracle 10g database hosted on a Dell R900 server with 16 Intel 64-bit processors connected to a CLARiiON CX4-960 storage array. The following figures show EMC’s hardware configurations. In the configuration shown next, six out of the total eight back-end buses on a CX4-960 are used. You should configure back-end buses depending on your I/O requirement and by following EMC best practices for bus and disk layout. Figure 4 shows the hardware system setup with front-end connections on the left side and the CX4-960 back-end connections on the right side.
For the SAP system, six RAID 5 pool LUNs were carved out of the storage pool on the CLARiiON CX4-960 and used for the SAP FAST configuration scenarios. Out of these six LUNs, four were used as DATA volumes (DATA1, DATA2, DATA3, DATA4), and two LUNs were used as LOG volumes (LOG1, LOG2) for the Oracle database. In the production scenario you may choose to place the DATA LUNs and LOG LUNs on different storage pools for better performance and recoverability. For our study we have created a storage pool with different numbers of drives and the details of this are covered later.

**SAP workload**

The SAP workload used in this study consists of 20 business processes from the SAP FI, SD, MM, and PP modules, which contained several batch jobs running in parallel accessing the 1.3 TB database. The workload characteristics have been kept constant for all the configuration scenarios described below so that one can make a relative comparison of application metrics. To understand the impact of FAST on an SAP ECC system in these tests, we focused on I/O throughput and response times of the batch jobs by running the workload on several configurations listed.

EMC also used the following configuration scenarios to compare application-level metrics to demonstrate the impact of FAST on the workload in terms of performance and TCO. The goal of this test is to show how FAST can significantly reduce the number of IOPS received from rotating spindles by relocating the hot data to faster Flash drives to improve performance and to lower the TCO.

**FAST configuration scenarios**

To characterize FAST with SAP transactions, EMC used the following configuration scenarios with the SAP workload described above and demonstrated the benefits of FAST technology in typical SAP
deployments. In this workload, the OLTP-style transactions read the customer data from the disk, process the data, and update it.

- **Baseline scenario**: The baseline metric is established using a storage pool with 90 x 600 GB FC drives configured as one tier.
- **Scenario 1**: The storage pool contains 45 x 600 GB FC drives.
- **Scenario 2**: The storage pool contains 5 x 200 GB Flash drives in tier-0, 45 x 600 GB FC drives, and 15 x 2 TB SATA II drives.
- **Scenario 3**: The storage pool contains 5 x 200 GB Flash drives in tier-0, 25 x 600 GB FC drives, and 20 x 2 TB SATA II drives.
- **Scenario 4**: The storage pool contains 5 x 200 GB Flash drives in tier-0, 15 x 600 GB FC drives, and 25 x 2 TB SATA II drives.

**Baseline scenario**

Figure 5 shows the SAP workload running on a storage pool configuration that contains only one tier with 90 FC drives. This workload is a baseline for our study. When the storage pool contains only one tier, as in this case, the FAST feature does not have any impact on performance. It took approximately 119,003 seconds (33 hours) for all 20 jobs to complete. The longest job took 6,793 seconds (113 minutes).

![SAP workload running in the baseline scenario with one tier (90 FC drives)](image-url)
Scenario 1

Figure 6 shows the SAP workload running on a storage pool configuration that contains only one tier with 45 FC drives. It took approximately 145,335 seconds (40.4 hours) for the 20 jobs to complete where the longest job took 8,548 seconds (142 minutes).

Figure 6. SAP workload running in the storage pool scenario with one tier (45 FC drives)
Scenario 2

Figure 7 shows the SAP workload running on a tiered storage pool configuration that contains tier-0 with 5 Flash drives, tier-1 with 45 FC drives, and tier-2 with 15 SATA II drives. It took approximately 53,203 seconds (14.8 hours) for all 20 jobs to complete. The longest job took 2,905 seconds (48 minutes).

Figure 7. SAP workload running on a storage pool with three tiers (5 Flash, 45 FC, 15 SATA drives)
**Scenario 3**

Figure 8 shows the SAP workload running on a tiered storage pool configuration that contains tier-0 with 5 Flash drives, tier-1 with 25 FC drives, and tier-2 with 20 SATA II drives. It took approximately 58,227 seconds (16.2 hours) for all 20 jobs to complete. The longest job took 3,268 seconds (54 minutes).

Figure 8. SAP workload running on a storage pool with three tiers (5 Flash, 25 FC, 20 SATA drives)
Scenario 4

Figure 9 shows the SAP workload running on a tiered storage pool configuration that contains tier-0 with 5 Flash drives, tier-1 with 15 FC drives, and tier-2 with 25 SATA II drives. It took approximately 67,480 seconds (18.7 hours) for all 20 jobs to complete. The longest job required 3,722 seconds (62 minutes).

Figure 9. SAP workload running on a storage pool with three tiers (5 Flash, 15 FC, 25 SATA drives)
**Analysis of results**

Table 1. Comparison of SAP workload durations

<table>
<thead>
<tr>
<th>FAST configuration scenario</th>
<th>Total duration (sec) for the workload</th>
<th>Duration (sec) for the longest job in the workload</th>
<th>Performance improvement factor with FAST</th>
<th>Storage capacity (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Scenario 1 (1 tier) (90 FC drives)</td>
<td>119003</td>
<td>6793</td>
<td>NA</td>
<td>54000</td>
</tr>
<tr>
<td>Scenario 1 (1 tier) (45 FC drives)</td>
<td>145335</td>
<td>8548</td>
<td>NA</td>
<td>27000</td>
</tr>
<tr>
<td>Scenario 2 (3 tiers) (5 Flash, 45 FC, 15 SATA drives)</td>
<td>53203</td>
<td>2905</td>
<td>~2.2 x</td>
<td>58000</td>
</tr>
<tr>
<td>Scenario 3 (3 tiers) (5 Flash, 25 FC, 20 SATA drives)</td>
<td>58227</td>
<td>3268</td>
<td>~2.0 x</td>
<td>56000</td>
</tr>
<tr>
<td>Scenario 4 (3 tiers) (5 Flash, 15 FC, 25 SATA drives)</td>
<td>67480</td>
<td>3722</td>
<td>~1.8 x</td>
<td>60000</td>
</tr>
</tbody>
</table>

After analyzing the results, in the case of the baseline storage pool with one tier that contains only FC drives, it took a longer time to complete all the transactions in the SAP workload. When using FAST, the phase of the longest running job in the workload changed from 6,793 seconds to 3,722 seconds when comparing the baseline scenario with Scenario 4 (see Table 1). This results in an improvement of approximately 1.8 times faster. The improvement we observed for the total duration of the workload when using the FAST feature (119,003 seconds vs. 67,480 seconds) also resulted in 1.8 times faster performance. This result is also in line with the individual workload job duration improvements. In our study, we have also observed considerable improvements with Scenario 2 and Scenario 3, but Scenario 4 provided the best price to performance ratio. In terms of TCO, by considering performance, storage capacity, and storage drive cost, Scenario 4 provides an optimal configuration with 1.8 times better performance along with 20% reduced cost. Figure 10 and Figure 11 show the value proposition and TCO benefits of using FAST in Scenario 4 when compared to the baseline (see Table 1). This shows that when using FAST with three tiers (11% Flash, 33% FC, and 54% SATA drives) compared to using with one tier (100% FC drives) we observed a 180% improvement in performance while reducing costs by 20%.

The results listed in the table for Scenarios 2, 3, and 4 are taken after the initial FAST warm-up. To perform FAST warm-up after the SAP system is set up we run the SAP workload several times and relocated the data manually until the size of the suggested data that needs be relocated goes down.
**Storage considerations for using FAST**

Before you choose your system configuration, take the following considerations into account:

- To expand the pool you should add as many drives as possible because it minimizes the likelihood of temporarily skewed I/O activity clustering. When you add new drives to the pool, the system usually assigns the new data coming in to the newly added drives first to ensure that there will be a balanced amount of data stored over all drives in the pool over time.
- Use thick LUNs and FAST for the SAP DATA LUNs.
- Use a separate homogeneous pool with only FC drives for the SAP LOG LUNs to achieve better performance and recoverability.

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**Figure 10. FAST value proposition (Scenario 4 vs. Baseline)**

**Figure 11. FAST TCO (Scenario 4 vs. Baseline)**
- Include the appropriate tiers in your storage pool for guaranteed performance (for example, Flash and Fibre Channel drives for high performance, Fibre Channel and SATA drives for high cost savings).
- Based on the results of our study (see Table 1), EMC suggests using these FAST tier proportions in terms of number of drives for SAP deployments:
  - 10%-15% Flash drives
  - 30%-35% FC drives
  - 50%-55% SATA drives

This ensures good performance in the case of large data allocation (table expansion, bulk loads) and periodic maintenance (batch jobs, reporting). The tier proportion recommendation may vary with each system depending on the working data set size, number of active users, and locality of the data.

**Impact of data placement and locality of data on FAST performance**

FAST operates at the granularity of 1 GB slices of data. High locality of data is important to realize the benefits of FAST technology. FAST recalculates the activity temperature of all slices in a pool periodically and proposes the movement of data based on this calculation. The relocation of data can be done manually or in a configurable scheduled time window. When the SAP system is installed for the first time, it takes a few relocation cycles until all the relevant data is relocated to the appropriate tiers and the data relocation may need to be configured to execute more frequently initially to speed up the data warm-up process. Since it may take some time before all the data is allocated to an appropriate tier, you will see improved performance with time. However, using the same system for totally different types of work during the day and night will change the locality of data and may have an impact on system performance.
Conclusion

FAST provides better performance with reduced TCO for SAP applications. EMC used an SAP workload study with 20 business processes (SAP FI, SD, MM, and PP) and ran those business processes with 1.3 TB of customer data. The results show an improvement in I/O times and in the time it took for the jobs to complete with FAST. In addition, we were able to maintain the same TCO. The minimum overall improvement we observed was over two times in the case of the read/write mix SAP workload scenarios. While the improvements with our scenarios may not be representative of all SAP customer scenarios that decide to switch to FAST, it nevertheless illustrates the potential for significant improvements in processing times and TCO. Also, we were able to improve the SAP system performance without changing the application, tuning the parameters, or adjusting the deployment process. FAST technology is very well suited for applications that access data with a high locality of reference. However, applications with other types of I/O patterns have also benefited from this solution.

References

The following documents can provide more information:

- *Leveraging EMC CLARiiON CX4 with Enterprise Flash Drives for SAP Deployments*  EMC white paper
- *EMC FAST for CLARiiON – A Detailed Review*  EMC white paper
- *Adaptive Hardware Infrastructures for SAP*
- *SAP Performance Optimization Guide*

The following websites can also provide more information:

- SAP Community Network: [http://sdn.sap.com](http://sdn.sap.com)