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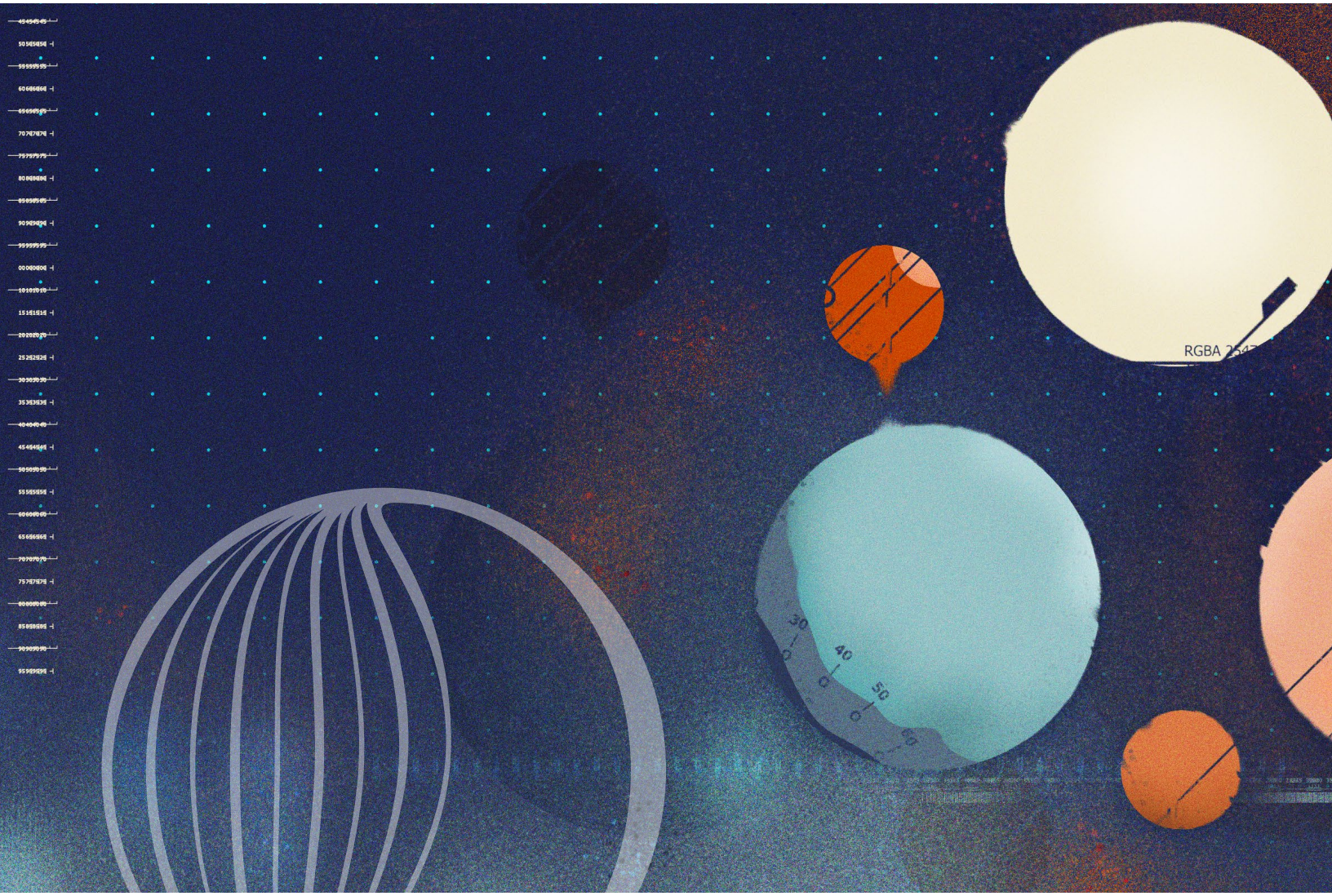

The Economics of Disaggregated Private Cloud Storage

Total Cost of Ownership Analysis of VMware vSAN and Fibre Channel SAN

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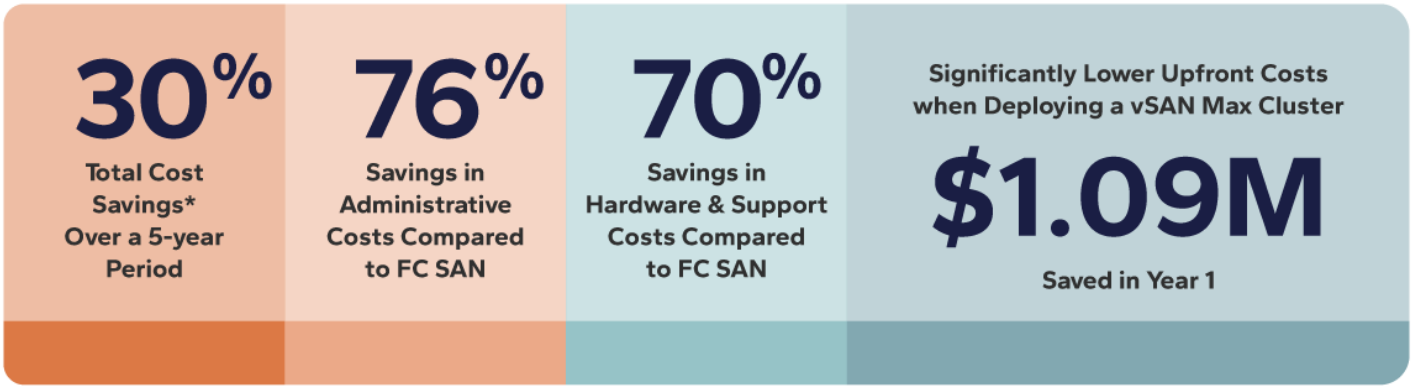
Executive Summary

For organizations building private clouds, choosing the right data storage solution is a key decision that can significantly impact the resulting environment. While storage is only a single component of a broader private cloud solution, it plays a key role in determining characteristics such as scalability and flexibility, as well as significantly impacting the operational complexity and overall cost of the solution. IT organizations must be aware of the important role that storage plays in their private cloud environments, and understand the attributes of available storage offerings that may have an impact.

The current data storage landscape includes a wide range of offerings, including both traditional storage arrays, with either scale up or scale out capabilities, and software defined storage solutions, all with varying ranges of performance and advanced feature sets. Beyond the technical capabilities, however, IT decision makers should also be aware of the operational and economic impacts of any solutions under consideration. To make a comprehensive evaluation, IT organizations should consider a range of characteristics including standard hardware, software, and support costs, as well as ongoing operational costs. Evaluation of operational costs requires an analysis of the time, complexity, and staffing involved with deploying and managing a storage solution. To understand the total cost of ownership, all of these considerations should be examined over a defined period of time alongside the context of technology changes and product lifecycles.

This report shows such an approach in evaluating the total cost of data storage solutions for organizations building private and hybrid clouds using VMware Virtual Cloud Foundation (VCF). The study provides an economic comparison between VMware's vSAN and a Fibre Channel SAN deployment as storage solutions for VCF. The study analyzed publicly available pricing for both solutions, alongside a detailed operational cost analysis, and considerations of financial flexibility over a 5-year period.

Key findings from the economic analysis include:



** 30% cost savings are calculated using a net present value calculation.*

The Need for Disaggregated Storage

Hyperconverged Infrastructure (HCI) has become a popular choice for deploying IT infrastructure by consolidating compute, storage, and networking within a single solution. HCI solutions offer several benefits including the ability to scale out compute alongside storage, use of cost-effective commodity hardware, and operational simplicity. The scalable nature and virtualization of HCI clusters additionally provides an agile, cloud-like infrastructure, making it well suited for modern data centers building private and hybrid cloud environments.

While HCI solutions have proven to be an effective technology for many workloads, the requirement to scale compute and storage resources together can present a challenge in some situations. Depending on the workload, the requirements for scaling compute resources and storage resources may not align. Due to the nature of HCI, however, scaling one resource requires scaling the other. This can lead to situations in which unnecessary compute resources must be added to accommodate larger storage capacities. From an economic perspective, this can become especially challenging when considering use cases requiring expensive, core-based licensing, such as many popular databases. In this scenario, as an organization scales out its HCI to accommodate a growing data capacity, they incur additional licensing fees for all of the compute cores added with each additional HCI node.

This scenario has typically left IT organizations to choose between one of two options, either overpaying for additional compute resources and expensive licensing fees as their HCI environments scale or forgoing HCI altogether in favor of a separate compute environment and a Fibre Channel SAN. The latter choice presents an advantage when scaling capacity; however, it sacrifices the operational simplicity, enhanced management, and agility provided by utilizing HCI.

More recently, some HCI solutions have overcome this challenge by enabling disaggregation of compute and storage. This allows either compute or storage resources to scale as needed, while maintaining the operational benefits of HCI.

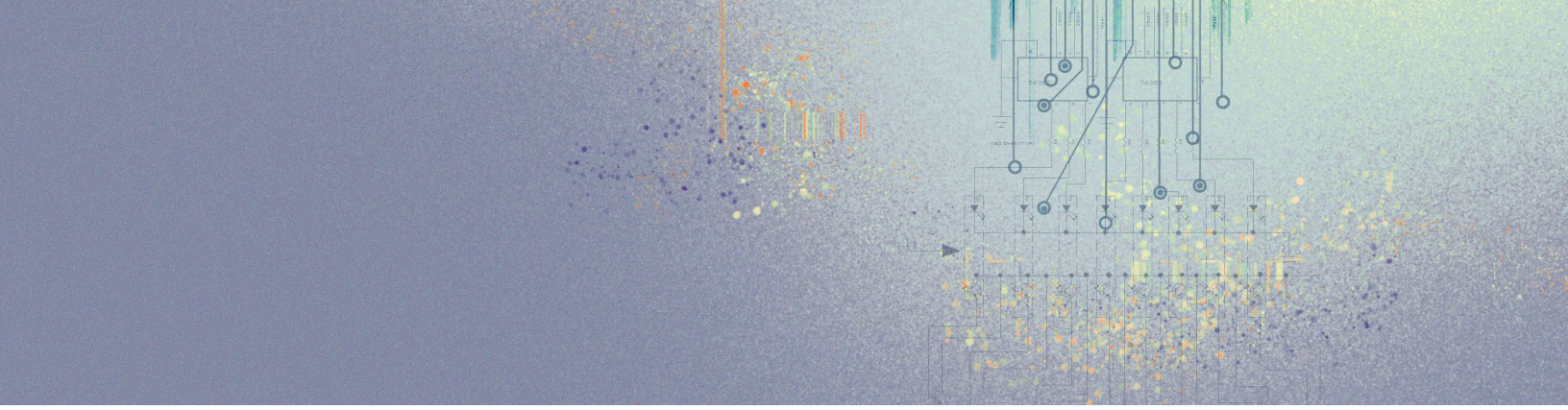
Disaggregated Storage with vSAN

VMware vSAN is a storage virtualization software solution from VMware designed to provide integrated storage for VMware environments. vSAN is available as part of VMware Cloud Foundation (VCF), which provides a powerful virtualization platform for IT organizations to build and manage private and hybrid clouds utilizing vSphere virtualized compute, vSAN storage, NSX Networking, and a suite of management and orchestration tools.

Traditionally, vSAN has been deployed as HCI, scaling compute and storage linearly and fully integrated with vSphere. Recent updates to vSAN, however, have enhanced the offering with an entirely new architecture, known as vSAN Express Storage Architecture (ESA), and vSAN Max, which bring both new capabilities and new flexible deployment methods. With the vSAN ESA architecture, and vSAN Max for disaggregation, vSAN can be deployed in three distinct deployments:

- **Traditional HCI:** A traditional HCI deployment that aggregates storage and compute within the same host.
- **Traditional HCI with Remote Datastores:** This configuration allows the sharing of storage capacity between separate vSAN HCI clusters.
- **vSAN Max:** A fully disaggregated configuration that separates compute nodes and storage nodes.

With vSAN Max functionality, vSAN can provide disaggregated storage, so organizations leveraging VCF within their datacenter can utilize vSAN storage and scale capacity as flexibly as needed. This provides an attractive option for IT organizations who require greater flexibility than a traditional HCI deployment. It additionally provides operational simplicity and economic benefits compared to deploying a SAN array.



Economic Analysis Overview and Assumptions

The goal of this analysis was to conduct an economic comparison of a VCF environment with vSAN disaggregated storage compared to the same VCF environment with a SAN storage array. As previously discussed, both configurations could be utilized to leverage VMware VCF while independently scaling storage capacity. The economic comparison evaluated several factors that impact the total cost of ownership for both solutions, including hardware costs, software licenses, support contracts, and operational costs.

To create an even comparison, both environments were modeled using the same compute configuration. The compute configuration was chosen to model a realistic data center deployment of VCF compute clusters. The compute clusters modeled include the following:

- A VCF management cluster consisting of 4 nodes
- A general-purpose compute cluster consisting of 10 nodes
- Two database clusters, each consisting of 2 nodes

Cost modeling of the compute environment was limited to the costs of the VCF Licensing and did not include modeling of compute, or any additional, hardware. This was done to focus the comparison on the associated storage environments. Any additional hardware was assumed to be the same in both environments and would not impact the economic comparison.

To create the economic comparison, two distinct storage environments were modeled. The first utilized VMware vSAN storage software deployed on commodity servers in a storage-only cluster following a vSAN Ready Node specification. The second environment modeled a leading midrange SAN system.

All hardware, software, and support costs used in modeling were taken from publicly available pricing. Storage software for the SAN environment was packaged with the price of the array, and therefore included under hardware costs. The comparison applied vendor discounts to list pricing, utilizing discount rates found in publicly available price lists. The discount rates utilized include the following:

- 17% discount on servers used for vSAN storage nodes
- 38% discount on SAN array
- 2% discount on all support costs

It should be noted that while this study used discount rates listed in publicly available price lists, actual discounts can vary and should be negotiated.

The economic model evaluated both environments over a 5-year period. This timeframe was chosen to correspond with a typical lifecycle for IT infrastructure. The model scaled both storage environments over the course of 5 years, with an assumed 20% rate of growth per year. Capacities were scaled incrementally to meet the growing storage requirements, while adhering to the configuration requirements of each storage solution. For both storage environments, capacity was first scaled up and then scaled out. To create an even comparison, both solutions were modeled using the same 15.36 TB NVMe SSD devices. The two storage systems were scaled as follows:

vSAN

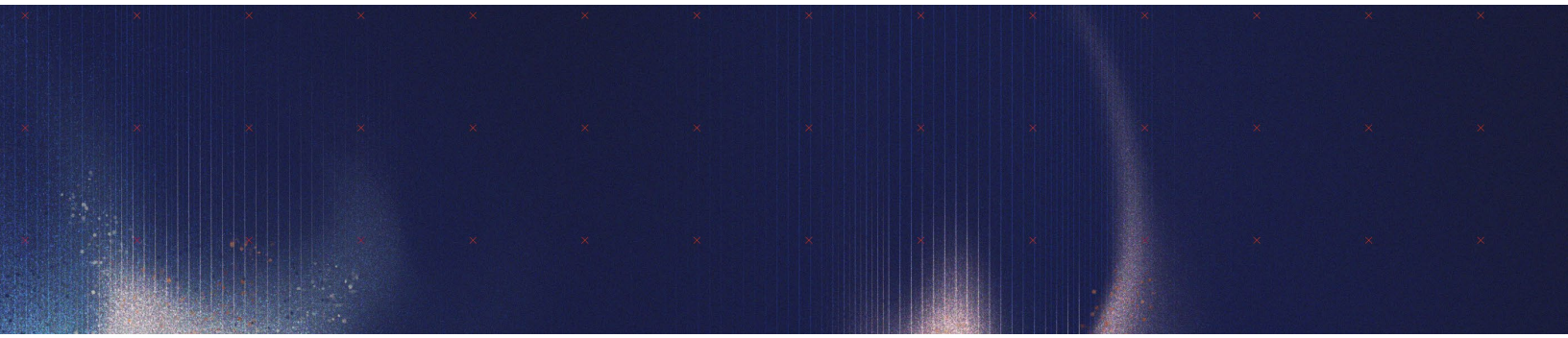
- Initial deployment included a 6-node cluster. Each node was partially populated with ten 15.36 TB NVMe devices for a total raw capacity of 921.6 TB.
- Capacity was first scaled up by adding devices to vSAN storage-only nodes, up to a limit of 15 devices per node.
- Additional capacity was added by scaling out the cluster with additional vSAN storage-only nodes. New scale-out nodes were required to hold a minimum number of storage devices.

SAN

- The SAN array modeled supports both scale-up and scale-out functionality. The system can scale out by adding additional controller nodes, up to a total of 4, and scale up by adding up to 3 expansion shelves per controller node.
- Each controller node is capable of housing 21 storage devices. Each expansion shelf can house an additional 24 devices.
- Initial deployment in Year 1 was modeled to match the 921.6TB capacity of the vSAN storage-only cluster. This configuration included one controller node and two device expansion shelves.
- During subsequent years, the system was first scaled up, adding devices via expansion shelves, and then scaled out as needed.

All capacity calculations in this analysis were achieved using raw capacities to simplify calculations and avoid the varying data reduction ratios of real-world workloads. It should be noted, however, that both storage solutions include data reduction capabilities. VMware, as well as leading SAN solutions, offer a variety of data reduction capabilities, but experienced data reduction ratios can vary depending on the workload type.

This study additionally evaluated the operational costs associated with each storage environment. This assessment was formulated based on a previous study by Evaluator Group (now Signal65) analysts comparing the administrative complexity and costs of vSAN compared to a Fibre Channel SAN. The prior study was utilized as a basis and updated to fit the vSAN Max and SAN environments modeled in this study. The operational costs were calculated based on the time required by a VM admin and an additional storage admin.



5-Year Overview

In Year 5, the economic model found the total cumulative cost of the vSAN Max environment to be $2,662,817.68, while the total cost of the SAN environment was found to be $3,689,566.21. This shows a total saving of 27.83% over 5 years.

Over the 5-year period, it can be seen that vSAN Max maintains an overall price advantage. The cumulative cost of each solution at the end of each year can be visualized in Figure 1.

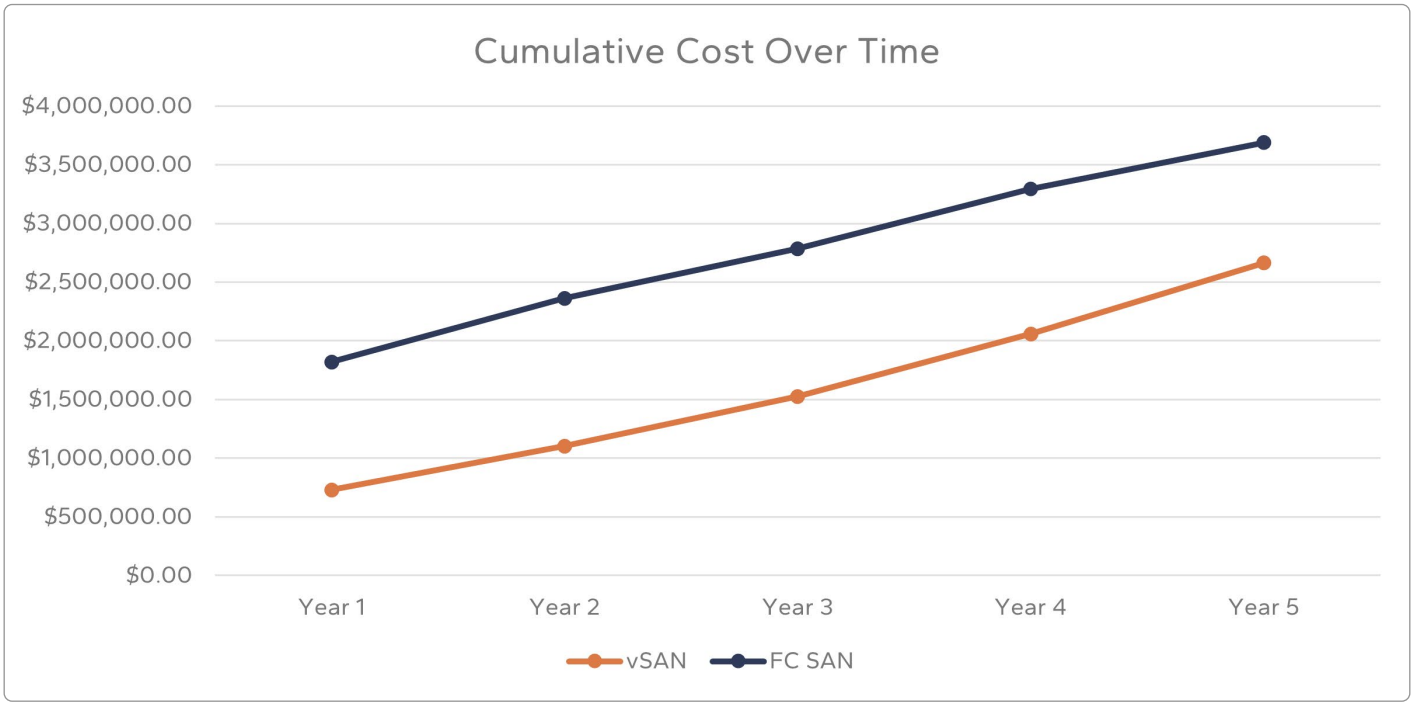


Figure 1: *Cumulative Cost Over Time*

To understand the total costs, the individual costs calculated in the economic analysis can be broken out for both solutions. These costs include the hardware and support, VMware licensing, and admin costs. VMware licensing has been further broken out to visualize the VCF licenses, which apply to both compute nodes and vSAN storage-only nodes, and vSAN Add-on licenses, which are only utilized by the vSAN environment. The admin costs have been further broken out to distinguish costs associated with a VM admin and to any other admins required. This breakdown can be visualized in Figure 2.

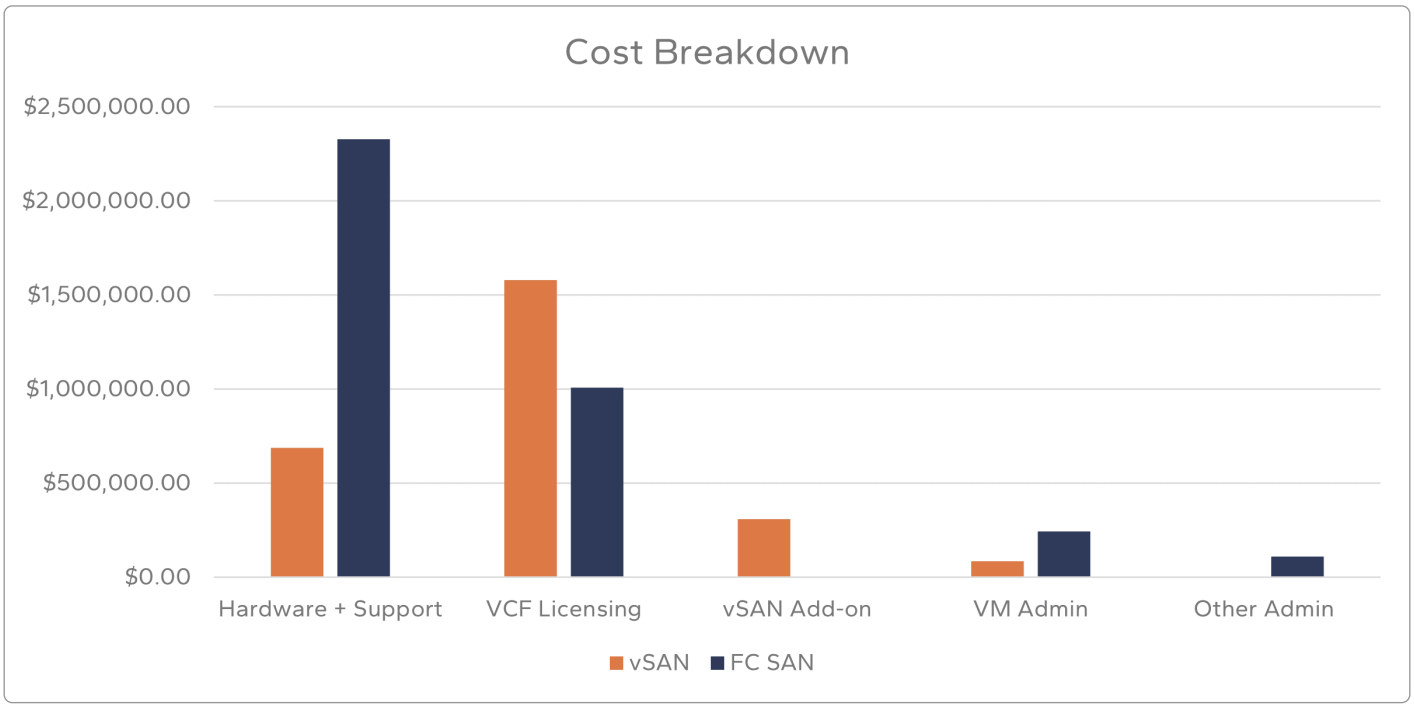


Figure 2: *Cost Breakdown*

This overview demonstrates that the vSAN environment was found to have an overall cost advantage in hardware costs, support costs, and all admin costs. The SAN solution required lower overall costs for VMware licensing, as it did not require any VCF or vSAN Add-on licenses for its storage nodes.

A more comprehensive comparison can be achieved by further analyzing these cost components and understanding their relevance to the overall TCO of each solution.

Hardware and Support Costs

A key feature in the deployment of a vSAN cluster is the ability to leverage commodity server hardware. This allows organizations the flexibility to purchase hardware from a variety of server vendors, lowering costs and allowing organizations to purchase from their preferred vendors. Meanwhile, the SAN deployment requires buying a dedicated SAN array from a specific vendor, packaged with that vendor's storage software. The total hardware costs for each solution calculated in the economic model highlight this dynamic. The vSAN deployment tallied a total of $489,663.48 in hardware costs over 5 years, while the SAN environment cost was $589,973.16. This represents a savings of 17% on hardware costs alone.

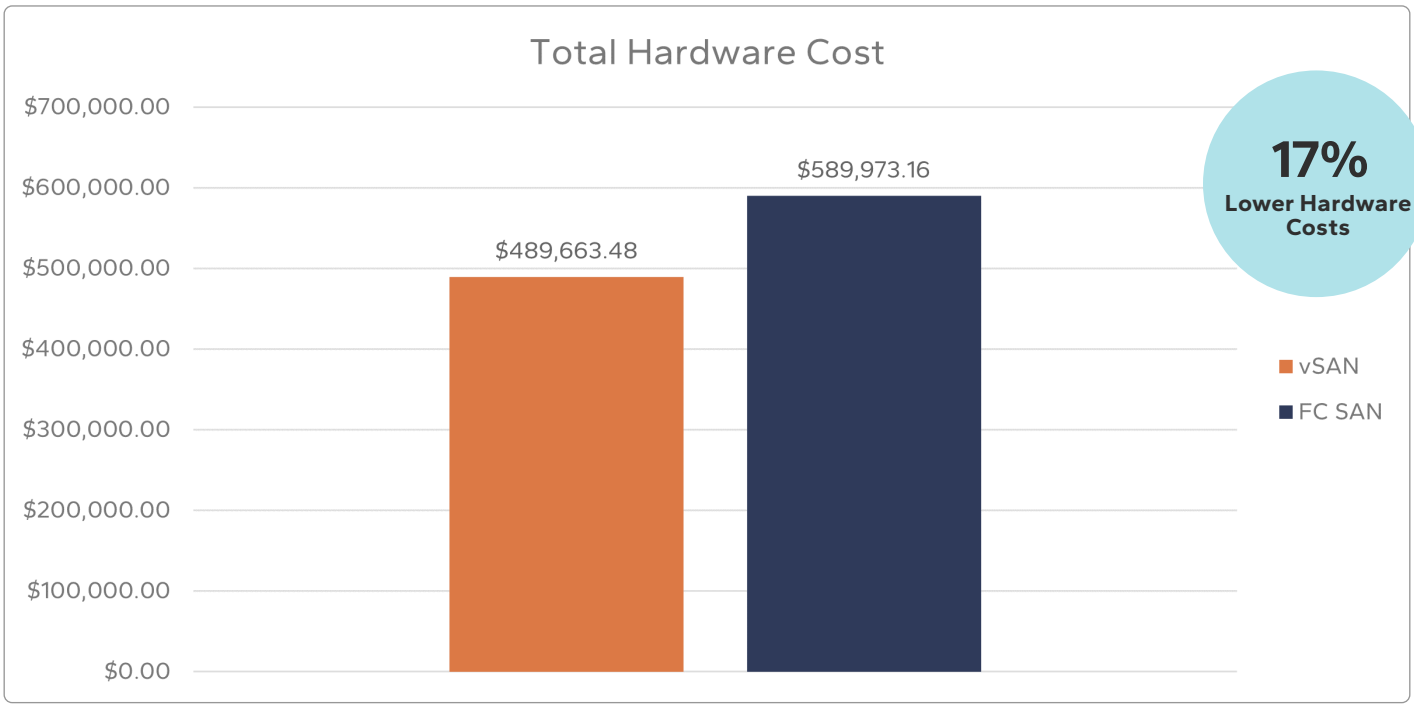


Figure 3: *Total Hardware Cost*

Even more notable is the significant difference in support costs. The vSAN environment was found to provide an 85% savings in support costs compared to the SAN environment. This highlights a second key economic advantage to vSAN's use of standard storage hardware. Support for dedicated storage arrays requires a significant cost. Comparatively, the cost of support for standard server hardware is much lower. By utilizing commodity servers with a software-defined storage layer, vSAN is able to dramatically lower both actual hardware costs and the associated support costs.

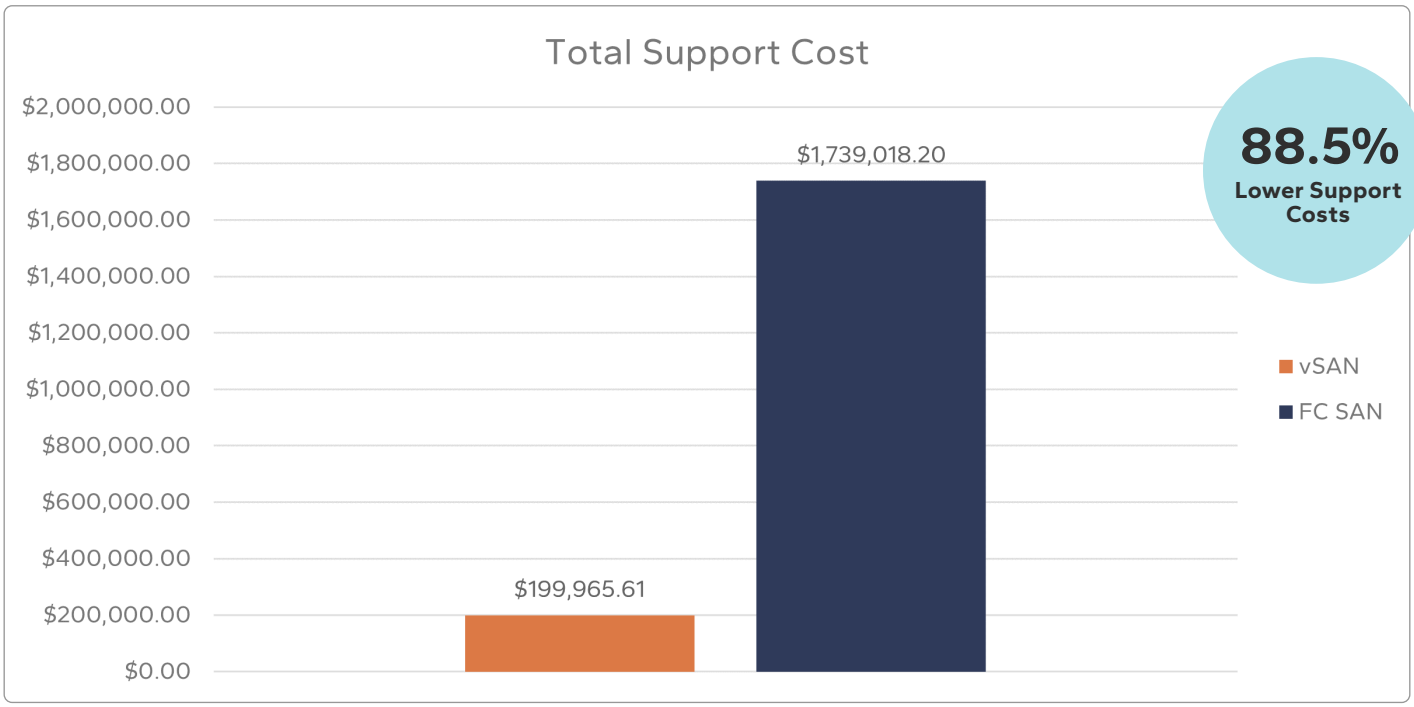


Figure 4: *Total Support Cost*

VMware Licensing Costs

One of the key differences between the vSAN environment and the standard SAN environment is the required VMware licensing. The overall goal of the economic analysis was to compare storage solutions for a VCF environment. Because of this, identical compute clusters were assumed, and VCF licensing for these clusters was kept consistent for both environments. These VCF licenses represent the entirety of the VMware licensing for the SAN environment, as the storage array does not leverage VCF or vSAN storage.

For the vSAN cluster, additional VCF licensing is required for each storage node. This was calculated using VCF's core-based licensing. This additional licensing requirement can be seen in the higher total VCF licensing cost of vSAN compared to the SAN array. It additionally requires capacity-based licensing for the vSAN software.

What is not apparent when only looking at the cost comparison, however, is that the VCF license additionally provides included vSAN licensing. VCF is licensed per core, and 1 TiB of vSAN storage per licensed core is included within VCF. This accounts for a significant portion of the environment's storage software, with any additional capacity purchased as an add-on vSAN subscription. For environments in which the included vSAN licensing covers the entire deployed capacity, this results in zero additional spending on storage software. It may additionally provide extra capacity available for scaling purposes or utilizing vSAN in additional use cases. The total amount of vSAN capacity included with VCF and the total amount purchased as an add-on license can be visualized in Figure 5.

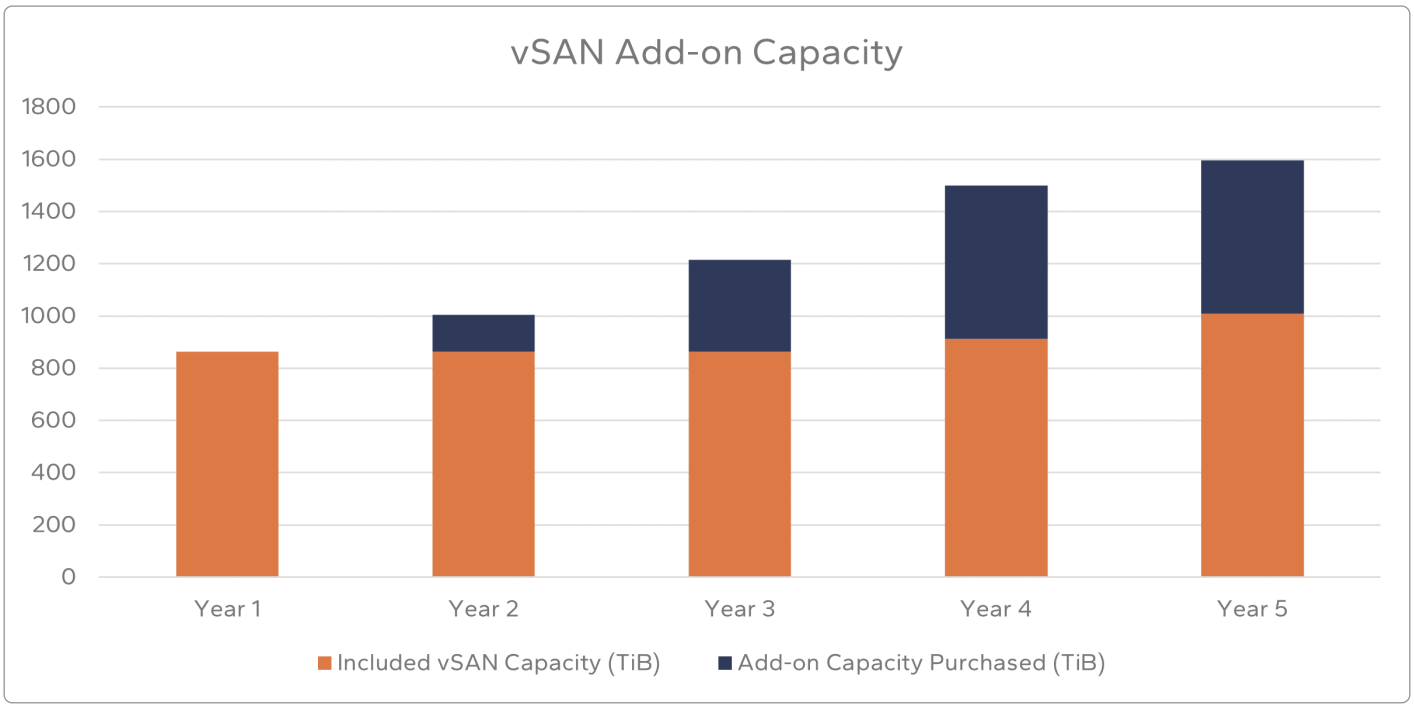


Figure 5: *vSAN Add-on Capacity*

Notably, an included capacity of vSAN licensing is available in both storage environments modeled, due to the common VCF licensing for the compute clusters. Although the vSAN environment shows a higher cost associated with VMware licensing, it should be noted that this environment capitalizes on the included storage software. Meanwhile, the SAN environment does not utilize the vSAN storage included with VCF and instead requires a full purchase of an additional storage array and resulting support.

Operational Costs

One of the main benefits of deploying vSAN is the operational simplicity it provides. vSAN is specifically designed to provide storage for VMware environments and is tightly integrated with VCF. This allows VM admins to leverage VMware tools such as vCenter, VCF Operations, and VCF Automation, reducing the overall time and complexity involved. While SAN storage can be added to a VCF environment, it involves a greater level of complexity and additional staffing requirements.

To evaluate operational efficiency, the amount of time required to perform necessary administrative tasks was measured for each system. Measurements were recorded for both initialization and setup of systems, as well as ongoing operations. Ongoing operations were organized into the following categories, each with several individual tasks:

- Storage Provisioning
- Storage Maintenance
- Storage Planning and Remediation
- Availability and Recoverability

The measured time of each task was recorded, along with how often such a task would be performed in a single year to provide a total time. For the SAN environment, tasks were measured by how much time would be attributed to a VM admin and how much time would be attributed to an additional SAN or storage admin. In the vSAN environment, it was determined that all tasks could be completed by a VM admin, without additional staff required.

While admin time did vary slightly between years due to growing capacity and added hardware, the average time required per year demonstrates the significant operational efficiency that vSAN can provide. The average admin time per year can be seen in Figure 6.

	FC SAN Storage			vSAN Storage
Item	**Storage Admin Average Hrs/Year**	**VM Admin Average Hrs/Year**	**Total**	**VM Admin Average Hrs/Year**
Initialization & Setup	2	0	2	0.47
Ongoing Operations	264	885	1,148	305.21
Storage Provisioning	17	23	40	20.9
Storage Maintenance	0	1	1	0.87
Storage Planning & Remediation	231	308	539	271.37
Availability & Recovery	16	553	569	12.07
Total Time	266	885	1,151	305.68

Figure 6: *Average Admin Time Comparison*

The operational efficiency of vSAN provides quick deployment and limited ongoing operational management, saving significant time and lowering staffing and training requirements. This additionally translates into a significant cost advantage. Admin costs were calculated using a yearly salary of $110,000 for VM admins and $165,000 for FC storage admins.

The total administrative cost for the vSAN Max environment over 5 years amounted to $83,998.75. In the SAN environment, the VM admin cost alone was much greater at $243,260.00, while additional admin time cost $109,314.86. In total, this amounted to a 76.18% savings in operational cost.

Cost Over Time

In addition to the specific costs evaluated in this study, IT organizations should also be aware of how cost is distributed over time. This can be seen by examining the individual cost per year, as seen in Figure 7.

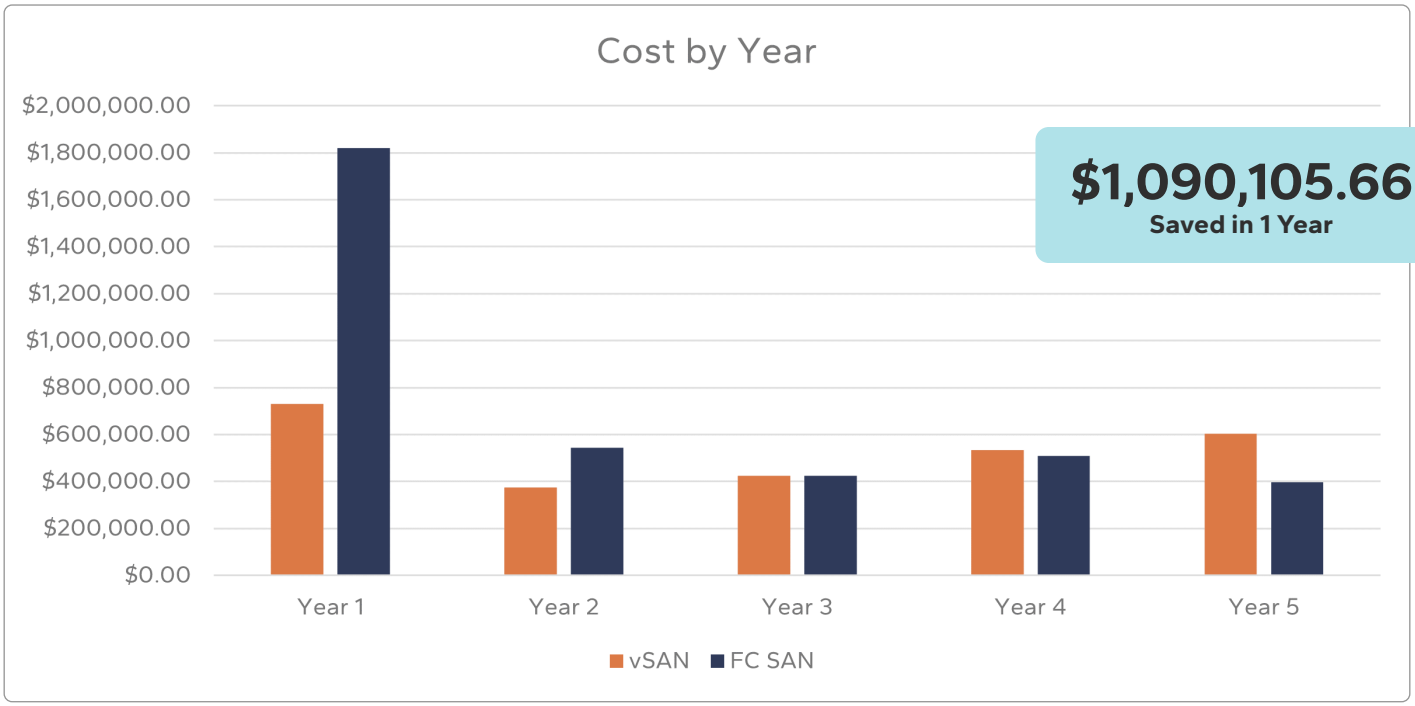


Figure 7: *Cost by Year*

While the total cost of the vSAN environment was found to be 27% less expensive over the full 5-year period, the yearly costs show that the majority of the cost savings are found in the first 2 years. In fact, the cost of the vSAN environment was found to be slightly more expensive in Years 3, 4, and 5. Despite this cost advantage in the last individual years, the large upfront cost required in the SAN environment ultimately makes the solution more expensive.

Along with its impact on total cost, the effects of this type of initial spending should be further evaluated by IT decision makers. Lower initial expenditure can provide greater financial flexibility and allow IT organizations to remain adaptable and agile. The time value of money should also be considered, as the value of money saved early on will be greater than the value of the same savings accrued later, due to the ability to grow money over time. Figure 8 displays the costs and savings found in each year, as well as their present value calculated with a 5% interest rate.

	vSAN Cost	vSAN - Present Value	FC SAN Cost	FC SAN - Present Value	Savings	Savings - Present Value
Year 1	$729,442.87	$729,442.87	$1,819,548.53	$1,819,548.53	$1,090,105.66	$1,090,105.66
Year 2	$373,709.13	$355,913.46	$542,692.14	$516,849.65	$168,983.01	$160,936.20
Year 3	$423,932.12	$384,518.93	$423,228.26	$383,880.51	($703.85)	($638.42)
Year 4	$532,829.01	$460,277.74	$508,182.46	$438,987.12	($24,646.55)	($21,290.62)
Year 5	$602,904.54	$496,011.06	$395,914.81	$325,720.10	($206,989.73)	($170,290.96)
Total	$2,662,817.68	$2,426,164.05	$3,689,566.21	$3,484,985.91	$1,026,748.53	$1,058,821.86
% Savings					27.83%	30.38%

Figure 8: *Yearly Costs and Present Value*

This chart makes it clear that although the FC SAN environment reaches a cost advantage in the later years, the savings are not enough to make up for the large spending in Years 1 and 2. Examining the present value calculations further shows the significant impact of such up front spending. By avoiding the large up-front costs of the FC SAN, the vSAN environment achieves its greatest savings in Year 1 when the value of money is the greatest. Additional spending in later years can be viewed as discounted, as the value of money is likely to be lower. This dynamic reduces the cost savings of an FC SAN environment found in later years, further reducing its impact on the total 5-year cost. By considering present value, the total cost savings of the vSAN environment over the FC SAN environment increases from 27.83% to 30.38%.

This dynamic should additionally be considered alongside hardware lifecycles. Storage hardware typically requires a refresh every 5 years. In an FC SAN environment, this entails purchase of an entirely new array, causing another large capital expense. It also limits the value of expansion hardware purchased in the later years of the system's lifecycle, as this hardware may be replaced after only a few years of use. Alternatively, in a vSAN environment using commodity servers, expansion hardware added in later years can utilize newer generation servers, which can be rolled forward as older hardware is refreshed. This creates more flexibility to refresh a vSAN cluster incrementally, avoiding large up-front purchases or refreshing hardware prematurely.

Final Thoughts

IT organizations deploying VCF to build private and hybrid cloud solutions are faced with several choices when considering data storage for their environment. Traditionally, vSAN has provided an efficient, optimized storage platform for VMware environments. However, the traditional HCI deployment of vSAN may not be efficient for some workloads. Alternatively, organizations can utilize a Fibre Channel SAN solution alongside VCF or leverage new flexible disaggregated deployments of vSAN. This analysis examined the economic factors of both solutions when deployed in an identical VCF environment. The results of the analysis demonstrated that vSAN provides a significant cost advantage and lower operational complexity than a FC SAN deployment.

vSAN achieves an economic advantage over SAN solutions due to several factors. By deploying software-defined storage, vSAN enables the use of low-cost server hardware and significantly lower support costs than dedicated storage arrays. It is additionally purpose built for VMware environments with capacity licensing included with VCF and built-in capabilities that reduce ongoing operational complexity and costs. vSAN also provides a flexible platform, allowing organizations to scale compute and storage resources as needed, while avoiding high upfront costs and costly hardware refresh cycles.

The economic benefits of deploying vSAN storage alongside VCF are further complimented by the capabilities of the vSAN ESA architecture. The new enhanced architecture was redesigned for modern, all-flash data centers and offers several benefits including, enhanced performance, greater efficiency, and better resiliency. The combination of vSAN's economic benefits alongside its technical capabilities offer a powerful virtual storage solution that is well suited for IT organizations deploying private and hybrid clouds with VCF.

Appendix

An overview of the compute environment utilized in this modeling is provided in Figure 9.

Cluster	Nodes	Cores Per Node	Total Cores
VCF Management	4	32	128
General Purpose Compute	10	32	320
Database Cluster 1	2	32	64
Database Cluster 2	2	32	64

Figure 9: *Compute Clusters*

Additional details of the servers modeled in the vSAN storage cluster can be found in Figure 10.

Compute	2 x 24 Core Processors
Memory	768 GB
Storage	Up to 15 x 15.36 TB NVMe SSDs

Figure 10: *vSAN Storage Node Server Specifications*

Details regarding the scaling of the two storage environments over a 5-year period, including the number of nodes, devices, and capacities, are detailed in Figure 11 and Figure 12.

	vSAN Nodes	Total Devices	Capacity
Year 1	6	60	921.6 TB
Year 2	6	72	1,105.92 TB
Year 3	6	87	1,336.32 TB
Year 4	7	104	1,597.44 TB
Year 5	9	125	1,920 TB

Figure 11: *vSAN Scaling Details*

	Controller Nodes	Expansion Shelves	Total Devices	Capacity
Year 1	1	2	60	921.6 TB
Year 2	1	3	75	1,152 TB
Year 3	1	3	87	1,336.32 TB
Year 4	2	3	104	1,597.44 TB
Year 5	2	4	125	1,920 TB

Figure 12: *FC SAN Scaling Details*

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