Monitoring and Managing Microsoft® Exchange Server 2007 on the Adaptable Modular Storage 2000 Family

Solution Cookbook

By Rick Andersen, Patricia Brailey and Steven Burns
Contributors

The information included in this document represents the expertise, feedback and suggestions of a number of skilled practitioners. The authors recognize and sincerely thank the following contributors and reviewers of this document:

- Steffen Bartsch, Solution Marketing and Business Development
- Larry Meese, Application Solutions
Executive Summary

This guide describes how various software and best practices from Hitachi Data Systems and Microsoft® can be applied to automate monitoring activities, streamline management operations, reduce complexity and deliver effective management capabilities to production Exchange 2007 implementations. While this paper focuses on the Adaptable Modular Storage 2000 family, with its intelligent, symmetrical active-active controllers, dynamic load balancing and native multipathing features that benefit Exchange administrators, the monitoring and management best practices that are discussed can be applied to any Hitachi modular storage system.

This guide is intended for Exchange 2007 e-mail and storage administrators who need to ensure stability, availability and acceptable response times, address server and storage consolidation initiatives, manage recent or planned transition or migration to Exchange 2007 or manage growth and changes in the Exchange environment. It also provides technical guidelines, best practices and recommendations for e-mail and storage administrators on how to effectively monitor and manage Exchange deployments on the 2000 family.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptable Modular Storage 2000 Family Overview</td>
<td>2</td>
</tr>
<tr>
<td>Features</td>
<td>2</td>
</tr>
<tr>
<td>Monitoring and Management Tools and Software</td>
<td>3</td>
</tr>
<tr>
<td>Hitachi Storage Navigator Modular 2 with Hitachi Performance Monitor Feature</td>
<td>3</td>
</tr>
<tr>
<td>Hitachi Device Manager Software</td>
<td>3</td>
</tr>
<tr>
<td>Hitachi Dynamic Link Manager Advanced Software</td>
<td>5</td>
</tr>
<tr>
<td>Hitachi Tuning Manager Software</td>
<td>6</td>
</tr>
<tr>
<td>Exchange Toolbox and Windows Performance Monitor</td>
<td>7</td>
</tr>
<tr>
<td>Other Services and Tools</td>
<td>8</td>
</tr>
<tr>
<td>Monitoring the Exchange 2007 Infrastructure</td>
<td>9</td>
</tr>
<tr>
<td>Host Monitoring</td>
<td>9</td>
</tr>
<tr>
<td>Defining and Validating a Healthy Baseline</td>
<td>18</td>
</tr>
<tr>
<td>Key Exchange Metrics</td>
<td>18</td>
</tr>
<tr>
<td>Key Storage System Metrics</td>
<td>18</td>
</tr>
<tr>
<td>Validation Tools</td>
<td>20</td>
</tr>
<tr>
<td>Managing a Changing Exchange Environment</td>
<td>22</td>
</tr>
<tr>
<td>Key Considerations for Managing Exchange</td>
<td>22</td>
</tr>
<tr>
<td>Scenario-specific Considerations</td>
<td>24</td>
</tr>
<tr>
<td>Appendix A Additional Reference Material</td>
<td>35</td>
</tr>
</tbody>
</table>
Monitoring and Managing Microsoft® Exchange Server 2007 on the Adaptable Modular Storage 2000 Family

Solution Cookbook

By Rick Andersen, Patricia Brailey and Steven Burns

Proactive, continual monitoring and management activities are required after a successful deployment of Exchange 2007. This guide describes how various software and best practices from Hitachi Data Systems and Microsoft can be applied to automate monitoring activities, streamline management operations, reduce complexity and deliver effective management capabilities to production Exchange 2007 implementations. While this paper focuses on the Adaptable Modular Storage 2000 family, the monitoring and management best practices that are discussed can be applied to any Hitachi modular storage system.

This guide is intended for Exchange 2007 e-mail and storage administrators who need to support any of the following scenarios:

- Ensure stability, availability and acceptable response times
- Address server and storage consolidation initiatives
- Manage recent or planned transition or migration to Exchange 2007
- Manage growth and changes in the Exchange environment

It also provides technical guidelines, best practices and recommendations for e-mail and storage administrators on how to effectively monitor and manage Exchange deployments on the 2000 family:

- What tools can be used to gather data
- What needs to be monitored
- How to establish and validate a healthy baseline
- How to analyze the data
- How to interpret the results
- What management actions are required based on data analysis

Intelligent, symmetrical active-active controllers, dynamic load balancing and native multipathing are some of the 2000 family’s key new features that benefit Exchange administrators.
Adaptable Modular Storage 2000 Family Overview

The 2000 family provides a reliable, flexible, scalable and cost-effective modular storage system for Exchange Server 2007. The 2000 family is ideal for more demanding application requirements and delivers enterprise-class performance, capacity and functionality at a midrange price.

Features

Several new features of the Hitachi Adaptable Modular Storage 2000 family simplify Exchange 2007 management. The task of RAID group placement is simplified with the addition of the switched, 3Gb/sec SAS back-end architecture. The SAS drive interface allows bandwidth to all disks in a tray by utilizing 16 wide links. The switched architecture also provides fault tolerance so that if one of the wide links fails, the SAS controller can detect the failure and continue to use the remaining links.

The Hitachi Dynamic Load Balancing Controller architecture simplifies management by automatically reassigning I/O workload when utilization of the two controllers is imbalanced. Rebalancing is transparent to servers and requires no intervention from the Exchange or storage administrator. The controller ensures that traffic to the back-end disk devices is dynamically managed, balanced and shared across both controllers even if the I/O load to specific logical units (LUs) is skewed due to peaks in activity.

Symmetric active-active storage controllers simplify SAN design and improve availability as well as performance. Exchange mailbox servers can access database or log LUs from any of the front-end host ports on either of the two controller modules as a result of this design feature. The storage system efficiently and automatically passes I/O to the associated controller for processing, regardless of the port on which the I/O arrives. In addition to the symmetric active-active controller feature, support for native MPIO and Hitachi’s multipathing software enables simplified SAN design. Multipathing improves basic availability, and can enhance performance under heavy load from multiple Exchange servers or when it is necessary to share ports with other applications.

With the 2000 family, updates to the microcode require no host downtime or path failover. In previous generations of some storage systems, host I/O was stopped to the controller while the microcode was being updated and then the controller required a re-boot. This meant that the I/O was stopped for any server utilizing that particular controller. For the affected server to maintain access to its disks, path failover software had to be utilized to ensure continued access to disk resources.

All data traffic is diverted to the other controller while the update takes place and a reboot is not required after the update is complete. Note that Hitachi Data Systems still recommends the use of path failover software to protect against path failures.

On storage systems that support multipathing, like the 2000 family, replacing components such as disks, circuit boards, cache boards and processor boards does not disrupt the host. This provides for non-disruptive maintenance of the Exchange storage infrastructure.

The following 2000 family features support non-disruptive maintenance:

- Symmetric active-active controllers
- Hot swappable major components
- Dual battery backup for cache
- Flexible drive sparing with no copy back required after a RAID rebuild
- RAID-5, RAID-1, RAID-1+0 and RAID-0 (SAS drives) support
- Hi-Track® Monitor remote support

The combination of these features of the 2000 family support a storage infrastructure that offers excellent performance and availability at a cost-effective price. The 2000 family also offers exceptional scalability due to its modular architecture.
Monitoring and Management Tools and Software

A number of tools and software applications make monitoring and managing an Exchange 2007 environment easier. Hitachi offers several management applications that allow administrators to easily provision storage with automated wizards and robust command-line interfaces, as well as to monitor performance and capacity. In addition, tools are available in the Windows Server 2008 operating system and within Exchange Server 2007 that are valuable to Exchange and storage administrators in both day-to-day and lifecycle tasks. The following sections describe the key tools available from Hitachi and Microsoft.

Hitachi Storage Navigator Modular 2 with Hitachi Performance Monitor Feature

Hitachi Storage Navigator Modular 2 is part of the Hitachi Basic Operating System software package. It monitors and manages Hitachi modular storage systems, including the Adaptable Modular Storage 2000 family, through either a graphical user interface (GUI) accessible or a command-line interface. Use Storage Navigator to create RAID groups and logical units and to assign those logical units to Exchange Server hosts. Storage Navigator is also useful for monitoring events and status of the various components on a modular storage subsystem.

Hitachi Performance Monitor feature is part of the Storage Navigator software package. It acquires information on the performance of RAID groups, logical units and other elements of the storage system while tracking the utilization rates of resources such as hard disk drives and processors. Information is displayed with line graphs in the Performance Monitor windows or saved in .csv files that can later be analyzed by the user.

Hitachi Device Manager Software

Hitachi Device Manager software provides centralized management of all Hitachi storage systems, including the 2000 family. Device Manager software can link to Storage Navigator, and it has the ability to provision using storage pools, manage replication between storage systems and logically group resources for more efficient management.

Hitachi Device Manager software centralizes storage operations and capacity management for multiple storage systems and hosts. Management of Exchange 2007 is taken one step further with the use of logical groups. In Device Manager software, a logical group is a container that you name. A logical group can contain more logical groups, or it can contain storage groups. A storage group is formed when LUs are created or are assigned to a server’s World Wide Name. A storage group only contains LUs from a single storage system. Figure 1 shows a logical group hierarchy.
If you create a logical group for Exchange, Device Manager software displays the total capacity and number of LUs for your entire application. You can drill down to see total capacity for each of your child groups within Exchange. For example, break down the LUs for each Mailbox server into a logical group for databases and logs.

In an existing Exchange environment, use the LU scan operation to bring the volumes being used by Exchange into a generic logical group created by Device Manager software. Then move these volumes to user-defined groups. The LU scan also discovers any server World Wide Names attached to the storage system ports and gives them a generic name (for example, host_1). These generic server names can be easily changed to user-friendly or corporate standard conventions after the LU scan is complete.
Device Manager Agent

Device Manager agent is a component of Device Manager software that is installed on Exchange 2007 Mailbox servers. It delivers the following information to Device Manager software from the Exchange server:

- Server WWN
- Server Name
- File System
- Percent Used
- Copy Type
- Copy Role
- Copy Status
- Last Updated

Without Device Manager agent, the server WWN and server name are not linked automatically, and the file system and percent used information are not available. You can download the Device Manager agent software directly from the Device Manager server. This can be useful if your data center imposes LAN restrictions. It is also ensures that you’re using the correct version of agent software for your version of Device Manager software.

Using Logical Groups

After you set up logical groups for Exchange, you can perform several functions in Device Manager software on those groups:

- Add Storage
- Add Like Storage
- Modify Security
- Move Storage
- Remove Storage

For more information, see Hitachi Device Manager software online help.

Hitachi Dynamic Link Manager Advanced Software

Hitachi Dynamic Link Manager Advanced software is a software package that consists of the Hitachi Dynamic Link Manager multipathing software and Hitachi Global Link Manager software. Hitachi Dynamic Link Manager software, which is installed on the Exchange mailbox server, includes capabilities such as path failover and failback and automatic load balancing to provide higher data availability and accessibility. The Hitachi device-specific module is integrated into Hitachi Dynamic Link Manager software and can replace the generic Microsoft MPIO device-specific module that is included in Windows Server 2008. Hitachi Dynamic Link Manager software includes the following load-balancing algorithms that are especially suited for Hitachi storage systems:

- Round robin
- Extended round robin
- Least I/Os
- Extended least I/Os
- Least blocks
- Extended least blocks
The choice of load-balancing algorithm depends on the specific environment. If the 2000 family storage system is dedicated to Exchange 2007, in most cases the round robin algorithm provides the best overall performance. In some environments, an environment shared with other applications for example, one of the other algorithms might give the best overall performance.

Hitachi Global Link Manager software consolidates, simplifies and enhances the management, configuration and reporting of multipath connections between servers and storage systems. Hitachi Global Link Manager software manages all of the Hitachi Dynamic Link Manager installations in the environment. Use it to configure multipathing on the Exchange mailbox servers, to monitor all the connections to the Adaptable Modular Storage system and to report on those connections. Global Link Manager also enables administrators to configure load balancing at a per-LU level. This functionality is important when the load-balancing algorithm must be set at a LU level to accommodate diverse I/O patterns. Hitachi Global Link Manager software also integrates with the Hitachi Storage Command Suite of products and is usually installed on the same server as Hitachi Device Manager. Figure 2 shows the Hitachi Global Link Manager interface.

**Figure 2. Hitachi Global Link Manager Interface**

![Hitachi Global Link Manager Interface](image)

When paired with the symmetric active-active controllers and load-balancing features of the 2000 family, Hitachi Dynamic Link Manager and Hitachi Global Link Manager increase the availability, reliability and efficiency of Exchange environments. Using these products simplifies monitoring and management of data paths within an Exchange storage infrastructure.

**Hitachi Tuning Manager Software**

Hitachi Tuning Manager software enables you to proactively monitor, manage and plan the performance and capacity for the Hitachi modular storage that is attached to your Exchange mailbox servers. Hitachi Tuning Manager software consolidates statistical performance data from the entire storage path. It collects performance and capacity data from the operating system, Exchange databases or storage groups, switch
ports, storage ports on the storage system, RAID groups and LUs where Exchange files are located and provides the administrator a complete performance picture. It provides historical, current and forecast views of these metrics. For more information about Hitachi Tuning Manager, see the Hitachi Data Systems support portal.

Exchange Toolbox and Windows Performance Monitor

The Exchange Management Console Toolbox contains several useful utilities to help manage the Exchange environment. They are divided into four categories: configuration management tools, disaster recovery tools, mail flow tools and performance tools. For more information about these tools, see Microsoft TechNet article bb123886, "Using the Toolbox."

Performance Monitor is a host-based application that is included with the Windows Server operating system. It acquires performance data on a wide range of server resources including processors, memory and hard disks. When you click the Performance Monitor link in the Exchange Management Console Toolbox Interface (see Figure 3), a standard Windows Performance Monitor application is launched. When launched from the toolbox, Performance Monitor is preconfigured with performance counters specific to the Exchange server roles installed on that server.

Figure 3. Exchange Management Console Toolbox Interface

Note that while Performance Monitor provides good overall performance information about the Microsoft Exchange server environment, it cannot identify all possible bottlenecks in an environment. Metrics from Performance Monitor can only provide a server-side view of your environment.

Exchange Best Practices Analyzer (ExBPA) analyzes the Exchange server and compares the results to a best practices database built and maintained by Microsoft. Run ExBPA after a new Exchange server is installed, after an existing Exchange server is upgraded, or after configuration changes are made.
ExBPA allows the Exchange administrator to perform the following functions:

- Verify that the Exchange environment is configured according to Microsoft best practices.
- Report any recent changes to the Exchange environment that might impact availability and performance.
- Report on any settings that differ from Exchange defaults.

This tool is located in the Exchange Management Console Toolbox or it can be downloaded as a separate installation. It can be run on an as-needed basis or it can be scheduled.

The Exchange Toolbox also includes these useful tools:

- Details Templates Editor
- Public Folder Management Console
- Database Recovery Management
- Database Troubleshooter
- Mail Flow Troubleshooter
- Message Tracking
- Queue Viewer
- Routing Log Viewer
- Performance Troubleshooter

For more information about these tools, see Microsoft TechNet article bb123886, “Using the Toolbox.”

Other Services and Tools

Many other tools and services are available for monitoring and managing Exchange environments. Some of these are no-cost tools that are readily available from Microsoft and some are fee-based services offered by Hitachi Data Systems.

Microsoft Tools

For more information about the Microsoft tools, see Microsoft TechNet article aa996057, “Exchange Server Tools Documentation,” which includes links to documentation for each of the tools.

Following are some of the tools that might be useful:

- **Exchange Profile Analyzer** — Data collection tool used to estimate the user profile for a group of mailboxes.
- **Exchange Monitor** — Command-line interface that allows administrators to monitor the activity of MAPI-connected users and the load they put on the server.
- **PowerShell** — Command-line interface that replaces and extends cmd.exe. For more information, see Microsoft TechNet articles bb124413, “Exchange Management Shell (SP1),” and aa996420, "Global Cmdlets."

Hitachi Service Offerings

The Hitachi Global Solution Services (GSS) organization offers services that can assess an Exchange environment and assist in the tuning of the environment for optimal storage resource performance. Storage Platform Assessment Services help to improve service-level agreements within organizations, enhance return on investment, create baseline monitoring and solve performance issues.

For more information about this service, contact your Hitachi account representative.
Monitoring the Exchange 2007 Infrastructure

Several performance counters are particularly important to monitor to assure the health of an Exchange 2007 environment and an acceptable performance level from a 2000 family storage subsystem. This section describes those counters and acceptable values that are specific to the storage infrastructure. When acceptable values differ from Microsoft documented values, an explanation is provided.

Host Monitoring

For complete lists of the counters applicable to Exchange 2007 environments, see the following articles on Microsoft TechNet:

- **Article cc671175, “Monitoring Common Counters”** — Counters and expected values common to all Exchange 2007 server roles.

- **Article bb201674, “Monitoring Client Access Servers”** — Counters and expected values specific to an Exchange 2007 server with the Client Access role installed.

- **Article bb201671, “Monitoring Unified Messaging Servers”** — Counters and expected values specific to an Exchange 2007 server with the Unified Messaging role installed.

- **Article bb201704, “Monitoring Hub Transport Servers”** — Counters and expected values specific to an Exchange 2007 server with the Hub Transport role installed.

- **Article bb201689, “Monitoring Mailbox Servers”** — Counters and expected values specific to an Exchange 2007 server with the Mailbox role installed.

Search by article number to find these documents.

**Windows Performance Counters**

Proactively monitoring the Exchange environment can identify performance trends and help avert problems before they affect the environment. The performance monitor included with Windows Server allows for the display of current or saved performance counter information. Windows performance monitor can display counters in real time or write them to a log file for later analysis. By saving the performance monitoring counters to a log file, comparisons can be made against a baseline to determine the effect of changes.

Displaying Windows performance counters in real-time mode is known as Chart mode. This is the default mode and is good for reactive monitoring of Exchange performance, however, it is important to remember that the data is not captured and thus cannot be analyzed later.

The Log and Report mode options in Windows performance monitor overcome these limitations by allowing the administrator to capture data. Use this mode for proactive monitoring of the Exchange environment.

When monitoring an Exchange environment, take into account the cycles that affect the load on the Exchange servers. For example, most businesses experience peaks and valleys in activity at certain times of the day, week and month. Make sure that you take this in to account when collecting performance data. To see how your servers handle the maximum expected load, monitor them during a period of peak activity. To establish a baseline determine what percentage of the time your servers are overloaded, monitor them for a complete activity cycle.

Any monitoring tool has an effect on the system. Microsoft indicates that the enabling of performance counters for disk can add an additional 10 percent overhead to the system. This can affect overall throughput and response time. It is important to take this into consideration when sizing or monitoring the Exchange mailbox server.

The set of counters to monitor for the Exchange environment is typically dependent on the role of the server. The Mailbox server counters are particularly important because this role is the one primarily affected by the performance of the storage system. When monitoring performance disk counters described within this section, a sampling interval of 5 seconds is normally appropriate.
Table 1 lists the important counters and thresholds for monitoring database disks. Monitor these counters to determine if the performance of a disk is outside the range of acceptable values. This might indicate that further analysis is needed.

Table 1. Performance Counters and Threshold Values for Database Disks

<table>
<thead>
<tr>
<th>Performance Monitor Counter</th>
<th>Microsoft Description</th>
<th>Hitachi Data Systems Notes</th>
<th>Acceptable Value</th>
<th>Abnormal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk Reads/sec</td>
<td>Shows the rate per second at which read and writes were performed on the disk.</td>
<td>Total number of Read or Write operations taking place per second for the selected logical or physical disk. This field does not indicate the size but rather the quantity of I/Os. Use these counters to establish an IOPS baseline. See “Defining and Validating a Healthy Baseline” section</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Disk Writes/sec</td>
<td>Shows the rate per second which read and writes were performed on the disk.</td>
<td>Total number of Read or Write operations taking place per second for the selected logical or physical disk. This field does not indicate the size but rather the quantity of I/Os. Use these counters to establish baselines and also to track trends related to I/O traffic.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Average Disk sec/Read</td>
<td>Database Read response time. Shows the average time in seconds of a read to disk. This is a measure of disk latency values.</td>
<td>Average response time in milliseconds for the selected logical or physical disk. This average can be affected not only by I/O size and RAID configuration but also by other factors in the data path. LT or = 20ms † &gt; 20ms No spikes &gt;50ms †</td>
<td>LT or = 20ms †</td>
<td>&gt; 20ms No spikes &gt;50ms †</td>
</tr>
<tr>
<td>Average Disk sec/Write</td>
<td>Database Write response time. Shows the average time in seconds of a write to disk. This is a measure of disk latency values.</td>
<td>Average response time in milliseconds for the selected logical or physical disk. This average can be affected not only by I/O size and RAID configuration but also by other factors in the data path. LT or = 20ms †</td>
<td>LT or = 20ms †</td>
<td>&gt; 20ms No spikes &gt;50ms †</td>
</tr>
<tr>
<td>Average Disk sec/Transfer</td>
<td>Time it takes a hard disk to fulfill requests. Measures the average time of each data transfer regardless of the number of bytes read or written.</td>
<td>Indicates how fast data is being moved. A high value might mean that the system is retrying requests due to lengthy queuing or other issues. &lt;20ms</td>
<td></td>
<td>20ms or greater No spikes &gt;50ms</td>
</tr>
</tbody>
</table>
Average Disk Queue Length

Average number of outstanding I/O requests. The general rule of thumb is <=2 per spindle but this can be hard to measure due to storage virtualization, differences in RAID level between configurations and so on.

Focus on higher than average disk queue length in combination with higher than average disk latencies. This combination could indicate that the storage system cache is being overutilized or spindle sharing with other applications is impacting performance.

A high Average Disk Queue Length in combination with a high Average Disk sec/Read (response time) might be an indication that the HBA queue depth is not set correctly for your environment. The intelligent controller on the storage system might be able to further optimize physical I/O when using an increased queue depth. A high Average Disk Queue Length can also be caused by other factors in the data path.

<table>
<thead>
<tr>
<th>Disk Read Bytes/sec</th>
<th>Measure of the total bandwidth for a particular disk or LUN.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk Write Bytes/sec</td>
<td>Total number of bytes either read or written per second for the selected logical or physical disk.</td>
</tr>
</tbody>
</table>

* Use caution when analyzing disk queue lengths for databases on SAN attached storage devices. A large queue length might not be a concern because of the storage system’s ability to service I/O at a faster rate than direct-attached storage. On a 2000 family storage subsystem, avoid queue lengths in excess of two times the number of physical disks that comprise the LU.

† See “Response Times or Latency” section.

Table 2 lists the important counters and thresholds for monitoring transaction log disks. Monitor these counters to determine if the performance of a disk is outside the range of acceptable values. This might indicate that further analysis is needed.
<table>
<thead>
<tr>
<th>Performance Monitor Counter</th>
<th>Microsoft Description</th>
<th>Hitachi Data Systems Notes</th>
<th>Acceptable Value</th>
<th>Abnormal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk Reads/sec</td>
<td>Number of I/Os per second (IOPS) being issued against a particular disk or volume. This number varies based on the size of I/Os issued.</td>
<td>Total number of Read or Write operations taking place per second for the selected logical or physical disk. This field does not indicate the size but rather the quantity of I/Os. Use these counters to establish an IOPS baseline. See “Defining and Validating a Healthy Baseline” section.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Disk Writes/sec</td>
<td></td>
<td></td>
<td>Use these counters to establish baselines and also to track trends related to I/O traffic</td>
<td></td>
</tr>
<tr>
<td>Average Disk sec/Read</td>
<td>Log Read response time. This is a measure of disk latency values.</td>
<td>Average response time in milliseconds for the selected logical or physical disk.</td>
<td>LT or = 20ms</td>
<td>&gt; 20ms</td>
</tr>
<tr>
<td>Average Disk sec/Write</td>
<td>Log Write response time. This is a measure of disk latency values</td>
<td>Average response time in milliseconds for the selected logical or physical disk</td>
<td>LT or = 10ms</td>
<td>&gt;10ms</td>
</tr>
<tr>
<td>Average Disk sec/Transfer</td>
<td>Time it takes a hard disk to fulfill requests. Measures the average time of each data transfer regardless of the number of bytes read or written.</td>
<td>Indicates how fast data is being moved. A high value might mean that the system is retrying requests due to lengthy queuing or other issues.</td>
<td>&lt;20ms</td>
<td>20ms or greater No spikes &gt;50ms</td>
</tr>
</tbody>
</table>
Avg Disk Queue Length

Average number of outstanding I/O requests. The general rule of thumb is <=2 per spindle but this may be hard to measure due to storage virtualization, differences in RAID level between configurations, and so on.

Focus on higher than average disk queue length in combination with higher than average disk latencies. This combination could indicate that the storage system cache is being overutilized or spindle sharing with other applications is impacting performance.

A high Average Disk Queue Length in combination with a high Average Disk sec/Read (response time) can be an indication that the HBA queue depth is not set correctly for your environment. The intelligent controller on the storage system might be able to further optimize physical I/O when using an increased queue depth. A high Average Disk Queue Length can also be caused by other factors in the data path.

Response Times or Latency

Many different types of latency can be monitored in an Exchange 2007 environment. This can be confusing if the type of latency being monitored is not clearly identified.

Differing recommendations add to the confusion. For some performance counters, different acceptable values are given depending upon the document being referenced. For example, Microsoft gives an acceptable value for database disks on a mailbox server of less than or equal to 50ms for reads and less than or equal to 100ms for writes. In Microsoft TechNet article bb201689, “Monitoring Mailbox Servers,” Microsoft cautions that “for servers with more than 1,000 users, 50ms disk times may not be fast enough to return responses to the client to accommodate user load.” Microsoft also recommends that you check remote procedure call (RPC) averaged latencies to make sure these are within recommended values.

If you use Jetstress to validate your storage subsystem before placing a new server into production, Microsoft considers the success criteria to be 20ms or less average response time with 50ms spikes allowable.

On a well performing Exchange 2007 mailbox server the average disk sec/read value should be 20ms or less and the average disk sec/write value should be less than 5ms.

Memory and Processor Counters

Although memory and processors are not directly related to storage performance, improper hardware processor and memory configurations can affect the underlying storage infrastructure. For example, a shortage of memory resources can lead to increased I/O load on the Exchange databases impacting performance. Follow the Microsoft recommendations for memory sizing. These are based on number of mailboxes and storage groups on a mailbox server. For more information about memory sizing for Exchange 2007 servers, see Microsoft TechNet article bb738124, “Planning Memory Configurations.”
For more information about monitoring memory and processor counters, see Microsoft TechNet article cc671175, “Monitoring Common Counters,” which includes counters for other elements of the infrastructure that can affect the end-user experience, including performance counters for network and active directory performance.

**Exchange Application Monitoring**

It’s important to monitor the Exchange 2007 mailbox server at the Exchange database layer. Database counters are useful for determining the amount of workload stress the Exchange 2007 database engine might be experiencing. Monitor the counters described in Table 3 to determine if a problem writing to the database and log disks exists.

### Table 3. Database and Log Counters

<table>
<thead>
<tr>
<th>Windows Performance Counters</th>
<th>Description</th>
<th>Hitachi Data Systems Notes</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSExchange Database Instances(*)\I/O Database Reads Average Latency</td>
<td>Average milliseconds per database read</td>
<td>Average response time in milliseconds per database read operation.</td>
<td>&lt; 20ms on average No spikes &gt; 50ms</td>
</tr>
<tr>
<td>MSExchange Database Instances(*)\I/O Database Writes Average Latency</td>
<td>Average milliseconds per database write</td>
<td>Average response time in milliseconds per database write operation.</td>
<td>&lt; 50ms on average No spikes &gt; 100ms</td>
</tr>
<tr>
<td>MSExchange Database(Information Store)\Log Record Stalls/sec</td>
<td>Number of log records outstanding due to log buffers being full</td>
<td>Indication of high log write latencies.</td>
<td>&lt; 10 on average</td>
</tr>
<tr>
<td>MSExchange Database(Information Store)\Log Threads Waiting</td>
<td>Number of outstanding threads waiting to be written to the log</td>
<td>Values higher than 10 for threads along with log stall spikes might indicate a log disk problem.</td>
<td>&lt; 10 on average</td>
</tr>
</tbody>
</table>

Another set of counters that might be helpful in troubleshooting slow response times for users that are using MAPI to attach to the server are the Information Store RPC counters. For more information about these counters, see Microsoft TechNet articles bb201689, “Monitoring Mailbox Servers,” and cc540464, “Troubleshooting Slow RPC Request Processing Issues.” Table 4 describes the two most important counters to monitor.
Table 4. Information Store RPC Counters

<table>
<thead>
<tr>
<th>Windows Performance Counters</th>
<th>Description</th>
<th>Hitachi Data Systems Notes</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSExchangeIS\RPC Requests</td>
<td>Indicates the overall RPC requests that are currently executing within the information store process</td>
<td>If this value exceeds 500, the information store rejects any new client connections.</td>
<td>&lt;70 at all times</td>
</tr>
<tr>
<td>MSExchangeIS\RPC Averaged Latency</td>
<td>Indicates the RPC latency, in milliseconds, averaged for all operations in the last 1,024 packets</td>
<td>High latencies can be caused by a specific protocol.</td>
<td>25ms or less on average</td>
</tr>
</tbody>
</table>

* See “Response Times or Latency” section.

Exchange 2007 Transport Monitoring

Edge and Hub Transport servers have a resource monitoring feature called back pressure. This feature monitors system resources such as disk space and available memory on servers with either of these two roles installed. If the message queue databases or transaction logs are stored on a 2000 family storage subsystem, consider utilizing this feature for monitoring. If a server has both the mailbox server and hub transport roles installed, consider the effect that this feature has on memory sizing and monitoring.

At a minimum, ensure that the Edge and Hub Transport servers have enough disk space allocated to support the message queue databases and message queue transaction logs. Keep in mind that the server resources are shared between all applications running on the server. The server might also be running multiple Exchange roles, which increases disk and memory requirements.

For more information, see Microsoft TechNet article bb201658, “Understanding Back Pressure.”

Windows Event Viewer and Performance Alerting

Use the Windows Event Viewer to obtain information about service failures, replication errors in the Active Directory service and warnings about system resources, such as virtual memory and disk space. Use Event Viewer to view and manage the following types of information:

- Event logs
- Hardware events
- Software events
- System problems

These logs can aid in identifying trends that may require immediate or future action. An Exchange administrator primarily checks the application logs recorded by the Exchange server.

When using Event Viewer with storage systems, it is especially important to track Event ID 1113 in the application event logs. This event is logged when any of the disks in the Exchange environment are full. Monitor the event logs daily or enable automated alerting for Exchange disks.

It is also possible to configure performance alerting from the Windows performance monitor. You can use this feature to monitor counters such as processor utilization, memory utilization, disk usage and more and trigger alerts when user-specified thresholds are exceeded. When an alert is triggered, the resulting action can take the form of logging an entry in the application event log, sending a network message to a specified computer or starting a performance data log.
Storage System Monitoring

Hitachi Performance Monitor feature is a controller-based software application, enabled through Hitachi Storage Navigator 2, which monitors the performance of RAID groups, logical units and other elements of the disk subsystem while tracking utilization rates of resources such as hard disk drives and processors. Information is displayed using line graphs in the Performance Monitor windows and can be saved in comma-separated value (.csv) files.

When the disk subsystem is monitored using Hitachi Performance Monitor feature, utilization rates of resources in the disk subsystem (such as load on the disks and ports) can be measured. When a problem such as slow response occurs in a host, an administrator can use Hitachi Performance Monitor feature to quickly determine if the disk subsystem is the source of the problem.

Performance monitoring must be enabled on the storage system to collect the proper counters. These storage system performance counters are enabled using the Storage Navigator Modular 2 management software. For more information on how to enable performance monitoring on the 2000 family, see the Hitachi Data Systems support portal.

For Hitachi Performance Monitor feature, use the counters shown in Table 5 when monitoring a Microsoft Exchange 2007 environment. Keep in mind that the performance of the storage system components (port, RAID groups, logical unit, cache, processor, drive, drive operation and back-end) is monitored from the controller level. For that reason, when both controllers are being utilized, select the following counters for both controllers.

Table 5. Storage System Counters

<table>
<thead>
<tr>
<th>Performance Monitor Counter</th>
<th>Storage System Category</th>
<th>Description</th>
<th>Acceptable Value</th>
<th>Abnormal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port I/O Rate (IOPS)</td>
<td>Port Information</td>
<td>Total number of Reads, Writes, and Commands per second on the selected ports. Port Read/Write I/O rates can be individually monitored as described in this table under Port Read and Write Rate.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Port Read Rate</td>
<td>Port Information</td>
<td>Number of Read/Write commands per second on the selected ports.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Port Write Rate (IOPS)</td>
<td>Port Information</td>
<td>Percentage of Read I/Os satisfied from cache. The Read Hit counters can also be monitored at a RAID group or logical unit level.</td>
<td>25% to 50%</td>
<td>&lt; 25%</td>
</tr>
<tr>
<td>Port Read Hit(%)</td>
<td>Port Information</td>
<td>Percentage of Write I/Os satisfied from cache. The Write Hit counters can also be monitored at a RAID group or logical unit level.</td>
<td>100%</td>
<td>&lt; 100%</td>
</tr>
<tr>
<td>Port Transfer Rate (MB/sec)</td>
<td>Port Information</td>
<td>Port Read/Write transfer rates can be individually monitored for a given port.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Metric</td>
<td>Information Type</td>
<td>Description</td>
<td>Value 1</td>
<td>Value 2</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>RAID group I/O Rate (IOPS)</td>
<td>RAID Group/LU Information</td>
<td>Total number Read, Writes and Commands per second on the selected RAID groups. RAID group Read/Write I/O rates can be individually monitored for a RAID group.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>RAID Group Read Rate</td>
<td>RAID Group/LU Information</td>
<td>Number of commands (Reads or Writes) per second on the selected RAID groups.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>RAID Group Write Rate (IOPS)</td>
<td>RAID Group/LU Information</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Cache Write Pending Rate (%)</td>
<td>Cache Information</td>
<td>Indication of cache being used to buffer Writes on the selected controller.</td>
<td>1% to 25%</td>
<td>&gt; 25%</td>
</tr>
<tr>
<td>Processor Usage (%)</td>
<td>Processor Information</td>
<td>Processor utilization rate on the selected controller.</td>
<td>1% to 50%</td>
<td>&gt; 50%</td>
</tr>
<tr>
<td>Drive I/O Rate (IOPS)</td>
<td>Drive Information</td>
<td>Total number of commands (Reads and Writes) per second on the selected physical drive. Drive Read/Write I/O rates can be individually monitored for a drive.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Drive Operating Rate (%)</td>
<td>Drive Operating Information</td>
<td>Percent utilization of the specified hard drive.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Defining and Validating a Healthy Baseline

Monitor key performance metrics from both the server and storage system on a daily basis to avoid problems such as slow response times and system failures. Because Windows Performance Monitor and the storage system have numerous counters applicable to Exchange, it can be overwhelming and time consuming to attempt to monitor them all. To overcome these management challenges, establish a performance baseline. Monitor the following key metrics for a complete business cycle, normally a month or more, to establish an effective baseline. These key values can be compared on a daily basis to the baseline to ensure a healthy Exchange 2007 environment.

Key Exchange Metrics

Use performance monitor from the Exchange toolbox to monitor two key Exchange metrics: RPC averaged latency and RPC requests. The RPC averaged latency counter shows the RPC latency, in milliseconds, averaged for the past 1024 packets. A value of 25ms or less on average is acceptable. Latency is the time it takes for a packet to travel to the Store.exe process and back. A counter that is greater than 25ms for more than several seconds indicates that the server is having difficulty keeping up with the load.

The RPC requests counter represents the number of MAPI RPC, or client, requests that are currently being processed by the Microsoft Exchange Information Store service. Aim for an average RPC requests counter value of less than 70 at all times. The maximum value for RPC requests is 500. This means that the Information Store can service only 500 RPC requests at the same time before it rejects client requests.

Establish a baseline for the following disk latency metrics, which are perhaps the most important metric to monitor in Exchange:

- Physical disk (<instance>)\Avg. disk sec/Read
- Physical disk (<instance>)\Avg. disk sec/Write
- Physical disk (<instance>)\Avg. disk sec/Transfer

Disk latency, or response time, indicates how the storage system is responding to Exchange and remains the performance metric most felt by end users. These are also the metrics on which the Exchange Jetstress performance tests are based.

These metrics measure the average response time in milliseconds for the selected logical or physical disk. They can be monitored using Performance Monitor in the Exchange toolbox. According to Microsoft, in a well-performing Exchange environment, average response time for database disks are less than 20ms for reads, and less than 5ms for writes. For log disks, average response time for reads are less than 20ms and less than 5ms for writes. Disk latency metrics can also be monitored using Hitachi Tuning Manager.

Key Storage System Metrics

I/O rate, or the number of I/Os per second (IOPS), is another critical metric for Exchange mail systems. Think of I/O rate as the amount of messages being delivered by an Exchange server. The I/O rate for a particular environment depends on several variables, including the server build, storage configuration and storage architecture. More specifically, I/O rate determines what RAID level, how many disks and how many RAID groups are needed to satisfy an Exchange environment. (For more information, see the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide.)

I/O rate is monitored using either Hitachi Performance Monitor feature or Hitachi Tuning Manager software. In Performance Monitor, I/O rate is found in the Ports category and can be displayed real time or written to a .csv file. Figure 4 shows a real-time graph display in Hitachi Performance Monitor feature.
It's also important to monitor cache write pending and processor usage. Cache write pending describes, on average, the percentage of cache used for write data that has not yet been written to disk. Aim to keep cache write pending lower than 25 percent. After the baseline is established, however, the cache write pending can run at a higher rate in the environment due to other variables like replication technologies running on the storage system.

Cache write pending can be monitored using either Hitachi Performance Monitor or Hitachi Tuning Manager. When cache write pending exceeds 25 percent or the threshold established in the baseline, it is an indication that the controller can’t process the amount of incoming I/O in the usual manner. The controller is writing data to cache faster than it can move it to disk. The storage controller writes to cache instead of straight to disk as a precautionary measure and to increase performance. If the write cache becomes full, the storage controller slows the incoming I/O to allow data in cache to be moved to disk. Response time is higher when moving data to disk than it is when moving it to cache. The purpose of the new features of the 2000 family, including the symmetric active-active controllers, the SAS back-end and the dynamic load-balancing feature, is to mitigate storage planning errors that lead to increased response time and ultimately performance and reliability problems in applications like Exchange 2007.

Processor usage shows the percentage of time that the storage controller processors are busy. Like cache write pending, processor usage can be monitored using either Hitachi Performance Monitor feature or Hitachi Tuning Manager software. Aim to keep storage processor usage on a 2000 family storage system lower than
100 percent between the two controllers during normal conditions. In the event that a storage controller fails over, the second controller must be able to take over the processes of the first controller. A processor usage baseline for the day, week or month is especially useful when monitoring Exchange because regular periods of high and low activity tend to match a normal business cycle. After the baseline is established, any differences in processor usage indicate that something else in the environment, such as replication, back-up processes or other applications housed on the same storage system, is competing for CPU cycles. If a significant difference in load between the two controllers occurs, the 2000 family storage system disperses the load automatically, which dramatically reduces the need for intervention and corrective action on the part of Exchange and storage administrators.

Validation Tools

Microsoft offers several other tools to validate a proposed or existing Exchange 2007 environment. While these tools do not monitor the Exchange environment on a daily basis, they are needed at some point during the lifecycle of any environment. For more information about these tools, see Microsoft TechNet article aa996057, “Exchange Server Tools Documentation,” which includes links to documentation for each of the tools.

Jetstress

Use Jetstress to verify the performance and stability of your disk subsystem prior to putting an Exchange server into production. Jetstress is loaded on a server before Exchange is installed and helps verify disk performance by simulating Exchange disk I/O load. Specifically, Jetstress simulates the Exchange database and log file loads produced by a specific number of users. Use Windows Performance Monitor and the Windows Server event viewer in conjunction with Jetstress to verify that your disk subsystem meets or exceeds the performance criteria you establish. At the completion of a Jetstress run, the results are written to an HTML file for analysis. Microsoft’s criteria for success are outlined in Table 6.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieved I/O</td>
<td>Meets or exceeds estimated IOPS</td>
</tr>
<tr>
<td>Database Avg. Disk sec/Read</td>
<td>Average &lt; 20ms, maximum &lt; 50ms</td>
</tr>
<tr>
<td>Database Avg. Disk sec/Write</td>
<td>Average &lt; 20ms</td>
</tr>
<tr>
<td>Log Avg. Disk sec/Read</td>
<td>Average &lt; 20ms, maximum &lt; 50ms</td>
</tr>
<tr>
<td>Log Avg. Disk sec/Write</td>
<td>Average &lt; 10ms, maximum &lt; 50ms</td>
</tr>
</tbody>
</table>

Keep in mind that these values for success criteria are meant for stress testing a particular Exchange storage configuration prior to production implementation. These values differ from the threshold values specified by Microsoft in TechNet when monitoring a production Exchange environment. The success criteria values for Jetstress are more stringent and ensure adequate headroom to accommodate spikes in the workload.

Load Generator

Use Microsoft Exchange Load Generator (LoadGen) as a simulation tool to measure the effect of MAPI clients on Exchange servers. LoadGen allows you to test how a server running Exchange responds to e-mail loads in a full Exchange environment. To simulate the delivery of these messaging requests, LoadGen tests are run on client computers. These tests send multiple messaging requests to the Exchange server, thereby causing a mail load.

LoadGen is a useful tool for administrators who are sizing servers and validating a deployment plan. Run it in a test or development environment as it affects any existing Exchange infrastructure. Use it before deploying, migrating or upgrading to another Exchange environment, or if a significant change is planned for the existing environment. Another use for LoadGen is to help validate the overall parts of an environment such as the network, along with server and storage performance.
This tool is not normally used to validate a storage system. Instead the best practice is to use Jetstress. However, Jetstress does not enable you to predict or test how the I/O footprint changes on an Exchange 2007 Mailbox server as the memory configuration is changed. Exchange Load Generator is required to quantify how memory affects Exchange I/O.
Managing a Changing Exchange Environment

Most Exchange environments are constantly changing. The change can range from minor, such as occasionally adding a new user, to major, such as changing all of your mailbox quotas. Changes can affect I/O requirements, capacity requirements or both. It is important to monitor your environment both to plan for upcoming changes and to measure the impact of a change after it takes place. Table 7 describes possible changes and the areas they affect.

Table 7. Effects of Exchange-related Changes on I/O and Capacity

<table>
<thead>
<tr>
<th>Scenario</th>
<th>I/O Effect</th>
<th>Capacity Requirements Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in number of users</td>
<td>Yes. *</td>
<td>Yes. *</td>
</tr>
<tr>
<td>Change in concurrency rate (percent of users connected at same time)</td>
<td>Yes. *</td>
<td>No.</td>
</tr>
<tr>
<td>Change in user I/O profiles for all or a portion of total users (includes mobile devices)</td>
<td>Yes. *</td>
<td>No.</td>
</tr>
<tr>
<td>Change in mailbox quota (maximum allowable size) for all or a portion of users</td>
<td>Yes. Effect is mainly due to added non-transactional I/O.</td>
<td>Yes. *</td>
</tr>
<tr>
<td>Change in mailbox store database size</td>
<td>Yes. Effect is dependent on cause of change.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Change in number of mailboxes per storage group or database</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Change in number of storage groups or databases per server</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Change in capacity utilization percentage</td>
<td>Yes.</td>
<td>N/A.</td>
</tr>
<tr>
<td>Change in amount of non-transactional I/Os caused by background operations such as indexing and online maintenance</td>
<td>Yes. Can increase or decrease depending on total amount of data stored.</td>
<td>No. Note, however, that changes to mailbox sizes (quotas) can affect the amount of non-transactional I/O.</td>
</tr>
</tbody>
</table>

* For more information about formulas to calculate I/O load and capacity requirements, see the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide.

The scenarios in Table 7 are described in more detail in the following sections, including host, application and storage considerations. Many of the scenarios can be related. For example, a change in the mailbox store database size can be caused by either an increase in the number of users or an increase in the mailbox quotas. In the two cases, the effect is different. The former affects the I/O load and capacity requirements while the latter affects primarily the capacity requirements.

Key Considerations for Managing Exchange

Several considerations must be kept in mind no matter what type of change your Exchange environment is experiencing. The following sections describe these considerations.
Exchange Server Key Considerations

The following critical factors must be considered at the server level when any change takes place in an Exchange environment:

- Number of processors
- Amount of memory
- Exchange storage group and database configuration
- Bandwidth between host and storage

Microsoft recommends one processor core per 1,000 users. While a greater number of users can be supported on most current processor cores, Hitachi Data Systems recommends following Microsoft’s guidance to guarantee enough capacity to handle unexpected growth or an increase in load and other spikes in Exchange activity.

Use the Microsoft recommendations for memory sizing, which are described in Microsoft TechNet article bb738124, “Planning Memory Configurations.” This article describes the memory requirements for mailbox servers based on the number of storage groups supported.

When adding additional storage for an Exchange environment, follow Microsoft's recommendation of one mailbox store database per storage group. This ensures one transaction log file for each database and takes advantage of the full checkpoint depth.

Before a planned change, verify that the available bandwidth from the server to the storage system is sufficient. After any change, monitor to verify that the expected increase in bandwidth demands and the actual increase match. Always use multiple HBAs and redundant paths from the host to the storage to support resiliency and availability in the environment and to take full advantage of the symmetric active-active feature of the 2000 family.

The following counters apply to all the scenarios included in this document. Monitor these performance counters on the host using Windows Performance Monitor:

- Processor(_Total)\% Processor Time
- System\Processor Queue Length (all instances)
- Memory\Available Mbytes
- Memory\Page Reads/sec
- PhysicalDisk(<instance>)\Avg. Disk sec/Read
- PhysicalDisk(<instance>)\Avg. Disk sec/Write
- PhysicalDisk(<instance>)\Avg. Disk sec/Transfer

For more information about these counters, see Microsoft TechNet documents cc671175, “Monitoring Common Counters,” and bb201689, “Monitoring Mailbox Servers.” The physical disk counters are used because in many Exchange environments the use of mount points means that the use of logical disk counters does not provide complete and accurate information. Monitoring of additional performance counters might be required in some environments.

Note: Online maintenance functions are also important in an Exchange environment. Online maintenance performs a series of important tasks to make sure that your databases are operating correctly and efficiently. These tasks include clearing items from the deleted items dumpster, cleaning up deleted mailboxes and performing an online defragmentation.

Microsoft recommends that online defragmentation be performed on the Exchange databases on a periodic basis. For more information about how to monitor online defragmentation and how to determine how often to perform it, see reference Microsoft TechNet article bb69141, “How to Monitor Online Defragmentation.”
**Hitachi Storage Key Considerations**

Consider the following storage best practices when managing an Exchange 2007 environment on a 2000 family storage system:

- Validate any proposed environment configurations with Jetstress.
- Monitor the following critical performance counters after a change is made to an Exchange environment:
  - **Cache write pending** — A high rate might indicate a problem on the storage system’s back-end and requires deeper analysis.
  - **Processor utilization** — Aim to keep utilization rates on both processors at similar levels.
- Use RAID-1+0 for database LUs and RAID-1 for transaction log LUs.
- Implement one Exchange storage group per RAID group.
- Use Jetstress to verify the performance and stability of your disk subsystem prior to putting an Exchange server into production.

Adding hard drives to the 2000 family system is the most common action required as a result of adding a significant number of users or increasing mailbox quotas. Because the 2000 family storage systems are modular in nature, adding drives is swift and straightforward.

**Scenario-specific Considerations**

Some changes to an Exchange environment require specific considerations. The following sections describe these considerations.

**Change in Number of Users**

Increasing the number of users affects both the I/O requirements and the capacity requirements in an Exchange environment. How this effect is distributed is dependent on how and where the increase takes place. Users can be added in the following ways:

- **Users are added to existing servers and mailbox store databases.** In a stable environment experiencing normal growth, this is the most common scenario.
- **Users are added to existing servers but into new mailbox store databases.** This occurs when existing databases are full but processing capacity still exists on the server. This type of growth can also be experienced in the case of an acquisition.
- **Users are added to new mailbox stores on new servers.** This occurs when existing servers reach the allowed limit on processing capacity. This type of growth might also be experienced in the case of an acquisition or a merger.

It is easier to plan for linear, consistent growth than sporadic growth. With any type of growth, it is important to leave enough headroom for both I/O and storage capacity. This gives the environment the flexibility to handle spikes in I/O or capacity requirements as they arise and supplies the added resources needed for maintenance and other non-transactional I/O.

**Host Considerations**

From a host perspective, it is important to consider memory and processor cores. In some cases, you might also need to verify that enough bandwidth exists on the Host Bus Adapters (HBAs) and SAN connections to handle the additional load. Consider using multipathing products such as Hitachi Dynamic Link Manager software or Windows native MPIO to fully utilize existing bandwidth and to support higher levels of availability and reliability. For more information about required memory and processor configuration for an Exchange 2007 server, see the Microsoft TechNet article bb738142, “Planning Your Server and Storage Architecture,” and the *Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide*. Before adding users to an existing server, collect baseline performance numbers.
Exchange Application Considerations

Depending on the number of users added, it might be necessary to add additional mailbox store and log databases and storage groups. If existing servers are operating at or near the acceptable limits for the environment, servers must be added. In addition to mailbox servers, other servers might be needed to support the following infrastructure and server roles:

- Exchange Hub Transport servers
- Exchange Client Access servers
- Exchange Edge servers
- Active Directory domain controllers if additional global catalog or DNS servers are needed

The number of additional servers required depends on the design of the Exchange 2007 and Windows Active Directory infrastructure.

When adding users, it is important to leave ample I/O and capacity headroom in the storage configuration. It is often tempting to add users to storage groups based only on mailbox size, but it is critical to size the storage environment based on performance requirements first and capacity second. It is also important to take into account corporate standards for deleted item and mailbox retention, as well as replication and backup requirements. For more information about sizing your storage environment, see the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide.

Storage Considerations

If additional storage groups and databases are required to support an increased number of users, storage resources must be added to the environment.

If the new users are added to existing storage groups, care must be taken to not exceed the storage or I/O capacity limitations of the existing environment. It is also critical to remember that IOPS capacity for a volume is reduced as capacity utilization percentage of the volume increases. This means that the fuller the volume is, the less I/O it can handle in a given amount of time. Capacity utilization for a drive is calculated with the following formula:

\[
\frac{\text{used space}}{\text{total capacity}} = \text{capacity utilization \%}
\]

To monitor capacity utilization, use Hitachi Device Manager or monitor it from the host using Windows Performance Monitor.

Monitor processor utilization and cache write pending performance counters for the storage system. Also monitor the I/O rate for the ports, RAID groups, LUs and drives and compare them to pre-change values to verify that they are still at acceptable levels.

Management Actions

When adding users, take these actions:

- Add users to existing mailbox stores if storage capacity exists and servers can handle additional I/O load.
- Add users to new mailbox store on existing server if existing databases are at capacity but existing server can handle the additional I/O load. Add storage groups on the server to maintain one-to-one relationships between storage groups and mailbox databases. Drives must be added to the storage system for the new databases and logs.
- Add users to new mailbox stores on new servers if existing servers cannot handle any additional I/O load. Drives must be added to the storage system for the new databases and logs.
- If existing storage system is at capacity or can not handle any additional I/O load, another storage system must be added to the environment.
• After changes are made, monitor performance of the Exchange servers and the storage system to verify that
  performance is acceptable and that no further changes need to be made.

**Change in Concurrency Rate**

The concurrency rate is the percentage of the total number of users connected to the Exchange environment at
any point in time. When the number of users connecting to the environment concurrently increases, the I/O
requirements increase proportionally dependent on the usage profiles of the new users. This type of change
does not increase storage requirements if the infrastructure was properly sized and validated. In most
Exchange environments, the concurrency rate is variable and is dependent on many factors such as time of
day, day of week and others. When sizing the environment, take peaks of activity into account. These peaks
might temporarily degrade user experience, but the acceptable extent and duration of this degradation must be
balanced against budgetary constraints.

**Host Considerations**

The critical considerations are memory and processor related. If budget constraints are such that servers need
to be sized to support acceptable performance the majority of the time, base sizing on the total number of
users multiplied by the average concurrency rate. The greater the activity peaks are in relation to the average,
the greater the performance degradation is during periods of high activity.

In some cases, you might also need to verify that enough bandwidth exists on the HBAs and SAN connections
to handle the additional load. Consider using multipathing products such as Hitachi Dynamic Link Manager or
Windows native MPIO to fully utilize existing bandwidth and to support higher levels of availability and
reliability.

**Exchange Application Considerations**

Because the scenario primarily affects I/O, it is important to monitor all aspects of the Exchange environment.
Higher concurrency rates can affect Hub Transport servers and Client Access servers. Peak activity rates can
also cause performance issues if the network and Active Directory infrastructure are not sized to handle the
traffic.

**Storage Considerations**

Because capacity requirements are not affected by the concurrency rate, the primary storage consideration is
IOPS. As in host considerations, sizing and acceptable performance are dependent on budget and extent and
duration of the concurrency change. If the change is long term or permanent, it increases the average number
of connected users upon which your initial sizing might have been based.

**Management Actions**

When a change in average concurrency rate occurs in your environment, take these actions:

• Verify that change is long term or permanent and not a short-term spike. If the change is short term but
  recurring and degrades performance, changes might still need to be made to the environment. This decision
  needs to be based on performance impact versus budget considerations.

• If additional I/O load is greater than existing an existing server can handle, a server or servers must be
  added to the environment and some users migrated to the new servers. This also requires that additional
  storage resources be added to the environment.

• If the processor utilization reaches unacceptable levels on the storage system, another storage system must
  be added to the environment and some users migrated to the new storage system. This also requires that
  additional storage groups be created on the server and additional database and log volumes be created on
  the storage system.

• A higher concurrency rate can also affect other segments of the environment, so it is important to monitor all
  of the Exchange servers in the environment when this type of change happens.
After changes are made, monitor performance of the Exchange servers and the storage system to verify that performance is acceptable and that no additional changes need to be made.

**Change in User I/O Profiles**

When the average user I/O profile changes, I/O requirements for the environment change. This type of change does not affect storage capacity requirements. This type of change can affect multiple facets of the Exchange environment.

One of the major reasons for this type of change is an increase in the number of users using BlackBerry or Windows Mobile devices. These devices create an I/O load that is roughly three times that of regular MAPI clients.

If the effect of this type of change is great enough, it becomes necessary to revalidate the environment based on the new I/O requirements. For more information about sizing your storage environment, see the *Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide*.

**Host Considerations**

Use the documentation available from Microsoft to make sure that servers are sized to handle the additional I/O load. Monitor the standard processor and memory performance counters for performance issues. Keep in mind that the I/O requirement for a user varies over a period of time. In most cases, sizing of an Exchange environment is based on an average profile and might need to be fine-tuned after the environment is placed into production. The Profile Analyzer tool available from Microsoft collects information from an Exchange environment and gives you an accurate picture of user profiles.

**Exchange Application Considerations**

The effect on the Exchange application is similar to a change in the number of users from an I/O perspective. This scenario has little or no effect on storage capacity requirements. Monitor the Exchange environment to watch for performance degradations caused by the increased I/O load. Keep in mind the difference in load caused by clients running in cached mode as opposed to clients running in online mode. When a client runs in online mode, the majority of the processing is done on the server. When a client runs in cached mode, the majority of the processing is moved to the client.

**Storage Considerations**

Because capacity requirements are not affected by user I/O profile changes, the primary storage consideration is IOPS. Sizing and acceptable performance are dependent on budget and extent and duration of the profile changes. If the changes are widespread and long-term or permanent, they affect the average user I/O profile upon which your initial sizing might be based. If changes degrade storage performance, additional storage resources might need to be added to the environment.

**Management Actions**

When a change in average user I/O profile occurs in your environment, take these actions:

- Verify that change is long term or permanent and not a short-term spike. If the change is short term but recurring and degrades performance, changes might still need to be made to the environment. This decision needs to be based on performance impact versus budget considerations.
- Verify whether the change is widespread or limited to a certain group of users (for example, a department issuing BlackBerry devices to its employees). A widespread change affects more servers and might require more changes to the environment. You might need to migrate users from multiple servers to a new server or servers.
- If additional I/O load is greater than an existing server can handle, an additional server or servers, must be added to the environment and some users migrated to the new servers. This also requires that storage resources be added to the environment.
• If the processor utilization reaches unacceptable levels on the storage system, another storage system must be added to the environment and some users migrated to the new storage system. This also requires that additional storage groups be created on the server and additional database and log volumes be created on the storage system.

• An increase in the average user I/O profile can also affect other segments of the environment so it is important to monitor all of the Exchange servers in the environment when this type of change happens.

• After changes are made, monitor performance of the Exchange servers and the storage system to verify that performance is acceptable and that no additional changes need to be made.

Change in Mailbox Quotas
In a best-case scenario, an increase in mailbox size has minimal affect on the environment. To ensure accurate sizing, always enforce mailbox quotas. This allows for more accurate sizing. Without quotas, mailboxes can grow without limits, which can degrade performance and eventually cause out-of-space conditions on the disks allocated to Exchange. If enough available space exists on the mailbox database volume where the increase is planned, an increase in the mailbox size can safely take place as long as the following considerations are kept in mind:

• As capacity utilization increases, the maximum number of IOPS a volume can support within stated latencies is reduced. Even if I/O traffic does not increase, the ability of the disks to support the load is reduced.

• Increasing the mailbox size without reducing the number of users assigned to a mailbox store increases the size of the store. This can affect multiple aspects of the environment including backup and recovery times, any replication services being used and the amount of non-transactional I/O.

• Confirm that adequate free space or headroom exists to handle deleted mailbox and item retention as well as other maintenance or background operations. For more information, see the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide.

• If the increase in mailbox size necessitates the addition of storage groups and migration of existing users, see the “Change in Number of SGs/dbs per Server” section below.

Host Considerations
Because the effect is primarily storage capacity related, the effect on the host is normally minimal. The following points might need to be addressed:

• If additional storage groups need to be added, verify that the recommended amount of memory is installed on the server. For more information about the amount of memory required for a given number of storage groups, see Microsoft TechNet article bb738142, “Planning Your Server and Storage Architecture,” or the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide.

• Non-transactional I/O might increase as the size of a mailbox increases.

• Because a portion of the I/O load is moved from the server to the client when cache mode is used, consider the effect of cache mode versus online mode.

• Processes such as backup and recovery are affected as the database size increases. Replication processes might also be affected.

Monitor disk space utilization or free space for the disks allocated to Exchange to avoid out-of-space conditions. Also monitor latency to verify that the changes do not affect responsiveness of the storage system.

Exchange Application Considerations
Any effect is mainly due to the increased size of the existing mailbox store databases or the addition of new ones. In most cases, an increase in mailbox sizes does not affect any Exchange server role other than the mailbox server role.
Storage Considerations

This change can have a major effect on the storage system design. If the existing design is based on a smaller mailbox size and each mailbox store database is fully utilized from either an I/O or capacity standpoint, new storage resources must be added and some existing users must be migrated.

Before implementing larger mailbox sizes, review the existing storage design and the baseline performance data that has been collected. Using formulas supplied in the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide, calculate whether the existing configuration supports the increase in mailbox size. The best-case scenario is that the mailbox size can be increased without modifying the existing storage configuration. In most situations, this is an unrealistic expectation and additional storage resources must be added and existing users will need to be moved to newly configured storage groups. In most cases adding additional storage groups is simpler than increasing the size of existing ones.

Another approach that can be used in some circumstances is the upgrade of the existing disks used for a mailbox store database to a larger size. For a 2000 family storage system, this might involve moving an existing database from a RAID group of 146GB drives to a new RAID group utilizing 300GB drives.

Regardless of the approach used, monitoring of the storage system before, during and following the implementation of larger mailboxes is critical. Pay special attention to the cache write pending, the operating rate counter (under drive operation) and processor utilization. Also compare I/O rates for port, RAID group, logical unit, drive and back-end to baselines from before the change to measure the effect of the change and to make sure all values stay within an acceptable range.

Management Actions

When increasing mailbox quotas, take these actions:

- Increase quotas for users and keep their mailboxes on existing mailbox stores if storage capacity exists.
- Migrate database to larger drives and increase quotas for users.
- Migrate some users to new mailbox stores and then increase quotas if the existing database volumes do not have the capacity to handle the increase. Add storage groups on the server to maintain one-to-one relationships between storage groups and mailbox databases. Drives must be added to the storage system for the new databases and logs.
- If you cannot add storage groups to existing servers due to either memory considerations or the maximum number of storage groups per server being reached, servers must be added to the environment.
- If existing storage system is at capacity, another storage system must be added to the environment.
- After changes are made, monitor performance of the Exchange servers and the storage system to verify that performance is acceptable and that no additional changes need to be made. Remember that changes to capacity utilization and the increase in non-transactional I/O can affect performance.

Change in Mailbox Store Database Size

An increase in mailbox store database size is either caused by the addition of users, enlarging existing mailboxes or both. In those cases where both an increase in the number of users and an increase in the mailbox quota take place, adjust the size of the mailbox quota before adding users to minimize the amount of reconfiguration and mailbox moves.

Unplanned increases in the size of the mailbox store database can be avoided by implementing mailbox quotas to limit the size of a user’s mailbox.

While the primary effect of this type of change is to storage capacity requirements, effects on I/O load need to be considered as well.
Host Considerations

Monitor capacity utilization of disks or volumes allocated to Exchange.

Exchange Application Considerations

As long as existing storage configuration can support growth without degrading performance, increasing the size of existing mailbox store databases minimally affects the Exchange application. After increasing the size of existing mailbox store databases, monitor latency to verify that application performance remains within acceptable limits.

Storage Considerations

Two options exist for this scenario:

- Add drives to house additional databases and logs and migrate some of the users from existing databases to keep the size of the databases static.
- Replace existing drives with larger drives and migrate existing databases to the larger drives.

Both of these options assume that the database volume cannot be expanded on the existing RAID group due to capacity constraints.

Management Actions

If the required increase exceeds what the existing storage configuration can support, take these actions:

- Decide whether larger databases are going to adversely affect backup and maintenance tasks.
- Migrate database to larger drives if feasible.
- Migrate some users to new mailbox stores. Add storage groups on the server to maintain one-to-one relationships between storage groups and mailbox databases. Drives must be added to the storage system for the new databases and logs.
- If you cannot add storage groups to existing servers due to either memory considerations or the maximum number of storage groups per server being reached, servers must be added to the environment.
- If existing storage system is at capacity, another storage system must be added to the environment.
- After changes are made, monitor performance of the Exchange servers and the storage system to verify that performance is acceptable and that no additional changes need to be made. Remember that changes to capacity utilization and the increase in non-transactional I/O can affect performance.

Change in Number of Mailboxes per SG/db

Multiple scenarios can produce this type of change:

- The number of mailboxes is increased and the size of the mailboxes is constant. This scenario is the most common and is caused by the adding of new users to an existing storage group. Both capacity utilization and I/O load are increased.
- The number of mailboxes is increased but the size of the mailboxes is decreased. This is not a common scenario, but can occur if mailbox quotas are reduced and the environment is consolidated. It can also occur if mailbox quotas are implemented into an environment that didn’t previously impose them. This scenario affects I/O load but might not affect capacity utilization.
- The number of mailboxes is decreased and the sizes of the mailboxes are increased. This scenario is usually the result of on increase in the mailbox quota. The capacity utilization might be affected and the I/O load decreases.
**Host Considerations**

From a host perspective, it is important to consider memory and processor cores. In some cases, you might also need to verify that enough bandwidth exists on the Host Bus Adapters (HBAs) and SAN connections to handle the additional load. Consider using multipathing products such as Hitachi Dynamic Link Manager software or Windows native MPIO to fully utilize existing bandwidth and to support higher levels of availability and reliability. For more information about the required memory and processor configuration for an Exchange 2007 server, see Microsoft TechNet article bb738142, “Planning Your Server and Storage Architecture,” or the *Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide*. Before adding users to an existing server, collect baseline performance numbers.

If the size of the database is expected to change, monitor capacity utilization of disks or volumes allocated to Exchange.

**Exchange Application Considerations**

When adding user mailboxes to an existing storage group, it is important to leave ample I/O and capacity headroom in the storage configuration. It is often tempting to add users to storage groups based only on mailbox size, but it is critical to size the storage environment based on performance requirements first and capacity second. It is also important to take into account corporate standards for deleted item and mailbox retention, as well as replication and backup requirements. For more information about sizing your storage environment, see the *Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide*.

**Storage Considerations**

If the new user mailboxes are added to existing storage groups, care must be taken to not exceed the storage or I/O capacity limitations of the existing environment. It is also critical to remember that IOPS capacity for a volume is reduced as capacity utilization percentage of the volume increases. This means that the fuller the volume is, the less I/O it can handle in a given amount of time. Capacity utilization for a drive is calculated with the following formula:

\[
\text{used space/total capacity} = \text{capacity utilization \%}
\]

To monitor capacity utilization, use Hitachi Device Manager or monitor it from the host using Windows Performance Monitor.

Monitor processor utilization and cache write pending performance counters for the storage system. Also monitor the I/O rate for the ports, RAID groups, LUs and drives and compare them to pre-change values to verify that they are still at acceptable levels.

**Management Actions**

The actions to be taken depend on the reason for the change. See the previous sections on actions to take if the change is due to a change in the number of users or a change in mailbox quotas.

**Change in Number of SGs/dbs per Server**

In many cases, adding storage groups and databases is the simplest and most efficient way of increasing the amount of storage capacity available to an Exchange server. In some cases, storage groups are added for organizational reasons instead of capacity reasons. Because Exchange Server 2007 Enterprise Edition can support 50 storage groups and 50 databases, best practice is to have only one database per storage group. This also maintains a one-to-one relationship between databases and logs, which results in better performance and simpler, more efficient backup and recovery processes.
Host Considerations

Memory requirements for the host increase as the number of storage groups defined for that Exchange server increases. For tables listing the required amount of memory, see Microsoft TechNet article bb738124, “Planning Memory Configurations.”

Exchange Application Considerations

The addition of storage groups or databases does not usually affect performance of the Exchange application as long as proper sizing procedures are used.

Monitor latency to verify changes do not degrade application performance.

Storage Considerations

Adding storage groups and databases requires additional storage resources. For each additional storage group, two new LUs must be created on the storage subsystem. The database requires a new RAID group. The log LU might require a new RAID group depending on the existing storage layout. Monitor cache write pending and utilization counters to verify acceptable performance.

Management Actions

If the number of storage groups change for an Exchange server, take the following actions:

- Verify that the version of Exchange on the server can support more storage groups or databases. The maximum number of databases is five for the standard version and 50 for the Enterprise version.
- Verify that enough memory is installed in the server to handle the increase in the number of storage groups.
- Drives must be added to the storage system to house the additional databases and logs.
- If you cannot add storage groups to existing servers due to either memory considerations or the maximum number of storage groups per server being reached, servers must be added to the environment.
- If existing storage system is at capacity, another storage system must be added to the environment.
- After changes are made, monitor performance of the Exchange servers and the storage system to verify that performance is acceptable and that no additional changes need to be made. Remember that changes to capacity utilization and the increase in non-transactional I/O can affect performance.

Change in Capacity Utilization

This scenario is a side effect of any change that causes an increase in the size of the databases. Capacity utilization is calculated with the following formula:

\[
\text{used space/total capacity = capacity utilization \%}
\]

Host Considerations

The primary concern is monitoring available free space on disks allocated to Exchange to verify that enough space is available for deleted mailbox and item retention and other background activities that require disk space. Remember that the ability of a disk drive to handle I/O decreases as the capacity utilization increases. For more information, see the Planning for Microsoft Exchange Server 2007 Deployments on the Hitachi Adaptable Modular Storage 2000 Family Reference Architecture and Best Practices Guide.

Exchange Application Considerations

It is important to remember that the ability of a disk or RAID group to handle IOPS decreases as capacity utilization increases. It is also critical that an Exchange database not experience an out-of-space condition because this causes the database to be dismounted.
Storage Considerations

Use Hitachi Device Manager software to monitor capacity utilization and available free space. At minimum, monitor cache write pending and utilization counters to verify acceptable performance of the storage system. Remember that the amount of I/O that a drive can process decreases as capacity utilization increases. Table 8 illustrates this for an Exchange environment consisting of eight LUs.

Table 8. Capacity Usage Ratio for an 8 LU Configuration

<table>
<thead>
<tr>
<th>Storage Configuration</th>
<th>Capacity Utilization (Percent)</th>
<th>Exchange Total Database Size (GB)</th>
<th>Percent of IOPS Measured Within 20ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 LU</td>
<td>22</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>8 LU</td>
<td>44</td>
<td>1000</td>
<td>84.5</td>
</tr>
<tr>
<td>8 LU</td>
<td>100*</td>
<td>2304</td>
<td>77.5</td>
</tr>
</tbody>
</table>

* Estimated values based on physical disk performance characteristics.

Management Actions

A change in capacity utilization is usually a side effect of another change. See the previous sections that address the cause of the change.

Change in Amount of Non-transactional I/Os

The reduction in transactional I/O — things like retrieving, receiving, sending and deleting items — in Exchange 2007 makes non-transactional I/O more important. With the trend toward larger mailbox sizes and the resulting increase in the amount of data on disk, you must now consider and plan for non-transaction I/O when designing and monitoring your storage configuration. Following are examples of non-transactional I/O:

- **Message record management (MRM)** — Allows users to manage their mailboxes through the use of policies. These policies normally address compliance requirements for e-mail retention and as a result e-mail might be moved or deleted. These actions require a synchronous crawl of the Exchange databases. Do not execute MRM at the same time as backup or online maintenance operations.

- **Content indexing** — Increases IOPS and size of the Exchange database by approximately five percent with Exchange 2007. This index is placed on the same LU as the database. Messages are indexed as they are received.

- **Online maintenance** — A series of operations performed by the Exchange Information Store that ensure logical consistency in the databases. Generally speaking, the operations ensure that items no longer needed by the system are removed from the database. Online maintenance activities include online defragmentation, which frees pages in the database by compacting records onto the fewest number of pages possible, thus reducing the amount of I/O necessary. By default, Exchange Server database maintenance occurs daily between 1:00 a.m. and 5:00 a.m., although these time periods can be modified. These processes increase the I/O load on Exchange databases.

- **Streaming backup and restore operations** — Streaming backups and restores use the Extensible Storage Engine (ESE) application programming interface. These can affect the I/O requirements for the storage system. The key metric for backup and restore is throughput, or the number of megabytes per second that can be copied from and to the database LUs. If these backup or restore operations are scheduled for an active production period, be sure to take this into account when calculating I/O requirements, paying particular attention to the effect this can have on the storage system. Streaming backup operations increase the load on mailbox servers. Schedule these backups during off-peak hours. If backups are required during peak periods, ensure that they are differential or incremental and perform full backups during off-peak hours. Consider running Volume Shadow Copy Services (VSS) backups from a passive copy, thus minimizing the effect of streaming backups on the mailbox servers.
Host Considerations

The primary concern is I/O load that might not have been included in initial sizing of the environment.

Exchange Application Considerations

The I/O load from processes such as indexing, backups and daily maintenance must be taken into account. Some of these processes, such as daily maintenance and backups, are usually done during periods of little or no activity but others can occur at any time.

Storage Considerations

Use the Performance Monitor feature in Storage Navigator Modular 2 to monitor cache write pending and processor utilization counters to verify acceptable performance of the storage system.

Management Actions

Because the amount of non-transactional I/O can vary for many reasons, it is important to monitor the servers and storage systems on an ongoing basis:

- Look for changes in performance that occur after changes in the size of mailboxes or databases.
- Look for changes in performance that occur at specific times of day that are caused by maintenance or backup activities.

See the previous sections that address the cause of the performance change you observe.
Appendix A Additional Reference Material

The following books were used as reference for this guide:

