Monitoring Business Critical Applications with VMware vCenter™ Operations Manager™
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1. Introduction

This document describes how to use VMware® vCenter™ Operations Manager™ to monitor the performance of SAP, Microsoft Exchange, Microsoft SQL Server databases, and Oracle databases in a VMware virtual environment. VMware categorizes these software products as business critical applications (BCAs). SAP and Exchange are direct applications, whereas SQL Server and Oracle databases are commonly used as backend persistent data storage for packaged and custom business critical applications.

vCenter Operations Manager provides a unified view into the health, risk, and efficiency of the virtual infrastructure and the health of applications to help improve quality of service and provide early detection of performance, capacity, and configuration issues. Visibility into business critical applications is possible using off-the-shelf adapters for SAP, Exchange, SQL Server, Oracle, and VMware vFabric™ Hyperic®. vFabric Hyperic is an agent-based performance management solution that can extract counters from the guest operating system and applications or databases. This document focuses on these adapters and shows how they can be used to extract and monitor application performance counters and metrics that are relevant for SAP, Exchange, Oracle, or SQL Server database administrators.

While many other applications and software products fall within the business critical applications classification (many of which can also be monitored with vCenter Operations Manager and vFabric Hyperic), the scope of this document is based on the software products described in this section.

1.1 Purpose

In physical environments, application administrators (defined in this document as SAP, Exchange, SQL Server database, and Oracle database administrators) traditionally rely on operating system level counters to monitor the infrastructure. This is no longer adequate in the VMware virtual environment where visibility requires access to the VMware vSphere® layer. vCenter Operations Manager provides single-pane visibility into the entire stack from the application level to the guest operating system and underlying virtual layer.

The content in this document is intended to provide guidance to administrators. It does not present strict design requirements, because enterprise requirements can vary from one implementation to another.

1.2 Target Audience

This document is intended for SAP, Exchange, SQL Server, Oracle, and VMware administrators responsible for managing the operations of business critical software applications on the vSphere platform.
2. Overview

The following sections describe the workings of vCenter Operations Manager and vFabric Hyperic, and how to use them as part of your monitoring strategy.

2.1 vCenter Operations Manager

vCenter Operations Manager ships as a virtual appliance that can be quickly installed and used to manage the performance and health of the vSphere infrastructure. vCenter Operations Manager includes the following functionality:

- Operations Dashboard provides at-a-glance views into health, risk, and efficiency of the virtual infrastructure.
- Health and Workload Views helps identify anomalies, faults, and stressed workloads that can impact the infrastructure performance and health.
- Workload Details View provides in-depth analysis of the causes of performance and health issues on virtual machines, hosts, data stores, and vSphere clusters.
- Adapters provide visibility into other application products.

vCenter Operations Manager uses adapters to collect data from a variety of data sources, including third-party products such as business critical applications. Adapters work with the vCenter Operations Manager Collector to collect and process data. The Collector acts as a gateway between vCenter Operations Manager and its adapters. Depending on the data source and the adapter implementation, an adapter might collect data by making API calls, using a command-line interface, or sending database queries.

The following adapters are covered in this document:

- vFabric Hyperic adapter – Collects data from vFabric Hyperic, which includes plug-ins to monitor many applications.
- Microsoft System Center Operations Manager (SCOM) adapter – Collects resource metrics, resource availability, and resource relationship data from Microsoft SCOM databases.
- Oracle Enterprise Manager (OEM) adapter – Collects data from Oracle Enterprise Manager database management tables.
- SQL Loader adapter – Reads data from an external database.
- SAP Computer Center Management System (CCMS) adapter – Collects metrics from the CCMS module of SAP systems.

This document refers to these adapters as BCA adapters. For a list of other adapters, see the VMware vCenter Operations Manager Adapter Guide (https://www.vmware.com/pdf/vcops-adapter-guide.pdf). There is also a vSphere adapter that collects metrics and events from vCenter Server. This adapter is part of the base installation and is pre-installed and pre-configured with vCenter Operations Manager.
The following diagram shows the high level architecture of vCenter Operations Manager.

**Figure 1. vCenter Operations Manager High Level Architecture**

The architecture includes the following components:

- **Analytics virtual machine** – Is responsible for collecting data from vCenter Server, vCenter Configuration Manager, and third party data sources.
- **BCA adapters** – Refers to adapters for SAP, Oracle OEM, vFabric Hyperic, SQL Loader, and SCOM.
  - Oracle metrics can be obtained from the Oracle Instance or vFabric Hyperic.
  - SQL Server metrics can be obtained from the SQL Server instance, SCOM, or vFabric Hyperic.
  - Exchange metrics can be obtained from SCOM or vFabric Hyperic.
  - SAP metrics can be obtained from the SAP system.
- **vSphere Adapter** – Collects virtual metrics, topology, relationships, and events from vCenter Server (comes pre-installed and pre-configured).
- **Collector** – Acts as a gateway between vCenter Operations Manager and its adapters.
- **ActiveMQ** – Serves as a message broker to pass metric information among vCenter Operations Manager components.
- **Performance Analytics** – Receives data gathered from monitored resources, analyzes the data, and creates statistical models to detect abnormal behavior.
- **File System Database (FDBS)** – Stores all of the metrics.
- **Analytics VM Postgres DB** – Stores non-metric based data such as change events, configuration settings, and alerts.
UI virtual machine – Allows access to analytics results in the form of badges and scores using the Web based application for the UI virtual machine. It also allows access to the administration portal for management tasks.

vSphere UI – Provides a summary and deeper view into the vSphere environment.

Custom UI – Provides a customizable web-based user interface. Custom dashboards are created using this user interface.

Administration UI – Provides a user interface for maintenance and management tasks.

Capacity Analytics – Provides capacity metering and trending and ability to right-size and optimize resources.

2.2 vFabric Hyperic

vFabric Hyperic monitors the application infrastructure for custom web applications and databases across physical or virtual infrastructure environments. It includes out-of-the-box monitoring of databases and guest operating systems (both Windows and Linux based). The main components of vFabric Hyperic include vFabric Hyperic Server, Agent, Database, and the vFabric Hyperic User Interface, also known as the vFabric Hyperic Portal.

A vFabric Hyperic Agent runs on the guest operating system of each virtual machine that needs to be monitored. The vFabric Hyperic Agent automatically discovers the resources and software in the virtual machine such as architecture, guest OS, RAM, CPU speed, IP address, and domain name. The agent uses resource plug-ins to discover software products such as Java-based application servers, web servers, and database servers. Agents send the inventory and performance data to a central vFabric Hyperic Server which stores it in the vFabric Hyperic database.

A vCenter Operations Manager vFabric Hyperic adapter runs SQL queries and uses standard JDBC access to retrieve data from the vFabric Hyperic database. This adapter collects metrics from vFabric Hyperic and creates vCenter Operations Manager resource objects dynamically according to platform types and server types in vFabric Hyperic.

2.3 Determine Monitoring Strategy

This section compares the metric data available from vFabric Hyperic and the other BCA data sources through vCenter Operations Manager adapters. The comparison can help determine a monitoring strategy for the final environment. The following table summarizes the adapters and their relevance to monitoring business critical applications.

<table>
<thead>
<tr>
<th>App</th>
<th>SQL Loader</th>
<th>SCOM</th>
<th>OEM</th>
<th>SAP CCMS</th>
<th>vFabric Hyperic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange</td>
<td>n/a</td>
<td>All guest OS counters.</td>
<td>n/a</td>
<td>n/a</td>
<td>All guest OS counters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All Exchange counters.</td>
<td></td>
<td></td>
<td>Many Exchange counters.</td>
</tr>
<tr>
<td>SQL Server</td>
<td>Custom query extracts any counter from Microsoft DMV views.</td>
<td>All guest OS counters.</td>
<td>n/a</td>
<td>CCMS data – database response times (for SAP databases).</td>
<td>All guest OS counters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Many SQL server counters.</td>
<td></td>
<td></td>
<td>Many SQL Server counters.</td>
</tr>
</tbody>
</table>
The major differences between vFabric Hyperic and the other BCA adapters are as follows:

- Currently vFabric Hyperic does not provide any SAP plug-in, so the vCenter Operations Manager SAP adapter is required for monitoring of SAP.

- For Exchange, SQL Server, and Oracle, there is overlap between the application metrics available from vFabric Hyperic and the other BCA adapters (SCOM, OEM, and SQL Loader). vFabric Hyperic provides visibility into multiple applications—a useful strategy for VMware administrators who need some quick application level monitoring beyond the vSphere layer. The other BCA adapters provide additional counters that application administrators can use for in-depth analysis of the application tiers.

- SCOM is typically used only in Windows environments where vFabric Hyperic can be deployed across many varieties of guest OS.

- vFabric Hyperic automatically discovers the applications in the guest OS and can monitor application-specific metrics with minimal assistance of an application administrator to help with setup and configuration. It does require an agent installation in each virtual machine. The other adapters (SCOM, SQL Loader, Oracle and SAP) require more involvement from an application administrator for correct operation.

- vFabric Hyperic and SCOM can provide access to all guest OS counters. The remaining BCA adapters also extract guest OS metrics, but not the complete set.

- A key capability of vCenter Operations Manager is to highlight performance issues and aid in performance troubleshooting. It can be the starting point for an investigation and can guide the analysis towards the correct layer and specific component in the application stack. It does not need to collect every detailed metric from the application, because application administrators can use their existing tools for final resolution.
The following diagram shows an example decision making process to determine what adapters to use.

**Figure 2. Example Monitoring Strategy**
3. Lab Environment Overview

The dashboard monitoring examples in this document are based on the following lab environment:

- vCenter Server and 3 x VMware ESXi™ hosts running vSphere 5.1.
- vCenter Operations Manager 5.6 (vApp version) plus the following additional adapters: vFabric Hyperic, SCOM, Oracle OEM, SAP, SQL Loader.
- vFabric Hyperic 5.0.0 (vApp version).
- SCOM 2012.
- Multiple virtual machines running Exchange, SQL Server, Oracle and SAP:
  - vFabric Hyperic agent installed in all virtual machines.
  - SCOM agent installed in virtual machines running Windows.

The following diagram depicts the setup of the lab environment.

**Figure 3. Lab Environment**
The following table lists the virtual machines.

**Table 2. List of Virtual Machines and Applications**

<table>
<thead>
<tr>
<th>Virtual Machine Name</th>
<th>DNS Name (Host Name if different)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>bca-exch01</td>
<td>bca-exch01.mgmt.loca (BCA-EXCH01)</td>
<td>Exchange (client access/hub transport)</td>
</tr>
<tr>
<td>bca-exch02</td>
<td>bca-exch02.mgmt.loca (BCA-EXCH02)</td>
<td>Exchange (client access/hub transport)</td>
</tr>
<tr>
<td>bca-exch03</td>
<td>bca-exch03.mgmt.loca (BCA-EXCH03)</td>
<td>Exchange (mailbox)</td>
</tr>
<tr>
<td>bca-exch04</td>
<td>bca-exch04.mgmt.loca (BCA-EXCH04)</td>
<td>Exchange (mailbox)</td>
</tr>
<tr>
<td>bca-sap-oradb-linux</td>
<td>bca-sap-oradb-linux.mgmt.local (hogwarts)</td>
<td>SAP Oracle database SID=PRD</td>
</tr>
<tr>
<td>bca-sap-ascs-linux</td>
<td>bca-sap-ascs-linux.mgmt.com (sapascs)</td>
<td>SAP central services SID=PRD</td>
</tr>
<tr>
<td>bca-sap-app-linux</td>
<td>bca-sap-app-linux.mgmt.com (sapapp1)</td>
<td>SAP primary application server Dialog Instance SID=PRD</td>
</tr>
<tr>
<td>bca-sql-analytics</td>
<td>bca-sql-analyti.mgmt.local (Bca-sql-analyti)</td>
<td>SQL Server 2012 analytics database</td>
</tr>
<tr>
<td>bca-loadgen01</td>
<td>bca-loadgen01.mgmt.loca (BCA-LOADGEN01)</td>
<td>Load Gen Exchange load generation</td>
</tr>
<tr>
<td>bca-sql-driver</td>
<td>bca-sql-driver.mgmt.local (bcasql-driver)</td>
<td>Load driver for SQL Server 2012 analytics database Generates queries and simulates user access</td>
</tr>
</tbody>
</table>
3.1 vCenter Operations Manager Setup


The adapters for the examples in this document were installed and configured as described in the VMware vCenter Operations Manager Adapter Guide ([https://www.vmware.com/pdf/vcops-adapter-guide.pdf](https://www.vmware.com/pdf/vcops-adapter-guide.pdf)).

3.2 vFabric Hyperic Setup

vFabric Hyperic Server 5.0.0 is available as a vApp. The vFabric Hyperic vApp consists of two virtual machines, one for the vFabric Hyperic Server and one for the vFabric Hyperic database. The database is vFabric Postgres 9.1.3.

The vFabric Hyperic vApp was deployed as described in Install Hyperic vApp ([http://pubs.vmware.com/vfabricHyperic50/index.jsp?topic=/com.vmware.vfabric.hyperic.5.0/Install_Hyperic_vApp.html](http://pubs.vmware.com/vfabricHyperic50/index.jsp?topic=/com.vmware.vfabric.hyperic.5.0/Install_Hyperic_vApp.html)).

vFabric Hyperic agents were installed in each virtual machine running a business critical application. vFabric Hyperic automatically discovers the applications for which it has a plug-in and the guest OS inside the virtual machines. The following figure shows the discovered virtual machines.

All of the discovered applications are collected by the vCenter Operations Manager vFabric Hyperic Adapter and created as resources in vCenter Operations Manager.

**Figure 4. vFabric Hyperic Discovered Resources**

![vFabric Hyperic Discovered Resources](image-url)
3.3 **System Center Operations Manager Setup**

System Center Operations Manager 2012 (SCOM) was installed and configured according to Microsoft installation guidelines.

3.4 **Resources and Overview of Installed Adapters**

A resource is any entity in the environment for which vCenter Operations Manager can collect data, such as a virtual machine, database, application server, or a container that holds other resources. Installation of a BCA adapter creates a resource *kind* (type or classification). The adapter resource kind is used to create a resource that is associated with or points to a specific data source such as an SAP system or database instance. The resource enables access to the specific counters and can be manually configured or automatically created by the adapter. The installation of multiple adapters generates multiple resource kinds within vCenter Operations Manager as described in the following table.

**Table 3. Adapter Resource Kinds**

<table>
<thead>
<tr>
<th>Adapter Kind</th>
<th>Resource Kind</th>
<th>Resource Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCOM</td>
<td>Various</td>
<td>Various – based on hostname, DNS name, and application of discovered entities.</td>
<td>Resources and names are automatically generated depending on what is available in SCOM.</td>
</tr>
<tr>
<td>vFabric Hyperic</td>
<td>Various</td>
<td>Various – based on hostname, DNS name, and application of discovered entities.</td>
<td>Resources and names are automatically generated depending on what is discovered by vFabric Hyperic.</td>
</tr>
<tr>
<td>SQL Loader GeneralSQL Adapter Instance</td>
<td>User defined.</td>
<td>Refers to the SQL loader adapter.</td>
<td></td>
</tr>
<tr>
<td>SQL Loader User defined e.g. SQL Server PERFMON Stats</td>
<td>User defined.</td>
<td>Points to and collects data from a specific database.</td>
<td></td>
</tr>
<tr>
<td>OEM</td>
<td>OEM Adapter Instance</td>
<td>User defined.</td>
<td>Points to and collects data from a specific Oracle database. User credentials are specified manually.</td>
</tr>
<tr>
<td>OEM</td>
<td>oracle_database</td>
<td>Defaults to the database instance name discovered by the adapter.</td>
<td>This is automatically generated by the adapter.</td>
</tr>
<tr>
<td>OEM</td>
<td>hosts</td>
<td>Name defaults to the guest OS hostname.</td>
<td>This is automatically generated by the adapter.</td>
</tr>
<tr>
<td>SAP</td>
<td>SAP Adapter Instance</td>
<td>User defined.</td>
<td>The SAP userid and password (to log onto SAP systems) is stored in this entity.</td>
</tr>
</tbody>
</table>

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### Adapter Kind | Resource Kind | Resource Name | Comment
--- | --- | --- | ---
SAP | SAP Resource | User defined. | Points and collects data from a specific SAP system. The SAP client and target system are specified.
vSphere | Various based on vCenter entities – “Virtual Machine” will be common | Automatically generated based on virtual machine name in vCenter. | Provides access to virtual counters.

The following figures show a partial list of resources created for each adapter (manually or automatically). The Data Source column indicates the adapter that is the source of the resource (and metrics):

- Blue SQL icon – SQL Loader adapter.
- Red Oracle logo – Oracle OEM adapter.
- Blue and white SAP logo – SAP adapter.
- Windows logo – SCOM adapter.
- vFabric Hyperic logo – vFabric Hyperic adapter.

**Figure 5. Resources Based on SQL Loader, OEM and SAP Adapters**
### Figure 6. Resources Based on SCOM Adapter

<table>
<thead>
<tr>
<th>Name</th>
<th>Resource Kind</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCA-SQL-ANALYT. MSQLSERVER</td>
<td>Microsoft.SQLServer.DBEngine</td>
<td></td>
</tr>
<tr>
<td>MSQLSERVER</td>
<td>Microsoft.SQLServer.DBEngine</td>
<td></td>
</tr>
<tr>
<td>MSQLSERVER</td>
<td>Microsoft.SQLServer.DBEngine</td>
<td></td>
</tr>
<tr>
<td>MSQLSERVER</td>
<td>Microsoft.SQLServer.DBEngine</td>
<td></td>
</tr>
<tr>
<td>SCOMP1.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-EXCH01.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-SQL-DRIVER.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-EXCH04.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-SQL-ANALYT.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-EXCH02.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-SQL01.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-SQL02.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>SCOM-SQL2K12.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>BCA-EXCH01.mgmt.local</td>
<td>Microsoft.Windows.Computer</td>
<td></td>
</tr>
<tr>
<td>M3 SCOM Adapter - 2012 SP1</td>
<td>M3 SCOM Adapter Instance</td>
<td></td>
</tr>
</tbody>
</table>

### Figure 7. Resources Based on vFabric Hyperic Adapter

<table>
<thead>
<tr>
<th>Name</th>
<th>Resource Kind</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCA-SQL-ANALYT. MSQLSERVER</td>
<td>MrSQL 2012</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SQL-DRIVER.MSQL 2012 MSQLSERVER</td>
<td>MrSQL 2012</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>MGMTPM-SQL2 MrSQL 2008 R2 MSQLSERVER</td>
<td>MrSQL 2008 R2</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>MGMTPM-SQL1 MrSQL 2008 R2 MSQLSERVER</td>
<td>MrSQL 2008 R2</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-DB-APP-WIN MsSQL 2005 SQLEXP_VMs</td>
<td>MsSQL 2005</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-DB-APP-WIN MsSQL 2005 MSQLSERVER</td>
<td>MsSQL 2005</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-ORADB-linux.mgmt.local</td>
<td>Linux</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-APP-linux.mgmt.local</td>
<td>Linux</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-ASCS-linux.mgmt.local</td>
<td>Linux</td>
<td>HYPERIC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Resource Kind</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCA-SQL-ANALYT.mgmt.local</td>
<td>Win32</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-DB-APP-WIN.mgmt.local</td>
<td>Win32</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>MGMTPM-SQL2.mgmt.local</td>
<td>Win32</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>MGMTPM-SQL1.mgmt.local</td>
<td>Win32</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>MGMTPM-VC51 VMware vCenter</td>
<td>VMware vCenter</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-ORADB-linux Oracle 10g</td>
<td>Oracle 10g</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-ORADB-linux OC4J 10</td>
<td>OC4J 10</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>BCA-SAP-ORADB-linux NTP 4.x</td>
<td>NTP 4.x</td>
<td>HYPERIC</td>
</tr>
<tr>
<td>MGMTPM-VC51.NET 2.0</td>
<td>.NET 2.0</td>
<td>HYPERIC</td>
</tr>
</tbody>
</table>

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3.5 Review Metrics Dashboard

This section describes a dashboard that can be used as a quick method to navigate to a resource and view the associated metrics.

To create a dashboard, log in to the custom user interface in a web browser. The tabs near the top of the Home page show your dashboards. Switch to a different dashboard by clicking its tab or selecting it from the Dashboards menu. To create a new dashboard, click the plus (+) sign to the right of the last dashboard tab. The dashboard editor opens as shown in the following figure. To create a custom dashboard, drag widgets in the left pane to the right pane.

Figure 8. Dashboard Editor
The panes on a dashboard are called widgets. A widget is a collection of related information about attributes, resources, or applications. Each dashboard contains one or more widgets. In this example, the following widgets are selected:

- **Resources Widget** – Lists all the defined resources.
- **Metric Selector Widget** – Shows all metrics for the resources that are selected in the Resources widget.
- **Metric Graph Widget** – Shows a graph of recent performance of the selected metrics.

The following figure shows the newly created dashboard.

**Figure 9. Dashboard Review Metrics Example**
For the dashboard to operate as shown in the previous figure, you must configure interactions between the widgets. For example, you can configure the interactions so that when a metric is selected in the metric selector widget, the graph is shown in the metric graph widget.

**To configure interactions**

1. Select **INTERACTIONS** in the top right area of the dashboard.
2. Configure the interactions as shown in the following figure.

![Configure Widget Interactions](image)

The resources provide access to the metrics, and each resource represents a view into a different level of the environment from the application down to the virtual layer. Additional dashboard examples in this document depict a single-pane-of-glass view for each business critical application by combining metrics from different resources. The majority of the interactions in the vCenter Operations Manager user interface described in this document require navigation to a resource.
4. **BCA Dashboard Overview**

The next sections provide details on example dashboards for Exchange, SQL Server, Oracle, and SAP. This section provides an overview of the metrics and key components of the dashboards (reference is made to widget types that are explained in the subsequent sections).

- Most of the dashboards have a Scoreboard widget that monitors application-specific counters that are relevant to application administrators:
  - For Exchange, RPC and submission queue length metrics provide an indication of the messaging workload.
  - For databases, database instance memory counters (for example, buffer cache hit ratio) are important because data in memory plays a major role in minimizing disk I/O and maximizing performance.
  - For SAP, online dialog and database response times are useful, as these are often used in defining service level agreements (SLAs).

- The following guest OS counters are of particular interest:
  - Guest OS swap counter – Business critical applications should not swap at any time.
  - Guest OS memory used – If memory reservations are set (recommended for memory-intensive business critical applications that are bound to strict SLAs), there is no chance of VMware ballooning inside the guest OS. Therefore, this counter can be used as an indicator of memory used by the application. (VMware ballooning is a memory reclamation technique that helps in memory over-commit scenarios.)
  - Guest OS Linux run queue or Windows System\Processor Queue Length – This can be used as an indicator of CPU bottleneck inside the guest OS. For example, if a virtual machine is running at 100% CPU with no contention with other virtual machines and high run queues in the guest OS, it is likely that the application could benefit from more CPU (for example, by increasing the number of vCPUs for the virtual machine or scaling out the application to more virtual machines).

- The following vSphere counters are of particular interest:
  - Virtual machine CPU usage and percent ready (measure of CPU contention between virtual machines). The CPU utilization metric inside the guest OS cannot be relied upon in virtual environments (especially during periods of high ESXi host CPU utilization).
  - I/O latency of the database datastores.

- Some of these guest OS and vSphere counters are presented in dashboards using the Metric Graph and Rollover Metric Graph widgets.

- Hierarchies in vCenter Operations Manager specify a multitier application architecture using the Application Detail and Health Tree widgets. The widgets help with troubleshooting and provide a fast way to discover all of the resources associated with a multitier application.

Most of the dashboards in this document are a combination of the following widgets: Scoreboard; Application Detail; Health Tree; Metric Graph; Rollover Metric Graph.

**Note** The metrics used in the dashboards in this document are examples. Final selection depends on customer-specific requirements.

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5. Exchange

Exchange has evolved to become a complex system with many components required to create a complete Exchange email environment. When Exchange is virtualized, Exchange and vSphere administrators need to work together to use data available natively in Windows for Exchange along with data from within vSphere to monitor Exchange and troubleshoot when issues arise. This can be a complex and confusing task when only native tools are used. Having a single dashboard with multiple metric sources can provide administrators with a single view of the environment to help with event correlation and root cause analysis.

This section describes performance management using vCenter Operations Manager for Exchange Server 2010. The examples in this section involve an Exchange 2010 environment that was deployed as shown in the following figure.

Figure 10. Exchange 2010 Lab Environment

To provide a perspective on how Exchange performance management can be accomplished for new and established environments, the following monitoring solutions were configured, as shown in the previous figure.

- Fabric Hyperic provides an Exchange plug-in to monitor Exchange metrics.
- System Center Operations Manager (SCOM) can be used if already present in the environment. The Exchange Management Pack for SCOM, along with the SCOM adapter for vCenter Operations Manager provides visibility of the Exchange environment through vCenter Operations Manager.
5.1 Overview of vFabric Hyperic Agent for Exchange

The vFabric Hyperic agent supports auto-discovery of Exchange components and allows you to manage your Exchange server infrastructure without sacrificing functionality that is normally accessible only through more complex Exchange monitoring tools. vFabric Hyperic auto-discovers the Exchange server and the SMTP, POP3, IMAP4, WebMail, and IIS components that make up the Exchange environment. This allows you to manage and monitor the consumption of mailbox storage, along with the performance of the Exchange's web services interface used by Outlook and web mail clients.

With the vFabric Hyperic adapter for vCenter Operations Manager, all vFabric Hyperic metrics enabled for collection are available to vCenter Operations Manager. For a complete listing of Exchange Server metrics available when using vFabric vFabric Hyperic go to the vFabric Hyperic support page at http://support.vFabric Hyperic.com/display/hyperforge/Exchange+2010+server. The following table lists metrics that are used in the dashboard examples in the next sections.

Table 4. Sample Counters Available Through Exchange Plug-In for vFabric Hyperic

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPC Operations per Minute</td>
<td>Provides an indication of how busy an Exchange server is. The number of observed operations is dependent on user and device activity.</td>
</tr>
<tr>
<td>RPC Requests</td>
<td>Shows the number of client requests currently being processed or in the queue. A healthy server should have no more than 50 Pending requests. The Exchange Information Store process (store.exe) has a hard limit of 100 RPC requests, after which it stops accepting requests.</td>
</tr>
<tr>
<td>RPC Avg Latency</td>
<td>Measures the time taken for store.exe to process a request. The value should be less than 50ms at all times. An increase in processing, memory or storage pressure on an Exchange server can cause this number to rise, affecting end-user performance</td>
</tr>
<tr>
<td>Sub Queue Length</td>
<td>Shows how many messages are in the queue waiting for categorization. A high number of messages (submitted by the transport server) in the queue is an indication that the mailbox server is unable to handle the load.</td>
</tr>
<tr>
<td>Messages Delivered per Minute</td>
<td>Shows the number of messages delivered per minute.</td>
</tr>
<tr>
<td>Messages Sent per Minute</td>
<td>Shows the number of messages sent by the SMTP send connector each minute.</td>
</tr>
</tbody>
</table>
5.2 Enabling vFabric Hyperic Metrics for Exchange

When the vFabric Hyperic agent is first installed, the metrics it collects are a small subset of the available metrics. vSphere and Exchange administrators can work together to enable more metrics as needed. Keeping the enabled metrics to only those that can provide clear indication of a problem helps to eliminate the noise often found in other monitoring solutions.

After installation of the vFabric Hyperic agent within the guest OS, the agent discovers running applications and activates the appropriate plug-ins. In the following figure, the resources list on the left shows discovered resources and services, including Exchange 2010, .NET, IIS 7.x, and the vFabric Hyperic agent itself.

Figure 11. vFabric Hyperic Overview of BCA-EXCH04
Selecting the Exchange 2010 service displays a subset of the metrics (referred to as indicators) currently being collected. The **INDICATORS** tab displays the metrics over the past eight hours (by default).

**Figure 12. BCA-EXCH04 Detailed View of Exchange 2010 Data**

![BCA-EXCH04 Detailed View of Exchange 2010 Data](image)

The **METRIC DATA** tab provides a detailed view of all the metrics currently being collected. Out of the box the number of metrics collected is small.

**Figure 13. Default Enabled Exchange 2010 Metrics**

![Default Enabled Exchange 2010 Metrics](image)
The **Show All Metrics** button displays all of the metrics that can be collected. The expanded list allows administrators to review the entire set of metrics available.

**Figure 14. Expanded List of Exchange 2010 Metrics**

Administrators can enable additional metrics to collect more data to provide to vCenter Operations Manager for analysis and trending. In the following figure, the VM Largest Block Size metric is selected to be enabled with a collection interval of 5 minutes.

**Figure 15. Enabling Additional Metrics**
When the desired metrics are enabled within vFabric Hyperic, they are automatically collected by the vFabric Hyperic Adapter. The data that is collected and analyzed within vCenter Operations Manager can then be used to create application-specific dashboards for administrators.

5.3 Exchange Application Container

The multitier Exchange environment in this example includes mailbox and client access hub transport layers. This architecture is described in a vCenter Operations Manager construct called an application container. The application container contains one or more tiers, and each tier contains one or more resources. The application container can be used to model the Exchange environment.

To create or view application containers, log in to the custom UI and select Environment > Applications Overview.

The following figure shows the Exchange application container (Exchange 2010) and the resources assigned to one of the tiers. All resource objects that are associated with the Exchange system must be assigned to the appropriate tier. The application container configuration in the figure defines a resource hierarchy that can be viewed in widgets for root cause analysis. This will be shown in the dashboards next.

Figure 16. Exchange Application Container
5.4 Define Exchange Super Metrics

Table 4 defines some of the Exchange metrics used in the example dashboard. This section shows how to define vCenter Operations Manager super metrics that represent an average view across the whole Exchange architecture. A super metric is a metric that is based on multiple individual metrics.

The example includes the following super metrics:

- **RPC Averaged Latency (Avg)** – Average value of this metric across all the Exchange servers.
- **RPC Operations per Minute (Avg)** – Average value of this metric across all the Exchange servers.
- **Exchange - RPC Requests (Max)** – Maximum value of this metric across all the Exchange servers.
- **Submission Queue Length (Avg)** – Average value of this metric across all the Transport servers.
- **Submission Queue Length (Max)** – Maximum value of this metric across all the Transport servers.
- **Submission Queue Length (Sum Total)** – Sum of this metric across all the Transport servers.

**To create a super metric**

1. Select **Environment > Advanced > Super Metrics > Super Metric Editor**.
2. Select **Add New Super Metric**.
3. Select the metrics and operators to add to the super metric. In the figure:
   - Exchange 2010 is the name of the application container defined previously and is the starting point for the search for the metric RPC Operations per Minute.
   - The application container is defined with level 1 (top) and level 2 (tier). vCenter Operations Manager reads two levels down from the top to the resources assigned to the tier, finds all occurrences of the metric RPC ops per minute, and averages them all together.

With this configuration, you do not need to change the super metric if you add more Exchange servers or components. vCenter Operations Manager automatically finds the metric defined in the super metric across all the relevant resources (as long as the resources have been correctly assigned to the application container).

**Figure 17. Create Exchange Super Metric**
After creating the super metric, assign it to a super metric package.

To assign a super metric to a package
2. Select Add New Attribute Package.
3. Select the super metric that you created.
4. Specify the thresholds in the Advanced Configuration section.
5. Select Violation of the hard threshold is a Key Indicator.
5.5 Exchange Custom Dashboards

The following sections show example dashboards for Exchange 2010.

5.5.1 Building an Exchange Custom Dashboard

Each dashboard can be created with multiple widgets, and each widget has its own configuration parameters. This section provides a basic overview of creating a dashboard. Detailed information on configuring each widget can be found in the vCenter Operations Manager documentation.

When the vCenter Operations Manager custom UI is launched, the default dashboard is displayed. To create a new dashboard, click the + tab found at the right-hand side of the tabs menu. The Dashboard Editing page is displayed. To create a custom dashboard, drag widgets in the left pane to the right pane. This dashboard shown in the following figure uses five widgets in a two-column layout. This can be adjusted as needed.

Figure 18. Exchange Dashboard Editing Page

Some widgets must be configured before they can display data. For example, the generic scoreboard widget must be configured to poll the desired metrics. In the following figure, the widget is renamed as the EXCHANGE SCOREBOARD. The configuration includes a refresh interval of 50 seconds, a layout of 3 columns, and specification of the metrics and responses.

To edit the widget

1. Log into the custom user interface.
2. Click the tab for the dashboard that contains the widget to edit.
3. Click the Edit Widget icon on the widget's toolbar.
4. Configure the widget (example is shown in the following figure).
5.5.2 Example 1 – Exchange Overview Dashboard

The following example dashboard provides an overview of the Exchange environment. This dashboard shows the versatility of the metric graph widget to display multiple metric trends for a configurable period of time. The dashboard includes the following widgets:

- 1 x Generic Scoreboard – Gives administrators an easy-to-understand dashboard tool for displaying the metrics that matter most. Thresholds can be assigned to each metric, causing it to change colors to enhance help desk monitoring.

- 3 x Metric Graph (rolling view) – Allows administrators to predefine a set of metrics to monitor. Each metric graph widget is configured with a set of metrics to display and a delay time to switch between metric graphs. At the predefined interval, the widget cycles through each metric. In this dashboard a widget has been created for a specific compute resource (CPU, memory, and network), and monitored for each Exchange virtual machine in the environment.
The widgets comprising the dashboard are numbered 1 to 4.

- **Widget 1 – Generic Scoreboard – EXCHANGE SCOREBOARD.** The counters shown here are based on the previously defined super metrics:
  - **RPC OPS PER MIN** – Indicates how busy an Exchange server is. The number of observed operations depends on user and device activity. This value is the average across all the Exchange servers.
  - **RPC REQUEST (MAX)** – Shows the maximum value of the number of queue requests in any of the Exchange servers. A healthy server should have no more than 50 pending request. The Exchange Information Store service (store.exe) process has a hard limit of 100 RPC requests, after which it stops accepting requests.
  - **RPC AVG LATENCY** – Shows the time taken (average across all the Exchange servers) for the Exchange Information Store service (store.exe) to process a request. This metric should stay under 50ms. Higher values might result in negative end-user performance.
  - **SUB QUEUE LENGTH (AVG)** - Shows the average number of messages in submission queue length across all transport servers. A high number of messages in the queue indicates a higher number of messages being submitted for transport than the server can handle.
  - **SUB QUEUE LENGTH (MAX)** – Shows the maximum number of messages in the submission queue length across all transport servers in the environment.
  - **SUB QUEUE LENGTH (TOTAL)** – Shows the total number of messages in the submission queue length across all transport servers in the environment.
- Widgets 2,3,4 – Metric Graph (Rolling View) – EXCHANGE NETWORK USAGE, EXCHANGE CPU USAGE and EXCHANGE MEMORY USAGE

In these dashboards each of the metric graph widgets are configured to display metric data for each Exchange Server virtual machine. A separate widget has been created to focus on network, CPU and memory usage counters. At a configurable interval, the metric graph cycles through each virtual machine’s metric to display the data in the main window.

In the following figure, the Exchange Memory Usage widget is focused on the virtual machine BCA-EXCH02. The grey area indicates the range of memory utilization that vCenter Operations Manager has identified as normal for this virtual machine. This is called the dynamic threshold (or normal bound). The blue line is the actual memory utilization for that metric collection interval. The yellow region shows the metric is currently running outside its dynamic threshold. The orange dots indicate upper and lower bound memory utilization during the displayed period of time. The sample period on the graph is configurable. This example uses the default of six hours.

Figure 20. Metric Graph Rolling View of Exchange Memory Utilization

5.5.3 Example 2 – Exchange Details Dashboard

This section describes a dashboard that is useful for root cause analysis. The functionality shown in this dashboard allows all actions to occur on the same screen. This is possible by using widget interaction functionality, which allows widgets to be populated with data based on inputs from other widgets.

This dashboard uses the following widgets:

- The Health Tree – Provides an overview of the environment to provide quick health status of the application as a whole and each individual tier of the application using red, yellow, and green format. The tree hierarchy is based upon the Exchange 2010 application container that was created manually. You can drill into the tiers to see the health of the individual objects.

- Resource Selector – Displays the resources available to feed into another widget. In this dashboard, this widget is populated by a selection in the health tree and is used to populate the metric selector for displaying specific metrics.
- Metric Selector – Displays the metrics available from specific resources based on the resource selector and serves as the basis for populating the metric graph.

- Root Cause Ranking – Shows the metrics that have caused alerts to be triggered and allows an administrator to quickly look at the reason for the alert, such as a dynamic threshold violation.

- Metric Graph (explained previously).

The following figure shows the default starting point for the dashboard. In this example, the health tree displays the entire Exchange environment including the upstream parent objects, the application itself, and its downstream tiers. The resource selector shows all of the resources related to the application. The other three widgets depend on data provided by one of the first two widgets.

**Figure 21. Exchange Details Dashboard**
Select INTERACTIONS at the top of the dashboard to show the configuration of the widget interactions, which enables data to be shared among the widgets.

**Figure 22. Exchange Details Dashboard Widget Interactions**

To examine a specific tier within the Exchange application, double-click the mailbox tier in the health tree widget. Selecting the mailbox tier filters the resources displayed in the resource selector widget to the components of the mailbox tier. Each Exchange Server object being monitored is composed of many different resource kinds. For example, in this environment we have vFabric Hyperic and System Center Operations Manager data fed into vCenter Operations Manager. Both of these data sources create a resource, each with its own metrics available for evaluation and trending.

**Figure 23. Health Tree Selection to Populate Resource Selector**
Selecting a resource within the resource selector widget populates the metric selector. The metrics displayed are specific to the resource selected. In the following figure, the Exchange 2010 resource of the vFabric Hyperic object for BCA-EXCH04 has been selected. The metric selector displays all of the metrics for which vCenter Operations Manager has collected data.

**Figure 24. vFabric Hyperic Resource Displays Available Metrics**

From the metric selector widget an administrator can select metrics to begin populating the metric graph.

**Figure 25. vFabric Hyperic Metrics Populating the Metric Graph**

**Note** A red badge next to a metric means that the metric has been identified by an administrator as a *Key Performance Indicator*. KPIs can be configured using vCenter Operation Manager.
5.5.4 Exchange Metrics from SCOM

The examples so far show Exchange metrics that have originated from vFabric Hyperic. This section shows Exchange metrics that originate from SCOM and are available in vCenter Operations Manager through the SCOM adapter.

In the following figure, the SCOM resource object for BCA-EXCH04 is selected. The metric selector displays all of the metrics for which vCenter Operations Manager has collected data.

Figure 26. SCOM Resource Displays Available Metrics
Many of the same metrics available through vFabric Hyperic for Exchange are also available using SCOM. The following figure shows metrics from SCOM inside vCenter Operations Manager.

**Figure 27. SCOM Metrics Populating the Metric Graph**
6. **SQL Server**

This chapter covers the monitoring of SQL Server. SQL Server metrics can be obtained by vCenter Operations Manager by any of the following methods:

- **Adapter for Microsoft System Center Operations Manager (SCOM)** – SCOM has a SQL Server Management Pack that provides monitoring of Microsoft SQL Server 2005, SQL Server 2008, SQL Server 2008 R2, and SQL Server 2012. The adapter monitors SQL Server components such as database engine instances, databases, and SQL Server agents. The monitoring provided by this management pack includes availability and configuration monitoring, performance data collection, and default thresholds.

- **SQL Loader adapter** – This adapter uses select statements in SQL query files to retrieve data from source database tables. Microsoft has created Dynamic Management Views (DMVs) that contain all the SQL server performance metrics. The SQL Loader adapter can be used to query data from the DMVs. An example is shown in Appendix A: SQL Loader Adapter Configuration.

- **Adapter for vFabric Hyperic - SQL Server Plug-in** – vFabric Hyperic has a SQL Server plug-in that discovers and monitors SQL Server database metrics.

The SQL server monitoring example described in the following sections is based on metrics obtained from vFabric Hyperic.

### 6.1 Overview of SQL Server Metrics

The following table is a partial list of some useful SQL Server metrics. Some of these metrics are included in the example dashboard described in the next sections.

<table>
<thead>
<tr>
<th>Counter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQL Compilations rate</td>
<td>Number of times that Transact-SQL compilations occurred per second or minute (including recompiles). The lower the value the better.</td>
</tr>
<tr>
<td>SQL Re-Compilations rate</td>
<td>Number of times, per second or minute that Transact-SQL objects attempted to be executed but had to be recompiled before completion. This should be near zero as possible.</td>
</tr>
<tr>
<td>Total Server Memory (KB)</td>
<td>Shows the amount of memory that SQL Server is currently using. This value should grow until it is equal to target server memory as it populates its caches and loads pages into memory.</td>
</tr>
<tr>
<td>Lazy writes/sec or min</td>
<td>Monitors the number of times per second that the Lazy Writer process moves dirty pages from the buffer to disk as it frees up buffer space. Lower is better with zero being ideal. High values indicate a need for more memory.</td>
</tr>
<tr>
<td>Checkpoint pages/sec or min</td>
<td>Monitors the number of dirty pages per second that are flushed to disk when SQL Server invokes the checkpoint process. Checkpoint frequency is influenced by the recovery interval setting in sp_configure. High values for this counter might indicate insufficient memory or that the recovery interval is too high.</td>
</tr>
<tr>
<td>Counter</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Page life expectancy</td>
<td>Indicates how many seconds SQL Server expects a data page to stay in cache on average. A sudden drop in this value might indicate a potential shortage of memory.</td>
</tr>
<tr>
<td>Memory Grants Pending</td>
<td>Show the total number of processes per second waiting for a workspace memory grant. Numbers higher than 0 indicate a lack of memory.</td>
</tr>
<tr>
<td>Buffer Cache Hit Ratio</td>
<td>Monitors the percentage of data requests answered from the buffer cache since the last reboot. Pay attention if the value is regularly below 90.</td>
</tr>
<tr>
<td>Log Flush Wait Time</td>
<td>Shows the total wait time to write all transaction log pages, in milliseconds. Ideally should be near zero.</td>
</tr>
</tbody>
</table>

### 6.2 vFabric Hyperic SQL Server Plug-In

vFabric Hyperic provides extensive support for Windows technology and manages SQL Server databases through the native Windows performance management interfaces. This enables access to all the metrics that Microsoft SQL Server exposes for the database engine and the individual database instance deployed in the system.

vFabric Hyperic includes the following functionality:

1. Auto-discovers the virtual hosts and Microsoft SQL Server servers. The discovered databases are collected by the vCenter Operations vFabric Hyperic adapter from which resources are automatically created inside of vCenter Operations Manager.

2. Monitors a large number of SQL Server metrics. For a list, see *SQL Server Monitoring and Management* ([http://www.vFabric Hyperic.com/products/mssql-monitoring](http://www.vFabric Hyperic.com/products/mssql-monitoring)).

3. Table 5 lists some of the SQL Server counters that are available from vFabric Hyperic. If more counters are required use the SQL Loader adapter to extract data from the Microsoft DMVs.
The following figure depicts the architecture.

**Figure 28. vFabric Hyperic Adapter for SQL Server Metrics**
vFabric Hyperic discovers the SQL Server virtual machine guest OS. The following figure shows the vFabric Hyperic user interface with the components that vFabric Hyperic has discovered inside the virtual machine.

**Figure 29. vFabric Hyperic SQL Server Virtual Machine Details**
For the virtual machine in the figure, vFabric Hyperic has discovered the following resources:

- BC_SQL-ANALYT HQ Agent 5.0.0 – vFabric Hyperic agent running in the guest OS.
- BCA-SQLANALYT IIS 7.x – Windows Internet Information Services (IIS) web server.
- BCA-SQL-ANALYT IIS 7.x SQLANALYT IIS 7.x – Microsoft SQL Server database. Further examination of this resource reveals the SQL Server metrics discovered by vFabric Hyperic.
- BCA-SQL-ANALYT IIS 7.x-ANALYT mgmt.local – DNS name of the guest OS in the virtual machine. Further examination of this resource reveals the guest OS metrics.

Not all the SQL Server metrics are required for initial monitoring inside vCenter Operations Manager. The required counters must be explicitly selected in vFabric Hyperic for it to be collected by the vCenter Operations Manager adapter. The following figure shows a partial list of SQL Server counters that have been selected for monitoring.

**Figure 30 SQL Server Counters Selected for Monitoring**

![SQL Server Counters Selected for Monitoring](image-url)

- Resource name created in vCenter Operations Manager
- Click to view all SQL Server metrics and to select more counters if required
- Only the counters selected here appear in vCenter Operations Manager
vFabric Hyperic discovers the SQL Server database and generates the resource name **BCA-SQL-ANALYTIC MsSQL 2012 MSSQLSERVER BCA-ANALYTIC Ms SQL 2012**. The vFabric Hyperic Adapter collects this and creates a resource in vCenter Operations Manager with the same name. This resource can be viewed in the vCenter Operations Manager user interface.

To view the resource

1. Log onto the vCenter Operations Manager custom user interface in a web browser.
2. Select **Environment > Environment Overview**.
3. Select the SQL Server resource and click **Show Detail** to show the SQL Server metrics from vFabric Hyperic.
6.3 Create SQL Server Dashboard

This section describes an example dashboard for SQL Server.

To create a dashboard

1. Log in to the custom user interface in a web browser.
   
   The tabs near the top of the Home page are your dashboards. You can switch to a different dashboard by clicking its tab or selecting it from the Dashboards menu.

2. Click the plus (+) sign to the right of the last dashboard tab to enter the dashboard editor as shown in the following figure.

3. Drag widgets in the left pane to the right pane.
Each selected widget generates a separate pane in the final dashboard. The following widgets are selected for this example dashboard:

- **2 x Metric Graph** – Shows a graph of the recent and predicted future performance of a metric. It is possible to show multiple metrics in separate graphs or have them merged into a single graph for easier comparison.
- **1 x Metric Sparklines** – Shows simple graphs that contain the values of selected metrics over time and provides a quick view of the trends.
- **2 x Generic Scoreboard** – Shows the current value for each selected metric. Each metric appears in a separate box. The value of the metric determines the color of the box. You define the values for each color when you edit the widget.

After the widgets are selected and the dashboard is displayed you must edit the widget to assign the required metrics. You can customize a widget by editing its configuration options. Some widgets do not show data until you configure them. This is shown next for two of the widgets.

### 6.3.1 Configure Metric Graph Widget

**To assign metrics to one of the Metric Graph widgets**

1. Log into the custom user interface.
2. Click the tab for the dashboard that contains the widget to edit.
3. Click the **Edit Widget** icon on the widget's toolbar.

![Configure Metric Graph Widget](image.png)
6.3.2 Configure Generic Scoreboard Widget

To assign metrics to one of the Generic Scoreboard Widgets

1. Log into the custom user interface.
2. Click the tab for the dashboard that contains the widget to edit.
3. Click the **Edit Widget** icon on the widget's toolbar.

Each metric appears in a separate box. The value of the metric determines the color of the box. The threshold values shown here are only for example.
6.3.3 Final SQL Server Dashboard

The final SQL Server dashboard is shown below. In the following figure the dashboard is monitoring a SQL analytics workload. The workload has been consistently running for multiple days and can be regarded as a baseline. The workload is I/O read intensive.

**Figure 31. Final SQL Server Dashboard Under Normal Load**

The widgets comprising the above dashboard are numbered 1 to 5.

- **Widget 1 - Metric Sparklines – SQL COMPILATIONS/CHECKPOINTS**, includes the following counters:
  - SQL Compilations rate – Shows the number of Transact-SQL compilations occurred per second or minute (including recompiles). The lower this value the better. High values can be an indicator of excessive ad hoc querying.
  - SQL Re-Compilations rate – Shows the number times per second or minute that Transact-SQL objects attempted to be executed but had to be recompiled before completion. This number should be at or near zero, because recompiles can cause deadlocks and exclusive compile locks.
  - Checkpoint pages – Monitors the number of dirty pages per second or minute that are flushed to disk when SQL Server invokes the checkpoint process. High values for this counter might indicate insufficient memory or that the recovery interval is too high. The workload in this example is not write-heavy, so this counter is not high in the dashboard.

- **Widget 2 – Generic Scoreboard – SQL SERVER MEMORY**, includes the following counters:
  - Lazy writes/min – Monitors the number of times per second that the Lazy Writer process moves dirty pages from the buffer to disk as it frees up buffer space. Lower is better with zero being ideal. When high, this counter indicates a need for more memory.
Memory Grants Pending – Shows the number of processes per second waiting for a workspace memory grant. Numbers higher than 0 indicate a lack of memory.

Buffer Cache Hit Ratio – Monitors the percentage of data requests answered from the buffer cache since the last reboot. Pay attention if the value is regularly below 90.

Total Server Memory – Shows the amount of memory that SQL Server is currently using. This value should grow as it populates its caches and loads pages into memory. As vSphere memory reservations are recommended for business critical applications, this value can help to show how the memory is being used by the actual application.

- Widget 3 – Generic Scoreboard – GUEST OS MEMORY, includes the following counters:
  - Guest OS used memory – Indicates amount of OS memory being used. If vSphere memory reservations are set then we can infer that the VMware balloon driver will not be using any of this memory and memory is being utilized by the SQL Server application in the guest OS
  - Guest OS used swap – Indicates amount of swap space being used.

- Widget 4 – Metric Graph – “CPU(%) + GUEST ACTIVE MEM USAGE (%), includes the following counters:
  - vSphere CPU – Shows CPU usage for the SQL Server database virtual machine. The vSphere metric is more reliable than the CPU metric inside the guest OS. For a database, a consistently high value over 90% might result in poor response times for users.
  - vSphere Guest Active Memory – Shows the memory currently used by the virtual machine, according to the VMkernel. It is an estimate calculated by statistical sampling and should be treated as a starting point to monitor the memory consumption of SQL Server. The SQL server and guest OS memory usage counters (assuming no VMware ballooning) can provide more accurate indication of memory usage.

- Widget 5 – Metric Graph – I/O PERFORMANCE, includes the following counters:
  - SQL Server Log Flush Wait Time - Total wait time, in milliseconds, to write all transaction log pages. A log flush occurs when data is written from the log cache to the physical log file. Ideally this counter should be near zero.
  - vSphere disk command latency – Shows the vSphere I/O latency metric for the datastore. The workload in this example is I/O read intensive and has a latency of 30-40ms (the back-end storage in this scenario has not been tuned for optimum performance).
  - SQL Server Transactions Per Minute – Shows the number of SQL transactions. It is included here for correlation with the disk command latency.
To show how dashboard counters change, an additional abnormal workload is introduced. The workload is the cloning of another virtual machine in the same datastore in which the SQL Server virtual machine resides. The next figure shows the results.

**Figure 32. SQL Server Dashboard Under Abnormal Load**

The additional I/O intensive workload causes increased disk latency above the normal readings and lowers the SQL transaction rate and CPU utilization.
7. Oracle Database

The following sections cover monitoring of Oracle Database Server. Oracle Database server metrics can be obtained by vCenter Operations Manager by the following methods:

- Oracle Enterprise Manager (OEM) adapter – Collects data from Oracle Enterprise Manager database management tables.
- Adapter for vFabric Hyperic - Oracle Plug-in – Discovers and monitors Oracle metrics. vFabric Hyperic Oracle metrics can be used for basic administration but for detailed analysis, such as investigating Oracle wait events, the OEM adapter is required.

The Oracle Database monitoring example described in the following sections is based on metrics obtained from the Oracle Enterprise Manager and Hyperic adapters.

7.1 Overview of Oracle Enterprise Manager Adapter

The Oracle Enterprise Manager (OEM) collects data from OEM database management tables. The adapter is compatible with Oracle Enterprise Manager versions 10g, 11g and 12c.

The OEM adapter requires a JDBC connection to the OEM database. The connection has the following requirements:

- An Oracle JDBC port must be open on the firewall. The default port number 1521.
- A valid Oracle JDBC connection URL must be used. The default URL format is jdbc:oracle:thin:@<host>:1521:<SID>.
- Credentials must allow reading from the following OEM database management (SYSMAN) tables:
  - MGMT$TARGET
  - MGMT$METRIC_CURRENT
  - MGMT$AVAILABILITY_CURRENT
  - MGMT$METRIC_DETAILS
The following figure shows the lab environment for monitoring Oracle.

**Figure 33. Oracle Lab Environment**

![Oracle Lab Environment Diagram](image)

### 7.2 Oracle Database Server Metrics

The following table is a partial list of Oracle Database server metrics (mostly from the OEM adapter). Some of these metrics are used in the example dashboard described in the following sections.

**Table 6 Some OEM Adapter Database Server Counters (partial list)**

<table>
<thead>
<tr>
<th>Counter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network interface Collisions (%)</td>
<td>Monitors network interface collisions for a particular network interface.</td>
</tr>
<tr>
<td>Network interface Read (MB/s)</td>
<td>Monitors network interface Read in MB/s.</td>
</tr>
<tr>
<td>Network interface Write (MB/s)</td>
<td>Monitors network interface Write in MB/s.</td>
</tr>
<tr>
<td>Load Run Queue Length (5min Avg.)</td>
<td>Shows the 5 minute average for run queue length.</td>
</tr>
<tr>
<td>Wait Time (%)</td>
<td>This metric represents the percentage of time spent waiting, instance-wide, for resources or objects during this sample period.</td>
</tr>
<tr>
<td>Counter</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Load Memory Utilization (%)</td>
<td>Monitors memory utilization.</td>
</tr>
<tr>
<td>Load Swap Utilization (%)</td>
<td>Monitors swap utilization.</td>
</tr>
<tr>
<td>Listener – Connections Established (per Min.)</td>
<td>Represents the average number of connections per minute that were established with the listener.</td>
</tr>
<tr>
<td>Active Sessions Waiting : I/O</td>
<td>Represents the active sessions waiting for I/O (database level).</td>
</tr>
<tr>
<td>Database Time Spent Waiting (%)</td>
<td>Represents the percentage of time that database calls spent waiting for an event.</td>
</tr>
<tr>
<td>Average Users Waiting Count</td>
<td>Represents the average number of users that have made a call to the database and that are waiting for an event, such as an I/O or a lock request, to complete. If the number of users waiting on events increases, it indicates that more users are running, workload is increasing, or waits are taking longer (for example, when maximum I/O capacity is reached and I/O times increase).</td>
</tr>
<tr>
<td>Data Guard Status</td>
<td>Reports on the status of each database in the Data Guard configuration.</td>
</tr>
<tr>
<td>Library Cache Hit Ratio</td>
<td>Monitors the percentage of entries in the library cache that were parsed more than once (reloads) over the lifetime of the instance (this metric is collected from Hyperic in the following example).</td>
</tr>
</tbody>
</table>
You can see a detailed list of metrics at [http://docs.oracle.com/cd/E11857_01/em.111/b25986.pdf](http://docs.oracle.com/cd/E11857_01/em.111/b25986.pdf). The following figure shows the available metrics from Oracle Enterprise Manager. All of these metrics can be pulled in to vCenter Operations Manager through the OEM adapter.

**Figure 34. Oracle Enterprise Manager – All Metrics**

Note  Only metrics are available if you use database control. For the complete set of metrics you need Oracle Grid Control and the correct license.
7.3 Validating OEM Adapter

After the OEM adapter is installed and configured, you can verify that the Oracle resources are created and that metrics are collected through the adapter instance in vCenter Operations Manager.

To view the Oracle resource

1. Log in to the Custom user interface as an administrator.
2. Select Environment > Environment Overview.

![Image of vCenter Operations Manager interface showing Oracle resources and OEM Adapter instances.]

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3. Select the **PRD** resource and click **Show Detail** to show the Oracle metrics from the OEM adapter.

### 7.4 Creating Oracle Database Dashboard

This section describes an example dashboard for the Oracle Database.

**To create a dashboard**

1. Log in to the custom user interface in a web browser.
   
   The tabs near the top of the Home page are your dashboards. You can switch to a different dashboard by clicking its tab or selecting it from the Dashboards menu.

2. Click the plus (✚) sign to the right of the last dashboard tab to enter the dashboard editor as shown in the following figure.
3. Drag widgets in the left pane to the right pane.

Each selected widget generates a separate pane in the final dashboard. The following widgets are selected for this example dashboard:

- 1 x Heath Tree Graph – Shows the resource hierarchy of the Oracle application container construct (manually created using Environment > Application Overview).
- 1 x Metric Graph – Shows a graph of the recent performance and predicted future performance of a metric. It is possible to show multiple metrics in separate graphs or have them merged into a single graph for easier comparison.
- 3 x Metric Graph (Rollover View) – Allows administrators to predefine a set of metrics to monitor. Each metric graph widget is configured with a set of metrics to display and a delay for each metric to switch between metric graphs. At the predefined interval the widget cycles through each metric.
- 1 x Generic Scoreboard – Shows the current value for each selected metric. Each metric appears in a separate box. The value of the metric determines the color of the box. Define the values for each color when you edit the widget.

After the widgets are selected and the dashboard is displayed, edit the widgets to assign the required metrics. To customize a widget, change its configuration options. Some widgets do not show data until they are configured as described in the next section.
7.4.1 Configure Metric Graph (Rollover View) Widget

To assign metrics to a Metric Graph (Rollover View) widget

1. Log into the custom user interface.
2. Select the tab for the dashboard that contains the widget to edit.
3. Select **Edit Widget** icon in the widget's toolbar.

![Configure Metric Graph (Rollover View) Widget](image.png)
7.4.2 Configure Generic Scoreboard Widget

To assign a metric to a Generic Scoreboard widget

1. Log into the custom user interface.
2. Click the tab for the dashboard that contains the widget to edit.
3. Click **Edit Widget** on the widget's toolbar.

![Generic Scoreboard Widget Configuration](image)

- **Select resource**
- **Select metrics**
- **Specify ranges**

Selected metrics appear here.
7.4.3 Final Oracle Database Dashboard

The final Oracle Database dashboard is shown in the following figure.

Figure 35. Final Oracle Database Dashboard Example

The widgets comprising the above dashboard are numbered 1 to 6.

- **Widget 1 – HEALTH TREE.** Shows the health of various resources that Oracle Database depends on (choose individual tiers to see the health of the individual items):
  - Mgmt_bca_1 – Data Store, source vSphere adapter.
  - Hogwarts – Source OEM adapter (automatically discovered and created).
  - Bca-sap-oradb-linux – Source vSphere adapter.
  - Mgmt_BCA – Cluster name, source vSphere adapter.
  - PRD – Oracle Database Instance, source OEM adapter.

- **Widget 2 – Metric Graph (Rollover View) – ORACLE 10G DB MEMORY, includes the following counters:**
  - Used Memory – Indicates how much operating system memory is used. If vSphere memory reservations are set, the VMware balloon driver does not use any of this memory. The memory is used by the Oracle DB Server application in the guest OS.
  - Guest Configured Memory – Shows how much memory is configured for the virtual machine.
• Widget 3 – Metric Graph (Rollover View) – ORACLE 10G DB CPU, includes the following counters:
  o Load CPU in I/O wait – Shows the CPU time in I/O wait.
  o Run Queue Length (5 min. Avg.) – Time spent on run queue 5 minute average.
  o CPU Usage (%) – CPU utilization of the database virtual machine.

• Widget 4 – Generic Score board – ORACLE 10G GOS MEMORY, includes the following counters:
  o Swap Utilization (%) – Shows how much swap space is used. This value should be zero.
  o Cache Hit Ratio – Monitors the Oracle library cache hit ratio. This measures the percentage of times the fully parsed SQL statements are already in memory. A low library cache hit ratio can result in additional parsing, which decreases performance and increases CPU consumption.
  o Memory Utilized – Shows the amount of memory that the Oracle DB server is currently using. As vSphere memory reservations are recommended for business critical applications, this value can help to show how the memory is being used by the actual application.
  o Total Server Memory – Shows the amount of memory configured for the virtual machine.

• Widget 5 – Metric Graph (Rollover View) – ORACLE 10G DB PHYSICAL I/O, includes the following counters:
  o Physical Read per Minute – Indicates the number of data blocks read from disk per minute during this sample period.
  o Physical Writes per Minute – Indicates the number of data blocks written from disk per minute during this sample period.

• Widget 6 – Metric Graph (Rollover View) – ORACLE 10G DB NETWORK, includes the following counters:
  o Network interface collisions (%) – Shows the collision in percent for a particular network interface.
  o Network interface read (Mb/s) – Shows the reads in Mb/s for a particular network interface.
  o Network interface write (Mb/s) – Shows the writes in Mb/s for a particular network interface.
8. SAP

The SAP business suite of applications supports business processes that can be business and mission critical. Because disruption of such business processes can lead to loss of revenue, monitoring is a key component of SAP deployments. Some of SAP performance counters are directly used in defining business level SLAs. A common SAP architecture is multtier, comprising application, database, and central services tiers (the latter manages SAP transaction lock management and messaging). SAP monitoring requires visibility into all these levels. The next sections show how this can be achieved in the virtual environment.

The following adapters are required to provide a comprehensive monitoring solution for SAP:

- SAP adapter – Obtains SAP application level metrics.
- The OEM/SQL Loader/SCOM/vFabric Hyperic adapters – Provides detailed monitoring of the SAP database.
- vFabric Hyperic Adapter – Provides access to all guest OS level metrics.

The following figure shows the SAP setup used in the examples.

**Figure 36. SAP Lab Setup**
8.1 SAP Computer Center Management System

SAP has a monitoring component called Computer Center Management System (CCMS), which provides a range of monitors for monitoring SAP environments. These monitors include performance counters for understanding and evaluating the behavior of the SAP processing environment. If performance values are poor, the monitors provide information to fine-tune the SAP system.

The performance data in CCMS can be accessed by SAP administrators through the SAP client (SAP GUI). The CCMS monitors are available in SAP transaction code RZ20. The following figure shows RZ20 and some performance counters.

Figure 37. Screenshot of SAP CCMS

For an explanation of SAP performance counters, see SAP CCMS Monitor Templates Monitor Set (http://help.sap.com/saphelp_nw73/helpdata/en/d4/0c823bd26a5c42e10000000a114084/content.htm).

The vCenter Operations Manager SAP adapter extracts all of the SAP CCMS counters. Some of the counters are covered in this document only as examples and are documented in the following table. SAP consultants and administrators should make the final choice as to which SAP performance counters need to be monitored within dashboards.
Table 7. Some Useful SAP Counters (from CCMS Adapter)

<table>
<thead>
<tr>
<th>Counter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialog Response Time</td>
<td>Period of time from the request of the dialog to the dispatcher through processing to the end of the dialog in the dispatcher and the transfer of the data to the presentation layer.</td>
</tr>
<tr>
<td>Database Request Time</td>
<td>Average time for processing logical database requests (calls to the SAP database interface).</td>
</tr>
<tr>
<td>Background Utilization</td>
<td>Percentage of the background processing capacity currently utilized. The value is averaged over the background work processes and, by default, averaged over the last hour.</td>
</tr>
<tr>
<td>Users Logged On</td>
<td>Number of users logged in to an application server or dialog instance.</td>
</tr>
<tr>
<td>Extended Memory utilization</td>
<td>Percentage usage of extended memory. Extended memory contains the largest part of the user context. The page management of this memory is performed not by the operating system, but directly by the SAP system.</td>
</tr>
<tr>
<td>Heap Memory Utilization</td>
<td>Percentage usage of private memory. A work process is only assigned private memory if the roll area and extended memory are occupied. The work process is then reserved for the current user context until the end of the transaction.</td>
</tr>
</tbody>
</table>

8.2 Connecting to SAP

The vCenter Operations Manager SAP adapter uses SAP Business Application Programming Interface (BAPI) calls to collect metrics from SAP CCMS. BAPIs are the SAP defined standard APIs to extract information from SAP systems. The following diagram provides an overview of how the adapter connects and extracts data from SAP.
The SAP Java Connector (SAP JCo) is used by vCenter Operations Manager. JCo is a middleware component that enables the development of SAP-compatible components and applications in Java. SAP JCo supports communication with the SAP Server—it allows the Java code to call ABAP-based BAPIs which in turn extract data from the SAP CCMS component.

After the SAP Adapter is installed and configured, you can view the SAP metrics inside vCenter Operations Manager.

To view SAP metrics

1. Select Environment > Environment Overview.
2. Select the SAP Resource and click **Show Detail** to display the SAP metrics from CCMS.

The preceding figure shows the SAP metrics in the same menu hierarchy that can be seen inside SAP transaction RZ20.
8.3 SAP Application Container

The SAP system for the example dashboard consists of a database, SAP Central Services, and an application server installed separately in the following virtual machines:

- bca-SAP_Oradb_linux – Runs the SAP Oracle database.
- bca-SAP_ascs_linux – Runs the SAP Central Services Instance. Central Services include messaging (manages client connections and communications) and enqueue (SAP lock management) services.
- bca-SAP_app_linux – Runs the SAP Primary Application Server Instance and a second dialog Instance (both are referred to as dialog instances).

This multitier architecture can be described in a vCenter Operations Manager application container.

8.3.1 Configure Application Container

An application is a type of vCenter Operations Manager container resource that can have multiple hierarchies. The application resource contains one or more tiers, and each tier contains one or more resources. In a multitier SAP deployment, the application tier constructs correspond to the different tiers of the SAP architecture.

The application container is used to capture the single SAP system consisting of the three previously mentioned virtual machines. The example has the following tiers:

- Database tier for the database virtual machine.
- Central Services tier for the Central Services virtual machine.
- Application tier for the SAP dialog server virtual machines.

8.3.2 Create an Application Container for a Single SAP System

To create or view vCenter Operations Manager application containers

1. Log in to vCenter Operations Manager Enterprise as an administrator.
2. Select Environment > Applications Overview.
3. Select Edit Application.
In the user interface, multiple resources are assigned to each tier as follows:

- **Application Server (SAP PRD) resources:**
  - Virtual machine running the primary SAP application server instance and a second dialog instance (bca-sap-app-linux).
  - The Linux guest OS (discovered by vFabric Hyperic – BCA-SAP-APP-linux.mgmt.local).
  - The SAP resource from the SAP adapter (PRD – 10.140.44.22).
  - The vFabric Hyperic agent (BCA-SAP-APP-linux HQ Agent 5.0.0).

- **Central Services (SAP PRD) resources:**
  - Virtual machine running Central Services (bca-sap-ascs-linux).
  - The Linux guest OS (discovered by vFabric Hyperic – BCA-SAP-ASCS-linux.mgmt.local).
  - The vFabric Hyperic agent (BCA-SAP-ASCS-linux HQ Agent 5.0.0).

- **Database (SAP PRD) resources:**
  - Virtual machine running the database (bca-sap-oradb-linux).
  - The Linux guest OS (discovered by vFabric Hyperic - BCA-SAP-ORADB-linux.mgmt.local).
  - The vFabric Hyperic agent (BCA-SAP-ORADB-linux HQ Agent 5.0.0).
  - The Oracle resource from the OEM adapter (PRD).

Resources are assigned that are relevant to monitor the SAP application from the application down to the vSphere level. This application container configuration defines a resource hierarchy that we can access for root-cause analysis.

After the application container is defined, you can view it by selecting **Environment > Applications Overview > SAP System (PRD)**. The health tree that is displayed shows the tiers of the application container created for the SAP system. Move down the application hierarchy to examine components such as the Database tier.

**Figure 39. SAP Application Container Overview**
Double-click **Database (SAP PRD)** to display the resources that were added database tier during the configuration of this application container. Double-click a specific resource to view additional details.

**Figure 40. SAP Database Tier Health tree**

---

### 8.4 Determine Key Metrics and Monitoring Requirements for SAP

Appendix B: Define SAP KPIs and Super Metrics, shows how to configure thresholds and monitoring criteria for SAP in vCenter Operations Manager. The following is an example list of criteria (final determination depends on specific customer requirements):

- Create an alert if any application server virtual machine exceeds 90% CPU.
- Create an alert if the dialog response time of any application server exceeds 1000ms (chosen because certified SAP OLTP benchmarks are based on one second response time).
- Create an alert if Central Services virtual machine exceeds 50% CPU (this is a SAP single-point-of-failure and configured with 1 x vCPU so it can be protected with VMware FT).
- Create an alert if the database server virtual machine is higher than 65% CPU (this is a SAP single-point-of-failure and this value is chosen because SAP sizing is typically done at this utilization level).
- Create an alert if the database server virtual machine storage latency exceeds a certain threshold. This alert can use thresholds that are already preconfigured by VMware in the vSphere adapter attributes.
- Create a super metric that corresponds to the total number of users logged onto the SAP system. In this example, the SAP metrics provide the user count by application server instance, so it is necessary to sum the values across all the application server instances to obtain the total. (In other SAP releases or different setups of CCMS, if the total user value is available directly from CCMS then this super metric is not required.)
A super metric is based on multiple individual metrics and is useful when a single metric cannot provide needed information on the behavior of the system. For all the previously mentioned alert criteria (which is based on the thresholds of a single attribute), the following actions are done in vCenter Operations Manager:

- Create a custom attribute package.
- Select the required attributes as a key indicator/KPI.
- Assign the threshold values.
- Assign the custom attribute package to the relevant virtual machine or SAP resource.

The total user criterion requires a super metric. This super metric is assigned to the Application Server (SAP PRD) application container tier.

Detailed steps are presented in Appendix B: Define SAP KPIs and Super Metrics. After defining the super metric, you can view it as a counter in vCenter Operations Manager. For example, to verify that the super metric is available in the application tier of the application container construct, select Environment > Applications Overview, and then select the SAP application container SAP System (PRD).

**Figure 41. Verify Total Users Super Metric is Working**

8.5 Create SAP Dashboard

This section describes an example dashboard for the SAP system.

**To create a dashboard**

1. Log in to the custom user interface in a web browser. The tabs near the top of the Home page are your dashboards. You can switch to a different dashboard by clicking its tab or selecting it from the Dashboards menu.

2. Click the plus (+) sign to the right of the last dashboard tab to enter the dashboard editor as shown in the following figure.
3. Drag widgets in the left pane to the right pane.

Each selected widget generates a separate pane in the final dashboard. The following widgets are selected for this example dashboard:

- **2 x Metric Graph** – Shows a graph of the recent predicted future performance of a metric. You can show multiple metrics in separate graphs or have them merged into a single graph for easier comparison.

- **1 x Application Detail** – Shows information for a selected application container. The top of the widget shows the number of tiers, resources, and metrics that the application contains and the number of alerts on the application. The Application Detail widget does not show information for child resources. For each tier in the application, the Application Detail widget shows the icons for the health of each resource in that tier, the tier name, the metric sparkline for the last 24 hours, the tier's current health score, and the number of active alerts for the tier itself. All this detail automatically appears in the dashboard when the application container is selected in the widget.

- **1 x Generic Scoreboard** – Shows the current value for each selected metric. Each metric is shown in a separate box. The value of the metric determines the color of the box. You define the values for each color when you edit the widget.

After the widgets are selected and the dashboard is displayed, you must edit the widget to assign the required metrics. Customize a widget by editing its configuration options. Some widgets do not show data until you configure them. This is shown in the next sections for two of the widgets.
8.5.1 Configure Metric Graph Widget

To assign metrics to one of the Metric Graph widgets, log into the custom user interface, click the tab for the dashboard that contains the widget to edit, and click the Edit Widget icon on the widget’s toolbar. The following figure shows how to configure the widget on the Edit Widget screen.

Figure 42. SAP Dashboard Configure Metric Graph Widget
8.5.2 Configure Generic Scoreboard Widget

To assign metrics to one of the Generic Scoreboard widget, log into the custom user interface, click the tab for the dashboard that contains the widget to edit, and click the Edit Widget icon on the widget’s toolbar. The following figure shows how to configure the widget on the Edit Widget screen.

Figure 43. SAP Dashboard Configure Generic Scoreboard Widget
8.5.3 Final SAP Dashboard

The final SAP dashboard is shown in the next figure. The dashboard is monitoring a custom workload that runs periodically. The workload has been consistently running for multiple days and can be regarded as a baseline.

Figure 44. SAP Dashboard with Baseline Workload

The widgets comprising the dashboard are numbered 1 to 4.

- **Widget 1 – APPLICATION DETAIL**
  Shows information for the SAP PRD application container. The top of the widget shows the number of tiers, resources, and metrics that the application contains and the number of alerts on the application. Each resource that was assigned to the tier appears as a separate tile (small square). By passing the cursor over the tiles you can see the name of the resource and view details, for example, see more information about an application server virtual machine. In this scenario there is one application server virtual machine. A large SAP system would have many more, and more tiles would be displayed.

- **Widget 2 – GENERIC SCOREBOARD**, includes the following counters:
  - **Dialog Instance 00 and 01 Response Time** – Shows the response time of the first and second dialog instance. The online response time can be used as a SLA measurement for SAP systems so is an important metric to observe.
  - **Dialog Instance 00 and 01 Database Response times** – SAP performance statistics can provide a breakdown of the online response time and can separate out the database component of the overall response time. This is useful to assess the health of the database. A bottleneck in the database causes this counter to rise.
  - **Total Users** – Shows the total number of users logged on the SAP system across all the dialog instances. This is a super metric that was created with a formula equal to the sum of the logged on users of each dialog instance.
  - **Batch Utilization** - an SAP application instance consists of multiple parallel processes called work processes. Some of these processes can be assigned to run background or batch tasks.

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batch utilization counter specifies the percentage of these processes that are busy running batch tasks. A high percent indicates a large batch workload that could lead to high CPU or I/O usage (depending on what the batch task is designed to do). Also it could mean that more batch processes need to be configured.

- **Widget 3 – Metric Graph – DB AND CENTRAL SERVICES CPU**, includes the following counters:
  - Database virtual machine vSphere CPU usage.
  - Central Services virtual machine vSphere CPU usage.

  These two components are single points of failure in the SAP system, so very high CPU utilization is not desirable. Central Services virtual machine can be configured with 1 x vCPU so it can be protected with VMware FT. The messaging and locking functions do not consume much CPU. CPU utilization should not be consistently high.

- **Widget 4 – Metric Graph – DB I/O LATENCY**, includes the following counter:

  vSphere read and write command latency for the database virtual machine datastores. SAP workloads can be I/O intensive so this is a useful metric to observe. Merging the SAP and vSphere counters in the same dashboard allows observation of how a possible I/O bottleneck that drives up the I/O latency values can affect the database response time as measured by SAP.

The following figure shows the result with a temporary extra workload executed in addition to the baseline workload to observe how the dashboard changed.

**Figure 45 SAP Dashboard with "Abnormal" Workload**

In the example, the introduction of the extra stress above the normal workload raised some alerts and tiles in the application detail widget have changed from green to yellow. The dialog and database response times have increased in one application server instance (the other is relatively idle) and the total users have increased. It could be that users are not evenly balanced across the two application server instances. Although this is not a serious issue (SAP response times are well within thresholds) an SAP administrator might want to investigate further.

In the Application Detail widget you can double-click to display the application container hierarchy, which is presented as a health tree and provides access to view more metrics.
9. Summary

The following list includes guidelines and best practices:

- The monitoring strategy for business critical applications on vSphere should involve a joint approach between the VMware and application administrators.
- Application administrators should be familiar with key vSphere counters, including percent usage, percent ready, memory reservations, virtual disk latency, and network packets lost.
- The dashboards shown here should be treated as examples only. They incorporate some of the application counters, but actual implementations will vary and the specific set of counters will be based on customer-specific requirements. The Exchange, database, and SAP administrators should make the final selection of application counters to be used in dashboards.
- If SCOM or OEM has been established as the standard in the datacenter, use the appropriate vCenter Operations Manager adapter.
- For database monitoring, you can use the SQL Loader adapter to supplement the metrics from the other adapters, as the SQL Loader adapter allows any counter to be obtained directly from database management system tables.
- If no preference has been made for SCOM or OEM by the application owners, use vFabric Hyperic. vFabric Hyperic provides a relatively easy way to view multiple applications (SAP is the exception) and needs minimal-to-no involvement from BCA administrators to install and configure.
  - vFabric Hyperic has plug-ins to monitor Exchange, SQL Server, Oracle, other databases, middleware, messaging systems, and JAVA based processes. More in-depth analysis may require the native monitoring tools of the respective applications or installation of the respective BCA adapter.
  - vFabric Hyperic can provide a homogeneous view of all the guest OS metrics in an environment that has both Linux and Windows systems.
- The SAP, OEM and SCOM adapters include guest OS counters which an application administrator might prefer to use.
- Metrics from vFabric Hyperic must be explicitly selected so they can be collected by the vCenter Operations Manager vFabric Hyperic adapter. The vFabric Hyperic SQL Server and Exchange plug-ins provide numerous counters. Select only the ones that are applicable, as some might not be relevant for initial capture.
- Adapter installation and configuration generates multiple resource kinds and resources within vCenter Operations Manager. The resource is the entity that collects metrics for display in graphs and dashboards (such as an SAP system, individual database, or virtual machine). Many of the resources are automatically generated by discovery processes in the adapter and are allocated a name based on the hostname or DNS name or virtual machine name (any non-standard hostnames and virtual machine names that do not follow pre-defined datacenter naming conventions appear inside vCenter Operations Manager).
- Create a dashboard to quickly view resource metrics based on the Resources, Metric Selector, and Metric Graph widgets. Configure widget interactions to allow metrics selected from one widget to pass over to another.
- The scoreboard widget provides an efficient way to present a summary of key application metrics in a color-coded fashion based on specified thresholds. You can associate this with a Metric Graph widget by configuring a widget interaction so that a double-click on a scoreboard counter produces a time
graph of that counter in the metric graph widget. This is a useful tool to quickly view history if the
counter value is in violation of a threshold.

- Create application containers to model a multtier application like SAP and Exchange. This container
  provides an overview from a single application perspective. Similarly, DBAs can create application
  containers that provide a view only into databases (they might not be responsible for application or
  web servers). You can allocate resources to the tiers based on what components and metrics need to
  be monitored.

Application containers can be assigned to health tree widgets to provide a hierarchical view into the
environment to facilitate top-down root cause analysis. Start at the top of the health tree hierarchy,
then move to the lower tiers and finally to the assigned resources that show the metrics. Any
threshold violation of a metric at the bottom of the hierarchy is rolled up the tree so it can be viewed
as an exception at the higher level. This can help direct the investigation when examining from the
top. For example, if you get alerts for an unhealthy application or an unhealthy application server tier,
you can examine the application server tier to see the offending component and the virtual machine
and service.

- For KPIs that require hardcoded thresholds and involve a single attribute, create a custom attribute
  package and assign it to the resource.

- For a KPI that is based on multiple metrics, create a super metric. This allows you, for example, to
  create averages for a metric that applies to multiple components in a scaled-out application (which
  has been defined in an application container construct). An example is average response times of
  multiple application servers. This means that you do not need to change the super metric if you add
  more application servers. vCenter Operations Manager automatically finds the metric defined in the
  super metric across all the relevant resources (as long as the resources have been correctly assigned
to the application container).
10. References

- VMware vFabric TM vFabric Hyperic Plug-ins
- VMware vFabric vFabric Hyperic Documentation
- VMware vCenter Operations Manager Documentation
  https://www.vmware.com/support/pubs/vcops-pubs.html
- VMware vCenter Operations Manager Adapter Guide
- VMware vCenter Operations Enterprise Installation and Administration Guide
- VMware vCenter Operations Manager Getting Started Guide

11. Acknowledgements

The following VMware staff were involved in creating this document:

- Vas Mitra (main author)
- Alex Fontana (Exchange chapter)
- Kannan Mani (Oracle chapter)

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Appendix A: SQL Loader Adapter Configuration

The SQL Loader adapter uses select statements in SQL query files to retrieve data from source database tables. This appendix describes an example installation and configuration of the SQL Loader adapter used to collect performance metrics from the SQL Server system view table `sys.dm_os_performance_counters`. Microsoft has created Dynamic Management Views (DMVs) that can be accessed through Transact-SQL statements to return server state information that can be used to monitor the health of a server instance, diagnose problems, and tune performance. For more background, see [http://msdn.microsoft.com/en-us/library/ms188754.aspx](http://msdn.microsoft.com/en-us/library/ms188754.aspx). For example, `sys.dm_os_performance_counters` provides different SQL server performance metrics.


The remainder of this appendix describes the tasks to configure the SQL Loader adapter.

Install SQL Loader Adapter

Install the SQL Loader adapter according to the instructions in the *SQL Loader Adapter Installation and Configuration Guide*. This creates the following folder in the analytics virtual machine:

```
/usr/lib/vmware-vcops/user/plugins/inbound/general_sql_adapter3/
```

Create Database Query File and Properties File


Contents of the file are as follows:

```sql
SELECT 'SQL LOADER' ADAPTERKIND, 'SQL Server PERFMON STATS' RESOURCEKIND, GETUTCDATE() TIMESTAMP, 'Agent' RESOURCEKIND, 'BCA-SQL-ANALYTISQLSERVER' RESOURCENAME, replace([object_name], ':', ' ')+ '|' + counter_name METRICNAME1, cntr_value VALUE1
FROM sys.dm_os_performance_counters
WHERE (GETUTCDATE() >= %f) AND ('1/1/2000' < %t) AND counter_name in (
    'User Connections', 'SQL Compilations/sec', 'SQL Re-Compilations/sec', 'Target Server Memory (KB)', 'Total Server Memory (KB')
```

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'Lazy writes/sec',
'Checkpoint pages/sec',
'Page life expectancy',
'Memory Grants Pending',
'Page IO latch waits',
'Wait for worker',
'Log write waits',
'Network IO waits'
)
ORDER BY
   TIMESTAMP

You can tune the adapter operation by modifying properties in the instance-level properties file. Create the following file in the Analytics virtual machine: /usr/lib/vmware-vcops/user/plugins/inbound/general_sql_adapter3/work/db_query_bca-sql-analyti.properties.

START_TIME = 03/07/2013 15:44
MAX_MIN_WAIT_FOR_DATA = 15
DB_QUERY_FILTER_DATE_FORMAT = yyyy-MM-dd HH:mm:ss
PROCESS_RELATIONSHIPS = false
MSSQL_WINDOWS_AUTHENTICATION = false
EVENT_PROCESSOR = false
EVENT_MANAGED_EXTERNALLY = false

These properties are documented in the SQL Loader Adapter Installation and Configuration Guide. The property MSSQL_WINDOWS_AUTHENTICATION = false defines how SQL Loader logs in to the source database. The example uses SQL authorization with a database user ID and password instead of Windows OS authentication.
Create Credential and Adapter Instance

Create a credential that specifies a user name and password to connect to the source SQL Server database.

1. Log in to the Custom user interface as an administrator.
2. Select Environment > Configuration > Credentials.
3. Select General Sql Data Loader from the Adapter Kind drop-down menu.
4. Select the credential kind from the Credential kind drop-down menu.
5. At the top of the list of credentials, next to Action, click Add. Enter a user name and password as shown in the following figure.

![Add Credential](image)

This example uses the SQL Server default system administrator account (sa) to log in into SQL server, as this account has all the system privileges. In customer environments, follow the security best practices of the SQL Server DBA. The DBA might have deactivated the sa account and can supply another account to log in to SQL server.

To create the SQL Adapter instance

1. Log in to the Custom user interface as an administrator.
2. Select Environment > Configuration > Adapter Instances.
3. Select the collector vCenter Operations Server from the Collector drop-down menu.
4. Select General Sql Data Loader from the Adapter Kind drop-down menu.
5. Click the Add New Adapter Instance icon and enter fields as shown in the following figure.
6. Click OK to save your configuration.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector</td>
<td>vCenter Operations Standard Server</td>
</tr>
<tr>
<td>Adapter Kind</td>
<td>General SQL Data Loader</td>
</tr>
<tr>
<td>Adapter Instance Name</td>
<td>SQL Server SQL Loader Adapter</td>
</tr>
<tr>
<td>DB Type</td>
<td>MsSql</td>
</tr>
<tr>
<td>Host</td>
<td>10.140.44.30</td>
</tr>
<tr>
<td>Port</td>
<td>1433</td>
</tr>
<tr>
<td>DB Name</td>
<td>master</td>
</tr>
<tr>
<td>Additional URL Field</td>
<td></td>
</tr>
<tr>
<td>Date Format</td>
<td>yyyy-MM-dd HH:mm:ss</td>
</tr>
<tr>
<td>Date Type</td>
<td>DATETIME</td>
</tr>
<tr>
<td>Timezone</td>
<td>America/Los_Angeles</td>
</tr>
<tr>
<td>Sql file</td>
<td>db_query_bca-sql-analyti.sql</td>
</tr>
<tr>
<td>Properties file</td>
<td>db_query_bca-sql-analyti.properties</td>
</tr>
<tr>
<td>Use default values</td>
<td>false</td>
</tr>
<tr>
<td>Use zero as all metrics default value</td>
<td>false</td>
</tr>
<tr>
<td>Autodiscovery</td>
<td>true</td>
</tr>
<tr>
<td>Credential</td>
<td>SQL Loader Adapter Credentials</td>
</tr>
</tbody>
</table>
View Metrics in Custom UI

You can now view the metrics in the custom user interface in the Environment overview section, as shown in the following figure.

The following figure shows the counters specified in the query file.
Appendix B: Define SAP KPIs and Super Metrics

This Appendix describes how to configure the following thresholds in vCenter Operations Manager for the SAP system:

- Create an alert if any application server virtual machine exceeds 90% CPU.
- Create an alert if the dialog response time of any application server exceeds 1000ms.
- Create an alert if Central Services virtual machine exceeds 50% CPU (this is an SAP single-point-of-failure and is configured with 1 x vCPU so it can be protected with VMware vSphere Fault Tolerance).
- Create an alert if the database server virtual machine goes above 65% CPU (this is a SAP single-point-of-failure and is used as SAP sizing is typically conducted at this CPU usage level).
- Create an alert if the database server virtual machine storage latency exceeds a certain threshold. It uses thresholds that are already preconfigured by VMware in the vSphere adapter attributes.
- Create a super metric that corresponds to the total number of users logged in to the SAP system. In this example, the SAP metrics provide the user count by application server instance, so you can sum the values across all the application server instances to obtain a total.

A super metric is based on multiple individual metrics and is useful when a single metric cannot provide the needed information about the behavior of your system. The following steps in vCenter Operations Manager are required for all the criteria (except the total users criteria) which are based on hard thresholds of a single attribute:

- Create a custom attribute package.
- Select the required attributes as a KPI.
- Assign the threshold values.
- Assign the custom attribute package to the relevant virtual machine or SAP resource.

The total user criterion requires a super metric, as it involves a calculation consisting of multiple metrics. This super metric is assigned to the application container tier Application Server (SAP PRD).

Create CPU Utilization KPIs for Database, Central Services, and Application Server

This section provides information to configure the following:

- Create an alert if any application server virtual machine exceeds 90% CPU.
- Create an alert if the dialog response time of any application server exceeds 1000ms.
- Create an alert/notification if Central Services virtual machine exceeds 50% CPU.
To clone the All Attributes package

1. Log in to vCenter Operations Manager Enterprise as an administrator.
2. Select **Environment > Configuration > Attribute Packages**.

The All Attributes package is cloned to produce a separate package for the application, Central Services and database servers.
To edit each package and configure the required metric as a key indicator

1. Select SAP Production App Servers to edit.
2. Specify the thresholds under the Advanced Configuration section.
3. Select Violation of the hard threshold is a Key Indicator.
To assign a custom attribute for the SAP application servers to all the SAP application virtual machines (in this example there is one)

1. Select **Environment > Environment Overview**.
2. Search and select the SAP application server virtual machine **bcasap-app-linux > edit resource**.

Repeat the steps in this section for the Central Services and database server virtual machine.
Configure Storage Latency Alert

For the database storage latency, the KPI is already specified in the default All Attributes package, which was cloned and assigned to the virtual machines (it has already been set by VMware).
Create Dialog Response Time KPI

This section shows how to configure an alert if the dialog response time exceeds 1000ms. The dialog response time KPI in the SAP all attributes package is defined (created when the SAP adapter was installed).

To configure the alert
1. Select Environment > Configuration > Attribute Packages.
2. Select SAP all attributes > Edit.
3. Specify the thresholds in the Advanced Configuration section.
4. Select Violation of the hard threshold is a Key Indicator.

To assign the SAP all attributes package to the SAP resource for this particular SAP system
1. Select Environment > Environment Overview.
2. Search for and select the SAP Resource PRD – 10.140.44.22 > edit resource.
3. Select SAP all attributes for the Attribute package field.
Create a Super Metric for Total SAP Users

This section shows how to do the following:

- Create a super metric for total users (based on the sum of logged on users for each dialog instance).
- Create a super metric package for total users and assign the above super metric to this package.
- Assign the total user super metric package to the application container Application Server (SAP PRD).

This example does not set any thresholds for the total user super metric. Instead, it is used directly for displaying in the final dashboard.

To create the super metric

1. Select Environment > Advanced > Super Metrics > Super Metric Editor.
2. Select Add New Super Metric.
3. Enter formula here: 
   \[(\text{Users for sapapp1_PRD_00}) + (\text{Users for sapapp1_PRD_01})\]
5. Select Add New Attribute Package.
6. Select the total users super metric.

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To assign a super metric package to the SAP application container, application tier

1. Select Environment > Environment Overview.

2. Search and select the Application container tier resource Application Server (SAP PRD) > edit resource.


To verify that the super metric is available in the database tier of the application container

1. Select Environment > Applications Overview.

2. Select the SAP application container SAP System (PRD).