



89 Fifth Avenue, 7th Floor  
New York, NY 10003  
[www.TheEdison.com](http://www.TheEdison.com)  
212.367.7400



## White Paper

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### **IBM PowerHA SystemMirror**

### **IBM PowerHA SystemMirror 7.1 — The Value of Deep Integration**



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Produced by: Craig Norris, Lead Analyst; Barry Cohen, Editor-in-Chief

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## Executive Summary

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High availability (HA) server clustering is an increasingly common strategy used to ensure the resilience of mission-critical business systems and the continuous availability of IT resources. Infrastructure hardware provides much of the redundancy characteristic of HA solutions; however, software is what orchestrates the solution and provides the monitoring, intercommunications, problem detection, and actions — such as failover — necessary in an HA clustering solution.

Almost without exception, organizations of even modest size have a mix of operating system platforms in their data centers. For this reason, those considering HA clustering solutions frequently turn to software products that claim the ability to manage clustering on multiple platforms. This seems logical and has business value, as well, because having a single interface to manage heterogeneous clusters reduces the learning curve for administrators.

However, multi-platform HA clustering solutions carry significant tradeoffs in functionality and capabilities compared with solutions designed for a specific platform. This is because such platform-specific HA clustering solutions tend to offer much deeper integration with the given operating system than any multi-platform solution could ever hope to offer. Such deep integration delivers considerable benefits and enables functionality beyond the reach of any multi-platform product.

Version 7.1 of IBM PowerHA SystemMirror for AIX takes clustering technology to a new level, moving cluster monitoring and event management functionality into the kernel of the cluster-aware AIX operating system. This makes for a much more robust, efficient operation, as well as greater end-to-end automation, reducing administration costs and complexity. Since the product acts as an extension of the operating system, operators familiar with AIX actually have a less steep learning curve than those having to learn an entirely new third party application.

IBM PowerHA SystemMirror also features a Director-based GUI management console that gives AIX users options that can increase productivity by extending the enterprise management system to HA clustering. It also reduces the learning curve for users accustomed to cluster management through graphical interfaces, as well as for those coming from other UNIX-like platforms.

Much of the clustering technology leveraged by PowerHA SystemMirror 7.1 is actually part of the operating system, providing for a considerably seamless solution that blends OS capabilities with high availability management. Compare this with a commonly used

multi-platform HA clustering solution: Symantec Veritas Cluster Server (VCS). Because it takes a cross-platform approach, it must ensure that all this clustering functionality is included in the software application itself. In essence, AIX customers deploying a VCS solution purchase functionality already present in the operating system, which in this case then remains unused.

# Introduction

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## Objective

This white paper describes the notable benefits and advantages that the IBM PowerHA SystemMirror 7.1 for AIX high availability clustering solution provides due to its deep integration with the cluster-aware operating system.

## Audience

Any IT manager, CIO, systems architect, etc. who is considering implementing or upgrading a HA clustering solution will find valuable information in this white paper. Additionally, IBM sales and marketing personnel will find this paper useful in understanding the value propositions of IBM PowerHA SystemMirror 7.1 for AIX.

## Contents of this Report

This white paper contains the following sections:

- **High Availability: Which Approach is Best** — This section gives an overview of high availability (HA) and HA clustering, explains the major categories of HA clustering software products, and discusses the differences between multi-platform and operating system-integrated solutions.
- **IBM's HA Solution: PowerHA SystemMirror** — This section describes IBM PowerHA SystemMirror 7.1 for AIX, its architecture, and the capabilities and features enabled by that architecture.
- **A Comparative Analysis: Integrated Solution vs. Multi-Platform** — This section sums up the comparison of operating system-integrated and multi-platform solutions, comparing IBM PowerHA SystemMirror 7.1 for AIX and Symantec Veritas Cluster Server as representative of each type.
- **Conclusion** — This section sums up the contents of the white paper and presents any conclusions drawn.

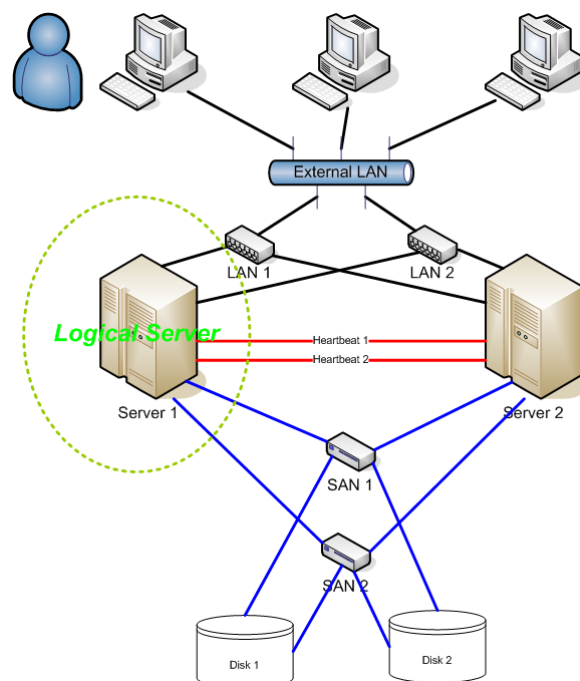
## High Availability Clusters: Which Approach is Best?

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In today's world, we have globalized and web-based commerce, 24-hour financial transactions, intense competition among technology-reliant businesses, and services expected to be accessible anytime, anywhere, and on any device. Little wonder that high availability has increasingly become a vital goal for many data centers. HA solutions are deployed with the objective of ensuring near continuous accessibility and uptime of critical IT application environments.

In the context of IT, such solutions always involve redundancy along with a failover process in which a resource that becomes unavailable — either because of a planned outage (as for maintenance) or because of unexpected malfunction — will be made available on another system, usually without requiring administrative intervention. HA clustering applies this principle to servers.

HA clusters consist of specialized software (such as IBM PowerHA SystemMirror) that enables at least two redundant computers (nodes) to provide failover for any essential system components that fail or otherwise become unavailable. A standard 2-node HA cluster network diagram is shown here.



The cluster software monitors the critical resources for changes that may indicate a failure, a pending failure, or a possible configuration change. The cluster software monitors the cluster components for health. Changes to a configuration within the cluster must be made consistent across the cluster. HA clusters usually employ one or more "heartbeat" communication channels, which are used in monitoring the health and status of each node in the cluster. The software that provides a cluster solution typically configures the target node before starting the application on it. For example, network hardware may have to be configured, appropriate file systems may need to be imported and mounted, and supporting applications may also need to be running.

## General Approaches to HA Clustering

HA clustering solutions can generally be categorized under two major subheads: those that are integrated with a particular operating system, and those that run strictly at the application level and are often multi-platform. Even within mid-sized organizations, data centers very rarely completely standardize on a single operating system platform. Usually there are several different platforms being used for various purposes. For this reason, a multi-platform clustering solution may appeal to many from an operator's point of view, and also has appeal from a business standpoint, since operators need to learn only one user interface for HA clusters throughout their data center.

However, choosing a multi-platform solution over one that is integrated with its host operating system entails important tradeoffs that anyone implementing a clustering solution should be aware of. A closer examination of integrated HA clustering solutions reveals that a solution integral to a platform's core kernel and operating system is the more robust, resilient, and easily managed of the two approaches.

## Cluster-Aware Operating Systems: Foundation for a Solid HA Solution

A cluster-aware operating system is one in which fundamental clustering capabilities, such as the creation and definition of the set of nodes comprised in the cluster, have been built in. Designing cluster awareness into the operating system enables operating system-based operations to be in harmony with the native cluster-wide HA solution. In particular, it ensures that operating system-based operations do not inadvertently disturb the cluster.

If conducted externally to the operating system (as with multi-platform HA cluster solutions), cluster monitoring and event management can be prone to job scheduling issues or other events related to operating system operations.

The health management process must be accomplished from within the operating system kernel if it is to be optimally reliable and less reliant on user monitoring and intervention. User involvement is also minimized in a cluster-aware operating system due to it enabling integral exploitation of hardware resources (such as network adapters, Storage Area Network connections, etc.) within the infrastructure, as well as it providing multiple redundant communication links between the nodes in the cluster. Such discovery-based configuration capability reduces the administrator's burden of monitoring and configuration in maintaining the health management infrastructure.

A HA solution designed for implementation with a cluster-aware operating system provides a powerful means of exploiting the operating system features for high availability, extending them across the cluster and enabling centralized topology and cluster management of the entire infrastructure.

## Business Advantages of Integrated HA Clustering Solutions

The reduced need for user intervention described above is one significant cost-related advantage of an operating system-integrated HA clustering solution. On closer inspection, several others also emerge:

- **Lower Acquisition Costs** – The integrated HA clustering solution exploits technology already existing in the operating system and kernel. Multi-platform solutions must provide desired functionality as separate technology components, raising the cost of the solution. A good example of such functionality is storage management. PowerHA SystemMirror exploits and enhances the capabilities of well-integrated AIX storage management to provide for continuous availability of storage, as well as multisite mirroring of data.
- **Reduced Learning Curve** – While this is the sole advantage claimed by multi-platform systems over those integrated with the operating system, users familiar with the operating system platform will actually have a less steep learning curve using an integrated product, which lets them work within the context of the operating system they already know.

## IBM's HA Solution: PowerHA SystemMirror

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The IBM PowerHA SystemMirror high availability clustering solution for AIX is based on and integrates at a deep level with a cluster-aware operating system, IBM's AIX. A set of tools, services, and APIs embedded into AIX 6.1 TL6 and 7.1 — Cluster Aware AIX (CAA) — helps enable clustering at the operating system level. IBM PowerHA SystemMirror exploits this functionality in its role of providing application monitoring and resource failover capabilities.

With version 7.1 of PowerHA SystemMirror, IBM has taken clustering technology to a new level by moving monitoring and much event management functionality deeper, into the actual kernel of the operating system. Successful failover, whether automated or semi-automated, stipulates that all of the resources a critical application requires in order to resume operation on an alternate node in the cluster — cluster resources — be present and accounted for on that alternate node.

The dependencies established between application and cluster resources make up the key control mechanism of any modern clustering solution. The clustering solution ensures that the resources are available and operational before an application needs to switch operation over to a standby node. Continual monitoring of the essential infrastructure resources checks for any changes that indicate a failure, potential failure, or possibly a configuration change that might trigger a cluster operation (such as failover), or alert an operator to take corrective action.

Running these essential HA operations in user space (the segregated portion of the operating system's virtual memory where all user mode applications operate) subjects them to interruptions and prioritizations of other processes running there. For example, in some instances where CPU utilization runs at 100 percent, the heartbeat can fail to process at all, which the cluster falsely perceives as an outage. Running these same operations beneath that level, with tight integration between PowerHA SystemMirror and the operating system kernel, means that system state and health management takes place in real time and that communication occurs kernel-to-kernel, involving no interruption of the core processes by the user space. Complete automation of end-to-end failover is made possible with policy-driven resource group relationship sequencing.

CAA device management is also aware of the network components and shared disks, enabling common device naming in the cluster. Cluster-wide, kernel-based event monitoring and communications for network and storage provides notification of outage events, such as root volume group failures and kernel crashes.

PowerHA SystemMirror 7.1 also takes advantage of its tight integration to provide superior automatic discovery of resources and resource dependencies in the cluster, which saves administrators a good deal of time and trouble they would otherwise devote to determining and assigning resource dependencies in third-party solutions.

AIX Dynamic Logical Partitioning (DLPAR) is another unique functionality PowerHA SystemMirror 7.1 can offer due to its OS-integrated architecture. This unique capability allows for dynamic expansion and collapse of partitions in order to accommodate the amount of processing power required for a given application being failed over. Essentially it load-balances machines used in failover scenarios. It enables an HA solution that does not demand that an entirely redundant system be reserved as a mere standalone, letting organizations run other (usually less business-critical) operations on those hardware resources until they are needed for failover.

One more advantage PowerHA SystemMirror brings to AIX environments entails ongoing management challenges involving the need to maintain change management on two different sets of binaries: that of the operating system and that of the HA clustering software itself. In the case of PowerHA SystemMirror, the application is always thoroughly tested to the latest, current AIX operating system level. Deploying a third-party HA clustering solution poses an ongoing challenge of maintaining the concurrency level between the two worlds, which can hold back an entire systems upgrade movement to the lowest common denominator represented by the last operating system version the HA clustering application has been tested to. For example, if an organization wishes to upgrade a business-critical software application that requires a given AIX service pack and the HA clustering solution is not operational with that level, the desired upgrade cannot take place.

## **IBM PowerHA SystemMirror 7.1: Leveraging Deep Integration**

The deeper operating system integration of IBM PowerHA SystemMirror enables numerous new features that exploit the powerful clustering functionality built into Cluster Aware AIX. Features new to this version include:

- Multicast heartbeat management that discovers and uses available data center network and Storage Area Network (SAN) fabric resources, ensuring a higher level of availability.
- A cluster repository for cluster configuration, internode synchronization management, and name space management.
- An intuitive GUI management console, included as a plug-in for IBM Systems Director, which provides a secure, centralized “single pane of glass” point of operation, streamlining cluster management and making users more productive.

- PowerHA SystemMirror Smart Assist for out-of-the-box setup and management of applications and application protocols, such as SAP, IBM Enterprise Content Manager, Tivoli Storage Manager, Lotus Domino Server, IBM LDAP, IBM HTTP, and others.
- Fencing disks or disk groups: a process that shuts off access to the shared disks in the cluster from other nodes, thus preventing accidental access.
- Supports a rich set of resource group definition interfaces and policy definitions for the management of relationships between multiple resource groups.
- Supports custom resource management and resource group relationships, such as Start After and Stop After dependencies.
- Simplified cluster security configuration that provides a choice of low, medium, and high settings to select the desired level of security. These levels map to the level of encryption and integrity checks performed on the cluster communication packets.
- PowerHA SystemMirror solution requires no system shutdown for installation, enabling on-the-fly startup without application outages.<sup>1</sup>
- PowerHA supports rolling upgrades that let administrators minimize service outage time by optimally relocating the workload across the nodes in the cluster during a migration or upgrade.

The following subsections describe in greater detail some of the new and/or unique functionality available in PowerHA SystemMirror 7.1 .

### ***Centralized Cluster Repository and Multi-Channel Heartbeat***

The centralized repository used by PowerHA SystemMirror 7.1 is actually a major part of CAA. When PowerHA SystemMirror 7.1 has been installed and configured, the cluster repository disk appears. Stored on a dedicated SAN disk, the repository is shared by all nodes participating in the clustered environment to maintain cluster configuration, internode synchronization management, and name space management.

The cluster repository plays a role in ensuring high availability beyond the usual means. PowerHA SystemMirror 7.1 uniquely exploits the SAN links for cluster communications. As with nearly every HA cluster solution, PowerHA SystemMirror employs a heartbeat private network connection used to monitor the status and health of each node in a cluster. The SAN links in the data center are used as an alternative high-

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<sup>1</sup> Migrating to a major release, such as 7.1, will require a node outage.

speed physical channel for this communication, in addition to the traditional network links deployed in the environment. In combination with the shared cluster repository, this innovation provides a triple redundant communication pipe: the traditional (TCP/IP) network, the SAN fabric, and the heartbeat information residing on the repository.

Aside from ensuring significantly enhanced availability, this multi-channel health management approach guards against the “split-brain” condition that stands as a potential threat within any clustering solution, where the communication link fails and triggers nodes to begin failover startup on behalf of other nodes that are in fact still operational. Having duplicate processes and services running simultaneously can cause a number of problems, such as data corruption on shared storage. The threefold communication approach used with PowerHA SystemMirror 7.1 considerably minimizes the risk of split-brain.

### ***IBM Systems Director-Based GUI***

As described earlier, administrators familiar with the AIX operating system easily adapt to using PowerHA SystemMirror 7.1, because it integrates with Cluster Aware AIX and acts as an extension of the operating system. Such users are frequently comfortable with the Command Line Interface (CLI) and often regard it as an elegant means of effecting and managing a clustering solution.

However, the new, intuitive graphical user interface, which comes with PowerHA SystemMirror 7.1 for no additional charge, offers yet another means of managing the cluster environment. A plug-in to IBM Systems Director, this user interface simplifies cluster management and makes users more productive via a secure, centralized point of operations. Administrators can readily deploy clusters and resource groups using wizards. Live updates are provided by graphically displaying the status of nodes, sites, resource groups, and clusters. A single view displays the health of the entire enterprise. There is no need for administrators already familiar with Systems Director to learn a new user interface for cluster management.

Even users with extensive AIX expertise can increase productivity by using the GUI plug-in. It considerably reduces the learning curve for users accustomed to cluster management through graphic interfaces and for those coming from other UNIX-like platforms.

### ***Smart Assists***

PowerHA SystemMirror 7.1 provides support for Smart Assists for easier, out-of-the-box HA setup and application management for many well-known middleware products.

High availability agents for application deployment and management, Smart Assists are used to define HA policies and to discover software deployed within the cluster. Discovery-based information aids in defining the HA policy and provides periodic health monitoring. It enables middleware and resource dependencies to be restarted via the specified policy.

With PowerHA SystemMirror 7.1, the Smart Assist portfolio has been enhanced to provide support for the following:

- DB2
- WebSphere®
- Oracle
- SAP
- FileNet® P8
- Tivoli Storage Manager
- Lotus® Domino® Server
- IBM LDAP
- IBM HTTP
- Printers

## A Comparative Analysis: Integrated Solution vs. Multi-Platform

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In broad and general terms, most HA clustering solutions share similar functional characteristics. Factors primarily distinguishing IBM PowerHA SystemMirror 7.1 include:

- The depth of its integration with the AIX operating system.
- The powerful impact this deep integration has on enhancing availability and performance.
- The savings delivered in terms of administrative time.
- The exclusive features enabled by this level of integration.
- The cost factors due to having much of the essential clustering functionality already built into the operating system.

For most organizations, one of the more obvious factors influencing decisions in considering various HA clustering solutions is whether to go with one solution that can be used in managing clusters running on different operating system platforms (that is, a multi-platform solution) or to go with operating system-based solutions. As explained previously in this paper, important tradeoffs inherent in multi-platform solutions make this choice far less clear-cut than might at first appear.

Examples of multi-platform HA clustering solutions on the market include Tivoli Systems Automation, Symantec Veritas Cluster Server, SteelEYE, and VMware HA. These HA clustering solutions are lightly integrated extensions of operating system options with alternatives to kernel services that generally operate at the application level, and that utilize the operating system in user space.

Examples of operating system-based HA clustering solutions on the market include IBM PowerHA SystemMirror for AIX, IBM PowerHA SystemMirror for i, IBM's z/OS Parallel Sysplex, HP ServiceGuard, and Oracle Solaris Cluster. These HA clustering solutions are deeply integrated extensions of operating system and kernel technologies.

It is by design that IBM PowerHA SystemMirror is not multi-platform. In fact, with version 7.1, it has evolved in such a way as to have become even more deeply integrated into the operating system than ever. For any HA clustering solution claiming multi-platform support, providing comparable integration for every operating system platform supported would price the solution well out of the market. For a business's

data center to attempt single-solution integration at this level for multiple operating system platforms, assuming this is even feasible, would entail considerable and almost certainly prohibitive expense to the organization.

The following subsection compares aspects of PowerHA SystemMirror 7.1 with a commonly used HA clustering solution representative of the multi-platform approach, Symantec Veritas Cluster Server.

### **Representative Comparison: PowerHA SystemMirror 7.1 and Symantec Veritas Cluster Server**

Symantec Veritas Cluster Server (VCS) is a well-established representative of an HA clustering solution that claims multi-platform support. Predominantly comprising user-level clustering software, most of its processes are normal system processes running on top of whichever operating system is installed. It has no special access to the operating system or kernel functions in the host system (although the heartbeat interconnection is a proprietary Ethernet-based protocol running through the kernel space using kernel modules).

Because it exists as a separate application running on top of the operating system, VCS is more demanding than is PowerHA SystemMirror 7.1 in terms of integration, administration, and change management, involving sets of binaries from two different vendors: one for the operating system and another for the application. PowerHA SystemMirror 7.1 essentially operates as an extension of AIX in delivering its clustering capabilities. It is shipped from the factory fully tested for integration with AIX, with any problems discovered in the field fixed and baked into the next release, resulting in a constantly improving and highly robust extension of the operating system. As a separate application, VCS also involves a steeper learning curve for seasoned AIX users, who can quickly grasp and make use of the functionality added to their familiar environment via PowerHA SystemMirror.

PowerHA SystemMirror 7.1 conducts cluster monitoring and event management (such as failover operations triggered by detected problems) at the operating system kernel level, in real time. This makes for more efficient HA operations than with VCS, which runs monitoring and event management in the user space, where it may have to contend with other processes. This kernel-to-kernel communication also improves end-to-end automation, reducing the need for administrator monitoring and intervention in clustering operations.

The cluster heartbeat monitoring is an essential component of nearly every HA solution. But what if the network connection transmitting the heartbeat intercommunication fails?

As mentioned earlier, VCS maintains a heartbeat communication pipe via Ethernet. By contrast, PowerHA SystemMirror maintains a triple redundant communication pipe using the TCP/IP network, the SAN fabric, and the heartbeat information residing on the centralized cluster repository. This ensures a greater degree of high availability and provides added protection against split-brain conditions. In addition, the centralized repository of shared cluster configuration further streamlines management of the cluster.

The following table provides a side-by-side comparison of some important functionality within IBM PowerHA SystemMirror compared to the functionality provided by Symantec VCS.

	IBM PowerHA SystemMirror 7.1	Symantec VERITAS Cluster Server
GUI Console	√	√
Kernel-Based Event Management	√	X
SAN-based Heartbeat	√	X
Out-of-Box Application Support	√	√
Centralized Cluster Repository	√	X
AIX DLPAR HA/DR Management	√	X

**Table 1 - Function/Feature Comparison Table**

Currently, all major UNIX flavors are cluster aware; however, cluster awareness is not restricted to UNIX or, for that matter, to any operating system platforms. Increasingly, many applications are also cluster aware, including storage systems as well as major commercial databases, such as DB2, SQL Server, and Oracle. In other words, a good deal of fundamental clustering functionality is already present in a typical data center stack, whether or not an HA clustering solution is actually implemented in order to enable it.

Such is the case with AIX. In integrating with this operating system, PowerHA SystemMirror 7.1 delivers an HA solution in part by exploiting the clustering functionality already present in the platform. With Symantec VCS, the clustering solution substitutes its own functionality for what is already present (but left unused) in the operating system. In essence, customers pay for clustering technology they already have. Because PowerHA SystemMirror 7.1 is designed specifically to utilize this technology, it involves far less to purchase, install, and maintain, as discussed in the following subsection.

### ***PowerHA SystemMirror 7.1 Comparison with Symantec HA Cluster Offering***

Since shared storage is a critical requirement for successful cluster-based HA, Symantec Veritas Cluster Server is usually sold in a bundle with Veritas Storage Foundation as Veritas Storage Foundation Enterprise HA/DR. Cobbling together what are actually separate products is the approach Symantec takes in providing an integrated solution that can work with multiple OS platforms.

The Storage Foundation Enterprise edition software included with the Veritas Storage Foundation Enterprise HA/DR bundle provides a range of storage management software tools, many of which are not specifically related to HA or clustering. Clusters are supported by the Storage Foundation Cluster File System (CFS). Veritas Volume Manager (VVM) provides volume management features. In addition, there is an array of agents for common applications (and, since it is multi-platform, multiple Operating Systems). Other software packages in the bundle include Dynamic Multi-Pathing, the Global Cluster Option (GCO) for site-based HA, Fire Drill for HA testing, and the Cluster Management Console, which provides a GUI administrative interface.

Table 2 , displayed below, presents a side-by-side presentation of how near-equivalent functionality is provided in PowerHA SystemMirror 7.1 as compared with Veritas Storage Foundation Enterprise HA/DR.

	<b>PowerHA</b>	<b>Symantec HA/DR</b>
AIX IT operations skill base	✓	New or different skills
AIX technical skill support base	✓	✓ No change for AIX; New skills needed for Symantec
AIX Shared Storage management	✓	Storage Foundation Server (SFS)
AIX Volume Manager/Mirroring	✓	SFS, Virtual Volume Manager
AIX File System	✓	Cluster Server; Cluster File System
AIX DLPAR HA/DR management	✓	Not Available
Application agents	✓	✓
Director-based user interface	✓	Cluster Management Console

	PowerHA	Symantec HA/DR
AIX Cluster Aware	✓	Not Available
Kernel-based event management	✓	Application or user-level event management
Centralized cluster repository	✓	Not Available
Triple redundant multi-cast heartbeat	✓	Single-network heartbeat
SAN-based communications	✓	Not Available
Multi-Path	✓	Dynamic Multi-Pathing

**Table 2 – Functionality Equivalency Table**

Other than certain functionality not available in the Symantec offering, the important thing to note in this table is the number of items provided by the AIX operating system itself, which are enabled by PowerHA SystemMirror 7.1, but which, with Veritas Storage Foundation Enterprise HA/DR, are provided by separately installed, configured, and managed software packages.<sup>2</sup> This adds to the software price; for example, a license for PowerHA for a 24-core Power 750 costs about \$2,500 per core. For the Symantec solution, the cost is about \$4,000 per core. The Symantec model also increases software overhead, administrative complexity, and number of potential points of failure for the HA solution. Unlike PowerHA SystemMirror 7.1, which is always concurrent with the AIX operating system version, the Symantec solution leaves maintaining the change management up to the customer.

It should also be noted that a good deal of storage system-specific functionality provided by Veritas Storage Foundation Enterprise HA/DR replicates the functionality offered by virtually all SAN storage solutions available today. This includes such features as snapshots, management of the storage volumes, and replication within and between arrays.

Using the Symantec solution requires two main management consoles: the Cluster Management Console to manage the clustered environment, and Veritas Operations Manager to manage Storage Foundation.

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<sup>2</sup> Almost all of this functionality is available when PowerHA SystemMirror 7.1 Standard Edition is deployed. A notable exception is the Global Cluster Option provided by the Symantec solution that enables site-based clusters. This functionality is included with PowerHA Enterprise Edition.

With PowerHA SystemMirror 7.1, the existing skills of the AIX IT operations team are all that is really needed – even the familiar SMIT and other AIX utilities can be used to manage the HA solution. The PowerHA solution includes an intuitive GUI management console as a plug-in for IBM Systems Director. This is in keeping with the general trend in IT operations, where managing HA clusters is no longer a separate discipline and where much of the functionality is provided by storage systems and operating systems. Organizations using Director can incorporate management of PowerHA SystemMirror 7.1 into management of the entire enterprise, with no need to switch contexts to, or learn, an entirely different user interface.

## Conclusion

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While multi-platform HA clustering software solutions have their merits, such as single-interface management of clusters running on different operating system platforms, these merits come with notable tradeoffs in terms of efficient operations, economical functionality, and enablement of truly system-enhancing features. Its deep integration into the cluster-aware AIX operating system makes IBM PowerHA SystemMirror 7.1 a powerful HA-enabling extension of the operating system itself for HA clustering solutions.

Such deep integration enables innovative features unavailable in other products, providing HA clustering solutions for UNIX. In addition, because the clustering solution and operating system evolve together, any flaws in the synthesis between the two discovered in the field are addressed, and the fixes are baked into the next release of the product. This ensures a product that continually improves over time into an extremely robust HA clustering solution.

IBM PowerHA SystemMirror 7.1 is unquestionably the optimal HA clustering software product for AIX, and because it leverages cluster functionality already present in the operating system itself, one of the most economical, as well. Its features and functionalities – including the IBM Systems Director-based console, superior discovery, and DLPAR – are perfectly suited for today's integrated, virtualized, and/or cloud-based IT environments.