Dell EMC VxFlex Family Overview

Transformation without trade-offs

Abstract
This whitepaper provides an overview of the Dell EMC™ VxFlex family, powered by Intel® Xeon® Scalable Processors, that offers “Transformation without Trade-offs,” explaining the compelling performance, resilience and flexibility of VxFlex systems.

May 2019
Revisions

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2019</td>
<td>Initial Publication</td>
</tr>
</tbody>
</table>

Acknowledgements

This paper was produced by the VxFlex product and technical marketing teams and sponsored by Intel®.

Content Owner: Donna Brasure
# Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revisions</td>
<td>2</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>2</td>
</tr>
<tr>
<td>Table of contents</td>
<td>3</td>
</tr>
<tr>
<td>Executive summary</td>
<td>5</td>
</tr>
<tr>
<td>1 Data Center/Business IT challenges</td>
<td>7</td>
</tr>
<tr>
<td>1.1 Storage Area Network (SAN)</td>
<td>7</td>
</tr>
<tr>
<td>1.2 Multiple infrastructure and application silos</td>
<td>7</td>
</tr>
<tr>
<td>1.3 Proprietary and costly fiber channel networking requirements</td>
<td>8</td>
</tr>
<tr>
<td>2 Hyperconverged infrastructure (HCI)</td>
<td>9</td>
</tr>
<tr>
<td>2.1 Key building blocks/technologies that make HCI a reality</td>
<td>9</td>
</tr>
<tr>
<td>2.2 HCI drives IT transformation</td>
<td>10</td>
</tr>
<tr>
<td>2.3 Total business value</td>
<td>11</td>
</tr>
<tr>
<td>3 VxFlex portfolio – transformation without trade-offs</td>
<td>12</td>
</tr>
<tr>
<td>3.1 Build-to-buy continuum</td>
<td>12</td>
</tr>
<tr>
<td>3.2 VxFlex key value propositions</td>
<td>14</td>
</tr>
<tr>
<td>3.2.1 Flexibility</td>
<td>14</td>
</tr>
<tr>
<td>3.2.2 Linear scalability and elasticity</td>
<td>14</td>
</tr>
<tr>
<td>3.2.3 Predictable high performance and enterprise-grade resilience</td>
<td>15</td>
</tr>
<tr>
<td>3.3 Power positions</td>
<td>15</td>
</tr>
<tr>
<td>3.3.1 Multi-hypervisor and bare metal support</td>
<td>15</td>
</tr>
<tr>
<td>3.3.2 Server SAN / two-layer architecture</td>
<td>15</td>
</tr>
<tr>
<td>3.3.3 High performance for applications and databases</td>
<td>15</td>
</tr>
<tr>
<td>4 VxFlex OS</td>
<td>18</td>
</tr>
<tr>
<td>4.1 Software-defined server SAN</td>
<td>18</td>
</tr>
<tr>
<td>4.2 VxFlex OS building blocks</td>
<td>18</td>
</tr>
<tr>
<td>4.2.1 Storage Data Server (SDS)</td>
<td>19</td>
</tr>
<tr>
<td>4.2.2 Metadata Manager (MDM)</td>
<td>19</td>
</tr>
<tr>
<td>4.3 Design fundamentals</td>
<td>19</td>
</tr>
<tr>
<td>4.3.1 Massive parallelism</td>
<td>19</td>
</tr>
<tr>
<td>4.3.2 High performance/ low footprint</td>
<td>20</td>
</tr>
<tr>
<td>4.3.3 Flexible deployment options:</td>
<td>21</td>
</tr>
<tr>
<td>4.3.4 Elastic infrastructure</td>
<td>23</td>
</tr>
<tr>
<td>4.3.5 Simple migration</td>
<td>23</td>
</tr>
<tr>
<td>4.4 VxFlex integrated systems and VxFlex OS storage schemes</td>
<td>24</td>
</tr>
<tr>
<td>4.5 VxFlex OS management</td>
<td>24</td>
</tr>
</tbody>
</table>
Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>VxFlex OS 3.0 enhancements</td>
<td>25</td>
</tr>
<tr>
<td>4.6.1</td>
<td>Data compression and drastically reduced snapshot overhead</td>
<td>25</td>
</tr>
<tr>
<td>4.6.2</td>
<td>Non-disruptive volume migration</td>
<td>26</td>
</tr>
<tr>
<td>4.6.3</td>
<td>Volume snapshot enhancements</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>VxFlex integrated rack and VxFlex appliance</td>
<td>28</td>
</tr>
<tr>
<td>5.1</td>
<td>VxFlex integrated rack</td>
<td>28</td>
</tr>
<tr>
<td>5.2</td>
<td>VxFlex appliance</td>
<td>29</td>
</tr>
<tr>
<td>5.3</td>
<td>VxFlex integrated systems turnkey experience</td>
<td>30</td>
</tr>
<tr>
<td>5.4</td>
<td>VxFlex integrated rack with integrated networking</td>
<td>30</td>
</tr>
<tr>
<td>5.5</td>
<td>VxFlex appliance “bring your own” networking</td>
<td>31</td>
</tr>
<tr>
<td>5.6</td>
<td>Scale compute and storage together or separately</td>
<td>32</td>
</tr>
<tr>
<td>5.7</td>
<td>Use cases for shared infrastructure</td>
<td>33</td>
</tr>
<tr>
<td>5.8</td>
<td>VxFlex Manager</td>
<td>33</td>
</tr>
<tr>
<td>5.9</td>
<td>Data protection for VxFlex integrated systems</td>
<td>35</td>
</tr>
<tr>
<td>5.9.1</td>
<td>Dell EMC Data Protection Suite for Backup</td>
<td>36</td>
</tr>
<tr>
<td>6</td>
<td>VxFlex Ready Nodes</td>
<td>37</td>
</tr>
<tr>
<td>6.1</td>
<td>VxFlex Ready Nodes customer benefits</td>
<td>37</td>
</tr>
<tr>
<td>7</td>
<td>Workloads</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>Dell Technologies Services for VxFlex portfolio</td>
<td>40</td>
</tr>
<tr>
<td>9</td>
<td>Conclusion</td>
<td>43</td>
</tr>
<tr>
<td>A</td>
<td>References</td>
<td>44</td>
</tr>
</tbody>
</table>
Executive summary

Business IT departments are experiencing challenges with the shortcomings of Storage Area Networks (overprovisioning, low agility, difficult storage migration), multiple infrastructure and application silos, and proprietary and costly fiber channel networking requirements.

Many of these challenges can be successfully addressed by Hyperconverged Infrastructure (HCI) that enables compute, storage and networking functions to be decoupled from the underlying infrastructure and run on a common set of physical resources. HCI uses software-defined storage (SDS), virtualization, x86 servers and high-speed ethernet together to create an x86 server-based SAN that provides the same high levels of performance, availability, and resiliency as a traditional SAN based on advanced storage arrays, specialized Fiber Channel networking, and high-end servers. HCI vastly improves infrastructure efficiency, lowers costs, and leads to IT transformation with improved agility, scalability and simplicity.

The VxFlex portfolio offers “Transformation without Trade-offs.” VxFlex makes it possible to transform from a traditional three-tier architecture to a modern data center without any trade-offs between performance, resilience or flexibility. A “buy” deployment strategy for HCI provides a simple and effective alternative to “build-your-own” and provides the benefits of previously integrated, configured, qualified and compliant components. VxFlex Ready Nodes powered by Intel® Xeon® Scalable Processors are for organizations wanting a full build experience. The VxFlex appliance offers a turnkey experience with components pre-validated and tested, while allowing organization’s to 'bring your own networking'. VxFlex integrated rack (previously known as VxRack FLEX) offers a turnkey experience at rack-scale with integrated networking.

VxFlex systems offers key value propositions of workload, deployment and operational flexibility, linear scalability, and predictable high performance and enterprise-grade resilience. VxFlex power positions are high performance for applications and databases, multi-hypervisor and bare metal support, and two-layer SAN deployment options.

VxFlex OS® is the central software layer providing scale-out block storage service. VxFlex OS uses the Storage Data Client (SDC), Storage Data Server (SDS), and Metadata Manager (MDM) to create, consume, and coordinate the storage layer in VxFlex systems. VxFlex OS uses massive parallelism to distribute I/O across numerous paths between servers with minimal CPU and memory consumption. VxFlex OS supports traditional two-layer, HCI one-layer (fully converged), or a mix of both configurations. VxFlex OS empowers adding and removing storage and compute resources on-the-fly and provides simple non-disruptive migration.

Dell EMC VxFlex integrated rack is the most flexible HCI rack-scale system with integrated networking that supports heterogeneous environments. VxFlex integrated rack can be ordered with factory integrated data protection including RecoverPoint for VMs, Avamar™, Data Domain®, and NetWorker™. The VxFlex appliance is available with smaller starting configurations than VxFlex integrated rack, and allows user supplied networking flexibility and provides management and automation using the same VxFlex Manager as VxFlex integrated rack. Dell EMC VxFlex Ready Nodes combine Dell EMC PowerEdge™ servers powered by Intel® Xeon® Scalable Processors and VxFlex OS software to create scalable, reliable and easy-to-deploy building blocks for hyperconverged or server SAN architecture, multi-hypervisor or bare metal environments, and high-performance databases.

1 The network switch must be supported by VxFlex Manager
Executive summary

VxFlex Manager is a comprehensive IT Operations Management (ITOM) software purpose built for VxFlex integrated rack and VxFlex appliance to automate and simplify implementation, expansion and lifecycle management.

VxFlex systems handle a wide variety of production workloads, both traditional and cloud-native workloads, and customers are steadily increasing the number and, due to its unparalleled flexibility, the range of production workloads they run on their VxFlex systems.
1. Data Center/Business IT challenges

1.1 Storage Area Network (SAN)

Storage Area Networks (SAN) arose as an alternative to Direct-Attached Storage (DAS) because of limitations inherent in the tight coupling between compute resources and their storage in DAS environments. With DAS, the storage on the local host determined the amount of capacity and performance available to the application. That capacity could only be used by the local host. A SAN aggregates storage in a RAID-protected array and provides administrators the ability to partition out logical pieces of storage (LUNs) from the array to many compute nodes. Each of these compute nodes can be running a different application. SANs allow shared access to LUNs from compute nodes, providing access to a LUN from a different node if the original node failed. SANs also aggregate performance and capacity, increasing both storage performance and overall storage capacity utilization.

SANs have been an effective approach for many years meeting the requirements of separating physical storage from logical allocations of that storage and making that storage accessible from multiple hosts. SANs have other advantages that persist today. Since SANs serve raw LUNs to compute nodes, they have the advantage for their storage to be consumed by disparate clusters of hypervisors and bare metal deployments.

However, SANs have operational issues with overprovisioning, agility, and the need for storage migration. Overprovisioning is a common practice both to avoid performance problems and to keep up with expected business growth. Overprovisioned resources are wasted until applications need them. Business growth is not always predictable, and sometimes customers find themselves wasting capital expense on never utilized storage capacity. SAN capacity and performance is unbalanced with demand, even in circumstances of purely linear, predictable growth. When individual workloads are unpredictable, fluctuate, or grow massively, the siloed approach becomes even more challenging. Large and overprovisioned SAN arrays are not agile enough to cater to unpredictable and fluctuating business needs.

As storage arrays inevitably reach the end of their usable life, the process of migrating a workload from one storage array to another is difficult. Since storage arrays add capacity and performance in large chunks, this means forklift upgrades and additional rack space during the transition activity.

1.2 Multiple infrastructure and application silos

A management system that is unable to operate with any other system, one that is closed off from other systems is a silo. An IT department organizationally structured with separate departments to manage applications, storage and networks leads to an environment of individual and disparate systems. Each department typically does not share the same priorities, goals or even the same tools, so they operate as individual business units or entities within the enterprise. The lack of communication and awareness of the priorities and goals of other departments results in stranded capacity and operational complexity.

Infrastructure from multiple hardware and software vendors leads to separately managed operational silos, relying on multiple IT staff with different areas of expertise. Without centralized management, achieving security and compliance is much more difficult. When there is a problem, support issues may get stuck in circular finger pointing where vendors blame one another. Even with careful planning, upgrades run into complications and increased risk from interactions between products from different vendors.

Each product in this type of legacy stack is likely to be grossly overprovisioned, using its own resources (CPU, memory and storage) to address the intermittent peak workloads of resident applications. The value of a single shared resource pool, offered by server virtualization, is still generally limited to the server layer. All
other components, such as networks and storage, are islands of overprovisioned resources that are often not shared. Therefore, low utilization of the overall stack results in the ripple effects of high acquisition, space and power costs. Too many resources are wasted in traditional legacy environments.

The physical infrastructure consists of complex hardware silos that are difficult to manage or automate. Regular maintenance tasks and hardware outages require expensive downtime. Mitigating the problem using dedicated standby hardware is expensive. The hardware-centric architecture results in operational inefficiencies because of factors such as the limited capacity of the CPUs in running applications, a single operating system image per machine and inflexible infrastructure that is difficult to troubleshoot.

1.3 **Proprietary and costly fiber channel networking requirements**

Traditional data centers require a separate Fibre Channel network infrastructure for storage. This adds the additional cost of separate switches, Network Interface Cards (NICs) and cables. Also required are staff with specialized knowledge of Fibre Channel and the added difficulty that Fibre Channel products from different vendors do not interact cleanly.

The alternative of sharing the application Ethernet network for storage use offers the ability to eliminate the costs associated with this second network. Ethernet’s generational performance improvements have outpaced Fiber Channel to help enable this transition. Ethernet also requires fewer and less expensive ports.
Hyperconverged infrastructure (HCI) enables compute, storage and networking functions to be decoupled from the underlying infrastructure and run on a common set of physical resources that are based on industry-standard x86 components.

Figure 1 compares a traditional SAN, CI and HCI. A traditional Storage Area Network (SAN) is a three-tier architecture with storage, compute and applications connected by networking. Converged Infrastructure (CI) is the same thing, all the same elements, compute, storage and network all wrapped up together in an engineered system with consolidated management to simplify the traditional SAN approach. Traditional SANs and CI both use the more expensive fiber channel for networking. With HCI the separate silos in the traditional and CI infrastructures are eliminated. Software-defined storage running on a standard x86 server pools its Direct Attached Storage (DAS) and presents it up to applications running on the virtual machines powered by the compute elements of the server.

### Key building blocks/technologies that make HCI a reality

**Software-defined storage** – abstracts storage functions from hardware and virtualizes direct-attach storage into a shared pool of capacity that can be centrally managed just like a traditional array. It also automates many storage functions, including host provisioning and load balancing.

**Virtualization** – enables physical resources to be shared and optimized, which greatly improves efficiency and lowers risk. Virtualization transforms physical systems into a virtual environment by creating a logical version of a device or resource - anything from a server to an operating system. Virtualization helps solve problems with utilization and rapid scalability. Without virtualization, traditional server utilization is typically in only the 6% to 12% range.

**x86 servers** – today’s modern servers are extremely powerful, with high-performance processors, large amounts of memory, and flash media to deliver exceptional, predictable performance.
High-speed Ethernet – modern Ethernet switches are used to connect HCI nodes together to create a virtual, clustered pool of resources, delivering high Input/Output Operations per Second (IOPS) and low latency for even the most demanding applications.

Together, these technologies enable IT to create an x86 server-based SAN that provides the same high levels of performance, availability, and resiliency as a traditional SAN based on advanced storage arrays, specialized Fibre Channel networking, and high-end servers.

2.2 HCI drives IT transformation

HCI vastly improves infrastructure efficiency and lowers costs. The three main drivers of this improvement are agility, scalability and simplicity.

- **Agility** – Public cloud speed, efficiency, and economics within the data center
- **Scalability** – Start small and easily scale up or scale out while maintaining performance levels
- **Simplicity** – Simplify operations with software-driven automation and lifecycle management

A company that transforms its IT infrastructure no longer must rely on rigid, manual, siloed, legacy technologies. IT operational speed, efficiency, scale, and cost effectiveness are boosted. Tasks are automated, processes are streamlined, and resources are freed up. These IT-level improvements fuel a larger-scale digital transformation, allowing the company to thrive in today’s digital economy. The company can out-innovate, out-think, and out-pace its competitors, enabled to become the disruptor, not the disrupted.

Based on ESG’s research\(^2\), transformed organizations are:

- 8x more likely to be cost competitive versus public cloud
- 10x more likely to deploy apps ahead of schedule
- 2x more likely to beat revenue targets

The research cites infrastructure convergence as one hallmark of a transformed organization. 98% of the transformed companies ESG surveyed are using converged infrastructure solutions, and 86% are using both CI and HCI. In contrast, most of the Legacy organizations surveyed (56%) have not yet deployed any type of converged infrastructure.

In an April 2018 IT transformation maturity study of 4,000 IT decision makers\(^3\) 81% of customers agree that if they do not embrace IT transformation, their firm will no longer be competitive in the market. This is a 10 percent increase from the year before.

The move to HCI can be difficult, especially for medium to large organizations which have historical organizational structures resistant to the change.


2.3 **Total business value**

With HCI, multiple pre-engineered and pre-integrated components operate under a single controlled architecture with a single point-of-management and a single source for end-to-end support. HCI provides a localized single resource pool that enables a higher overall resource utilization than can be achieved with legacy infrastructure. Overall Total Cost of Ownership (TCO) is lower with operational savings from simplified management. In the data center, HCI typically has a smaller footprint with less cabling and can be deployed much faster and at lower total cost than traditional infrastructure.

By exclusively viewing and evaluating IT as a cost center, organizations are ignoring as much as two thirds of the potential business value from new technology. Years of focusing on TCO have left many IT purchasers unable to forecast or measure total business value. This creates a huge gap in the acquisition evaluation process because IT is a critical enabler of nearly every aspect of organizational effectiveness.

Business success depends upon being competitive and agile much more than it depends upon saving money. The true value of HCI is when it is a foundation in which people and processes are radically changed to be more agile. An IDC study analyzes and substantiates these transformative cost savings for a varied group of Dell EMC HCI customers⁴.

![Total business value](image-url)

---

3 VxFlex portfolio – transformation without trade-offs

VxFlex is a subset of Dell EMC’s HCI portfolio. The VxFlex portfolio is unique in offering “Transformation without Trade-offs.” Other HCI solutions offer a path to transform the data center, but forces the organization to trade-off performance, resilience or flexibility. VxFlex makes transforming from a traditional three-tier architecture to a modern data center without any trade-offs, meeting business requirements without compromise. The central software layer for VxFlex is VxFlex OS, scale-out block storage service that enables customers to create a scale-out Server SAN or hyperconverged infrastructure. The systems of VxFlex currently include VxFlex Ready Nodes, VxFlex appliance and VxFlex integrated rack. VxFlex Ready Nodes powered by Intel® Xeon® Scalable Processors are quick, reliable and easy-to-deploy building blocks. VxFlex appliance is a fully integrated, pre-validated and tested HCI appliance. VxFlex integrated rack is an engineered HCI system with integrated rack-scale network fabric. VxFlex integrated rack was previously named VxRack FLEX.

VxFlex Ready Nodes™ are managed by VxFlex OS GUI, Integrated Dell Remote Access Controller (iDRAC), and OpenManage™ Essentials (OME) to discover, deploy and manage node clusters. The VxFlex appliance and VxFlex integrated rack use VxFlex Manager, a comprehensive IT Operations Management (ITOM) software instance.

Figure 3 VxFlex portfolio

<table>
<thead>
<tr>
<th>VxFlex OS</th>
<th>VxFlex OS is a scale-out block storage service that enables customers to create a scale-out Server SAN or hyperconverged infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VxFlex Ready Node</strong></td>
<td><strong>VxFlex appliance</strong></td>
</tr>
<tr>
<td>Scalable, reliable and highly configurable</td>
<td>Simplified, economic form factor</td>
</tr>
<tr>
<td>Powered by Intel® Xeon® Scalable Processors</td>
<td></td>
</tr>
</tbody>
</table>

3.1 Build-to-buy continuum

Industry infrastructure deployment is transforming as customers begin to shift from a “build” to a “buy” approach. This deployment shift is being driven by the need for IT to focus limited economic and human capital resources on driving business innovation, which results in fewer resources available to focus on infrastructure. While a “build-your-own” deployment strategy can achieve a productive IT infrastructure, this strategy can be difficult and lengthy to implement, vulnerable to higher operating costs and susceptible to greater risk related to component integration, configuration, qualification, compliance and management. A “buy” deployment strategy for HCI provides the benefits of previously integrated, configured, qualified and compliant components. Purchasing an HCI system provides a single optimized IT solution that is quick and
easy to deploy. A “buy” deployment strategy for HCI provides a simple and effective alternative to “build-your-own” and it has been widely adopted.

Businesses have the option of building a completely customized solution, integrating storage, networking, compute, data protection, monitoring and reporting. Figuring out how to get all the hardware and software components to work together can be time consuming but provides the most flexibility. Planning, designing and building a custom solution is a complex project that often takes months or years to come to fruition, too long if a business needs to roll out a solution to address immediate business needs, and it can be costly to maintain or upgrade over the long term.

For most businesses, the best way to consume HCI solutions is to buy them fully integrated with lifecycle management and single source of support. Buying versus building delivers the best time-to-value, operational simplicity, and 5-year return on investment (ROI) of 619% over a traditional three-tier, build-your-own approach.\(^5\)

Figure 4 illustrates the VxFlex build-to-buy-continuum. The lower left corner shows the most complex deployment option implementing VxFlex OS on the organizations completely flexible choice of hardware and software components. As the deployment choices move toward the buy end of the spectrum on the right, the complexity and TCO decrease, and the speed of implementation and ease of use increase.

Figure 4 VxFlex build-to-buy-continuum

VxFlex Ready Nodes are for organizations wanting a full build experience. The VxFlex appliance offers a turnkey experience with components pre-validated and tested prior to shipping, while allowing organization’s the flexibility to ‘bring your own’ networking. VxFlex appliance moves towards the “buy” end of the spectrum

with the benefit of pre-configuration in the factory for faster deployment, and offers enhanced lifecycle management and automation utilizing VxFlex Manager. VxFlex integrated rack offers a turnkey experience at rack-scale, an engineered system with integrated networking that enables organizations to achieve the scalability and management requirements of a modern data center.

Compare the integrated networking of VxFlex integrated rack has advantages over an appliance or build-it-yourself scenario. Many things need to be considered for this solution to work over time: onsite resources, a network expert to design and plan for future growth, multiple IT teams for everything to work, complexity that often gets overlooked like bandwidth, ports, oversubscription rates, and maintaining the same performance over time. These complexities are removed with a VxFlex integrated rack engineered system with integrated switches.

3.2 VxFlex key value propositions

3.2.1 Flexibility
VxFlex emphasizes the word “flex” indicating it accommodates a wide range of flexible options. The architecture supports multi-OS, multi-hypervisor and bare metal options in the same cluster (Linux®, Windows®, ESXi™, RHV, or Hyper-V®). Customers have flexibility in deployment options and can choose two-layer or fully converged, compute or storage only, or mix and match different combinations. Notably, deploying as two-layer does not incur a performance penalty, as with other software-based systems. VxFlex OS achieves performance without requiring data locality. VxFlex supports multiple types of Flash, including NVMe and future storage class memory. There is also workload flexibility with the ability to run any mix of traditional workloads as well as new scale-out workloads. Customers have the utmost choice when it comes to workload flexibility, deployment flexibility and operational flexibility.

3.2.2 Linear scalability and elasticity
VxFlex delivers extreme performance that is linearly scalable. VxFlex OS uses a unique protocol to move storage commands over the TCP/IP layer. It is efficient, lightweight, and massively parallel, as the number of nodes is increased, performance scales up linearly. VxFlex enables customers of all sizes to support their growing and changing environment with its scalability and elasticity. With VxFlex, you can start small and grow incrementally with no bottlenecks or resiliency tradeoffs. Compute and storage can be scaled independently or together to minimize TCO. Linear scalability makes it easy to deliver consistent performance and latency.

Elasticity refers to the capability of a storage system to adapt to variable workload changes by allocating and deallocating resources as required by each application. VxFlex performs the resource allocation and deallocation in real-time without human intervention. Elasticity ensures that the application consumption level can easily grow without disruption to other running applications.
3.2.3 Predictable high performance and enterprise-grade resilience

VxFlex offers unmatched fault tolerance and meets requirements for six nines\textsuperscript{6} availability. There can be multiple protection domains in a single cluster. The hardware is designed for extensive fault tolerance and high availability, and there is no single point of failure.

VxFlex has a self-healing architecture that employs many-to-many, fine-grained rebuilds, superior to the serial rebuilds seen with most storage products. When hardware fails, data is automatically rebuilt using all other resources in the cluster. This enables a six nines availability profile while using x86 commodity hardware. A Flex system can rebuild an entire node with 24 drives in mere minutes, a fraction of the time it takes to rebuild a single drive on a traditional array. As the number of nodes is increased, rebuild times are reduced even more. Performance is predictable even in mixed workloads with high variability.

3.3 Power positions

Unmatched combination of performance, resiliency and flexibility to address enterprise data center needs. Ideal for server SAN, heterogeneous virtualized environments and high-performance databases.

3.3.1 Multi-hypervisor and bare metal support

VxFlex offers VMware\textsuperscript{®} vSphere and Red Hat\textsuperscript{®} Virtualization (RHV) integration and full stack support alongside the ability to support other hypervisors and even bare-metal configurations\textsuperscript{7} (Hyper-V, etc.). This unique ability provides workload flexibility and gives groups within the organization the ability to change requirements as needed if new projects and workloads arise without lock-in. Storage pools are not limited by ESXi/RHV clusters. VxFlex OS enables customers to deploy apps on both virtual and/or physical nodes within the same system. Storage can be gracefully repurposed and accessed by different generations of PowerEdge nodes powered by Intel\textsuperscript{®} Xeon\textsuperscript{®} Scalable Processors.

3.3.2 Server SAN / two-layer architecture

The VxFlex storage environment can be designed to resemble a traditional two-layer SAN architecture. A two-layer model provides efficient parallelism and no single points of failure. Additionally, storage and compute nodes remain separate operationally, giving teams the flexibility to manage each infrastructure independently. An organization can choose to continue with their current two-layer operational model or transform. VxFlex provides the option to combine or not combine storage and compute teams.

For VxFlex OS software only and VxFlex Ready Nodes, pre-existing external compute can consume volumes and participate in the native many-to-many relationships. With VxFlex OS there is no iSCSI bottlenecking.

VxFlex provides a way to simplify traditional SAN environments with high operational costs that are difficult to scale. Instead, customers can scale a system according to application, operational and business requirements. VxFlex is an HCI system which provides asymmetrical compute and storage expansion.

3.3.3 High performance for applications and databases

VxFlex is ideal to consolidate multiple workloads that demand high performance. VxFlex OS delivers consistent sub one millisecond (ms) response times and removes I/O bottlenecks. IOPS and throughput scale

\[\text{\textsuperscript{6} 99.9999\% availability or 31.56 seconds downtime per year}\]

\[\text{\textsuperscript{7} Bare metal option and hypervisors other than vSphere and RHV require approval}\]
linearly in direct proportion to the number of nodes added to the system, while latency remains at 1 ms. Massive I/O parallelism eliminates performance and throughput bottlenecks. Performance optimization is automatic. Rebuilds and rebalances are extremely fast and occur in the background with minimal or no impact to applications and users.

Dell EMC lab testing verifies the high performance of VxFlex integrated rack with VxFlex OS. VxFlex integrated rack achieved up to 630,000 cumulative IOPs with less than 1 millisecond latency as shown in Figure 5. These results are based on internal Dell EMC testing in January 2019, using 100% reads and 4K block size in an 8-node (8RU) R640 cluster with two protection domains that each consisted of four nodes and VxFlex OS 2.6.1. Results based on HCI Bench using ESXi 6.5. The CPU utilization on each VM was less than 35%. Results may vary based on configurations.

Figure 5  VxFlex integrated rack cumulative IOPs with less than 1 ms latency
From the same test, VxFlex integrated rack achieved up to 721,000 cumulative IOPs with less than or equal to 1.5 millisecond latency as shown in Figure 6.

Figure 6  VxFlex integrated rack cumulative IOPs with 1.5 ms latency or less

VxFlex integrated rack can achieve up to 7.4 million cumulative Transactions per Minute (TPMs) with an average read latency of 1 ms. as shown in Figure 7. These results are based on internal Dell EMC testing, January 2019, using HammerDB (TPC-C benchmark) tool in an 8-node (8RU) R640 cluster with two protection domains that each consisted of four nodes and VxFlex OS 2.6.1 and SQL 2016. Results may vary based on configurations. The average read latency was 1ms and average write latency was 2ms.

Figure 7  VxFlex integrated rack cumulative TPMs with an average read latency of 1 ms
4 VxFlex OS

4.1 Software-defined server SAN
VxFlex OS applies the principles of server virtualization to standard x86 servers with local disks, creating high-performance, sharable pools of block storage. VxFlex OS abstracts the local storage out of each contained within each server, including HDDs, SSDs, and all-flash.

VxFlex OS pools all of the storage resources together, leaving no resources stranded. In Figure 8, instead of having 100K IOPS and 10 terabytes available in each server, you now have a global pool of 1 Million IOPS and 100 terabytes. The applications are no longer constrained by what is within the local server, these resources are shared across the entire cluster.

Figure 8 VxFlex OS abstracts and pools

VxFlex OS automatically maintains balance across all resources, supporting each application’s need. Storage and/or compute can be added on-the-fly with no downtime or impact to applications because VxFlex OS seamlessly balances the available resources. This enables data center operation with the efficiency of a web-scale company, regardless of the organization size, in the most efficient and cost-effective way possible.

4.2 VxFlex OS building blocks
VxFlex OS uses three lightweight pieces of software to create, consume, and coordinate the storage layer in VxFlex systems. Installed in pre-validated Dell EMC PowerEdge servers powered by Intel® Xeon® Scalable Processors and communicating over an Ethernet fabric, these software building blocks form a set of clusters that interact to create the efficient and robust storage.

Storage Data Client (SDC)
The Storage Data Client is installed on nodes that will consume the storage volumes from the system. Because the volume’s data and copies are spread evenly across the nodes and drives that comprise the pool, the SDC communicates over multiple pathways to all of the nodes. In this multi-point peer-to-peer fashion, it
reads and writes data to and from all points simultaneously, eliminating bottlenecks and quickly routing around failed paths.

- Provides front-end volume access to applications and filesystems
- Installed on servers consuming storage
- Maintains peer-to-peer connections to every SDS managing a pool of storage

4.2.1 Storage Data Server (SDS)
The Storage Data Server is installed on every node that will contribute its storage to the system. It owns the contributing drives and together with the other SDSs forms a protected mesh from which storage pools are created. Volumes carved out of the pool are presented to the SDCs for consumption.

- Abstracts local storage, maintains storage pools, and presents volumes to the SDCs
- Installed on servers contributing local storage to the cluster

4.2.2 Metadata Manager (MDM)
The Metadata Manager software installs on 3 or 5 nodes and forms a tightly-knit cluster that supervises the operations of the entire cluster and its parts, while staying outside of the data path itself. The MDM hands out instructions to each SDC and SDS about its role and how to play it, giving each component all the information it needs but nothing more.

- Oversees storage cluster configurations, monitoring, rebalances, and rebuilds
- Highly available, independent cluster installed on 3 or 5 different nodes
- May reside alongside SDCs and/or SDSs, or on separate nodes
- Sits outside the data path

4.3 Design fundamentals

4.3.1 Massive parallelism
VxFlex OS distributes I/O across numerous paths between servers with minimal CPU and memory consumption enabling great value:

- Very high-performance aggregate of all servers’ media
- Failed media recovery in mere seconds
- Elastic capacity and linear performance
- Leaves most of the memory and CPU for applications
- Extreme flexibility!

If a storage system starts with three nodes, and three nodes are added, the number of network interconnects and rebuild paths rises from 3 to 15. The speed at which a failed disk rebuild data is re-protected is increased accordingly.
Near-linear scalability is enabled with storage parallelism, and the parallelism is dramatically increased when the server count is increased. For applications requiring extreme performance, nodes can be scaled up to 1024 servers. The distributed workload enables the storage software to only consume 10% of CPU capacity, leaving 90% of CPU capacity available for applications. Flex widely distributes data across all storage resources in the cluster, which eliminates the architectural problems of other IP-based storage systems. Because of the mobile distribution of data, software and firmware upgrades can be performed in a rolling fashion without downtime, thus requiring fewer, if any, planned outages.

4.3.2 High performance/low footprint
The VxFlex OS distributed architecture leads to high performance with a low footprint. Every SDC knows how to direct an I/O operation to the relevant destination SDS. There is no flooding or broadcasting. This extremely efficient parallelism eliminates single points of failure. There is no central point of routing, each SDC does its own routing, independent from any other SDC. The SDC has all the intelligence needed to route every request, preventing unnecessary network traffic and redundant SDS resource usage. This results in a multi-controller architecture that is highly optimized and massively parallel. It allows performance to scale linearly as the number of nodes increases. A fully converged configuration will have even higher parallelism and load distribution between the nodes. With VxFlex OS, all of the IOPS and bandwidth of the underlying infrastructure are realized by a perfectly balanced system with no hot spots. With no metadata in the data path, there is no scaling limitation that exists within other architectures.

Lightweight communications at every level enable many benefits:

- High availability and load balancing at every level
- Lightweight meta-data management and access
- Direct data access for clients, no critical path, no iSCSI bottleneck
- Non-RAID, SAN-like back-end storage pools
- No data locality constraints

Any combination of the fully converged and two-layer configuration options is valid and operational. Figure 10 shows an example of the maximally fully converged configuration for ten nodes with 25 (of 45) paths shown.
4.3.3 Flexible deployment options:
VxFlex OS supports traditional two-layer, HCI one-layer (fully converged), or a mix of both configurations.

4.3.3.1 Modern one-layer hyperconverged (HCI) deployment
In a modern one-layer hyperconverged (HCI) deployment, the SDCs and SDSs run on the same set of nodes. This deployment maximizes hardware utilization and reduces infrastructure requirements.

In HCI deployments with storage servers and clients running on the same physical nodes, the resource utilization efficiency of the overall stack (storage, CPU and memory) is extremely high. This approach works very well in environments where a single group manages both storage and compute.
4.3.3.2 Traditional two-layer server and storage

In many environments, traditional SAN is supported by a storage team, and the compute resources are managed by a separate team. VxFlex systems work well in these environments because of the unique way VxFlex OS can be deployed on the nodes. In a two-layer (also known as storage-only) deployment, compute resources exist on one set of nodes and storage resources exist on another set of nodes.

A two-layer deployment provides operational autonomy between existing teams of application owners and storage professionals. Two-layer deployments also allow compute and storage resources to grow independently. In two-layer deployments, existing compute and storage teams can work together to build a large-scale, software defined infrastructure.

Figure 12  VxFlex OS two-layer server and storage deployment

4.3.3.3 Mixed HCI/modern and traditional deployment

VxFlex OS also enables deployments that mix the one and two-layer deployments. This flexibility allows organizations to adopt both approaches and enable each of an organization’s departments to choose the model that best aligns to their processes.

Depending on the VxFlex hardware on which VxFlex OS is running, these configurations can be mingled within a single rack or cluster.

Because VxFlex OS is software-based, it is possible to convert a two-layer deployment to a hyperconverged deployment over time. Converting a two-layer deployment to a HCI deployment is simply a matter of adding SDS components to existing compute nodes and adding SDC components to existing storage nodes.
4.3.4 Elastic infrastructure

VxFlex OS also has a unique and highly parallelized architecture which creates an elastic infrastructure. VxFlex OS empowers adding and removing storage and compute resources on-the-fly. Additions and removals can be done in small or large increments because the VxFlex OS system automatically reconfigures itself as the underlying resources change to optimize performance and enhance resiliency. Data is rearranged and spread across the servers without requiring operator intervention. This eliminates the need for costly and disruptive data migrations.

Supported operations include:

- Auto-balance of resources across nodes/clusters
- Auto-rebalance storage dynamically when nodes or disks are added or removed
- Auto-rebuild when resources fail then heal
- Auto-rebuild when resources are removed
- Handle additions and removals simultaneously

4.3.5 Simple migration

There always come a time when new generations of servers and storage media create enough value to justify hardware upgrades. Server migrations are accomplished by simply adding new servers and decommissioning old ones. Using the various automation tools like VxFlex Manager to add and remove servers, VxFlex OS will non-disruptively expand and rebalance the data across the cluster.
4.4 VxFlex integrated systems and VxFlex OS storage schemes

VxFlex integrated rack storage layout includes Protection Domains, Storage Pools and Fault Sets.

A **Protection Domain (PD)** is a group of nodes or SDSs that provide data isolation, security and performance benefits. A node can only participate in one Protection Domain at a time. Only nodes in the same PD can affect each other, nodes outside the PD are isolated. Secure multi-tenancy can be created with PDs since data will not mingle across PDs. Different PD can be created for different node types with unequal performance profiles.

**Storage Pools** are a subset of physical storage devices in a PD. Each storage device belongs to one (and only one) Storage Pool. The best practice is to have the same type of storage devices (HHD versus SSD) within a Storage Pool to ensure that the volumes will be distributed over the same type of storage within the PD.

A **Fault Set** is a logical entity that contains a group of SDSs within a PD, that have a higher chance of going down together, for example if they are all powered in the same rack. By grouping them into a Fault Set, VxFlex OS will mirror data for a Fault Set on SDSs that are outside the Fault Set. Thus availability is assured even if all the servers within one Fault Set fail simultaneously.

![Example of Protection Domain, Storage Pools and Fault Sets](image-url)

4.5 VxFlex OS management

VxFlex OS management is available via a GUI, CLI, and REST clients. There is a VMware vSphere® plug-in that allows VMware admins to deploy, upgrade, configure and manage VxFlex OS in an ESX® environment within VMware vSphere.

Figure 15 shows the VxFlex OS GUI Dashboard which displays the overall system status. Each tile displays a certain aspect of the storage system. The dashboard display can be customized. The GUI can be used for most management tasks.
VxFlex OS 3.0 enhancements

VxFlex OS continues its evolution with significant new features available through a seamless upgrade experience. VxFlex OS 3.0 introduces new functionality around space efficiency, data management, data integrity, and support for the VxFlex appliance.

4.6.1 Data compression and drastically reduced snapshot overhead

VxFlex OS 3.0 adds a completely new storage layout option, with a new storage architecture, in addition to the existing method of storing data. The traditional layout, in which volumes are divided into 1MB allocation units, distributed and replicated across all disks contributing to a pool, is now referred to as the Medium Granularity (MG) layout. The new layout is more space efficient, with an allocation unit of just 4KB and a physical data placement scheme based on Log Structure Array (LSA) architecture. This new Fine Granularity (FG) layout requires both Flash media (SSD or NVMe) as well as NVDIMM in order to create an FG pool. FG layout is thin-provisioned and zero-padded by nature, and enables VxFlex OS to support in-line compression, more efficient snapshots, and persistent checksums.

MG storage pools support either thick or thin-provisioned volumes, and no attempt is made to reduce the size of user-data written to disk (except with all-zero data). FG pools support only thin-provisioned, “zero-padded” volumes, and whenever possible the actual size of user-data stored on disk will be reduced. Users should expect an average compression ratio of at least 2:1. Because of the 4K allocation, FG pools drastically reduce snapshot overhead, because new writes and updates to the volume’s data do not each require a 1MB read/copy action. All data written to an FG pool receives a checksum and is tested for compressibility. The checksum for every write is stored with the metadata and adds an additional layer of data integrity to the system.
In effect, with VxFlex OS 3.0, there are two distinct storage systems in one platform, each with its own advantages and use cases. Users are free to choose between both layouts. A system can support both FG and MG pools on the same SDS nodes, and volumes can be non-disruptively migrated between the two layouts. Within an FG pool, compression may be enabled or disabled on a per-volume basis.

VxFlex OS offers a distinctive, competitive advantage with the ability to enable compression per-volume versus globally, and the ability to choose the best layout for each individual workload. The MG layout is still the best choice for workloads with high performance requirements. FG pools offer space-saving services and additional data integrity. Within an FG pool, enabling compression or making heavy use of snapshots has almost zero impact on the performance of the volumes.

FG pools have the same elasticity and scalability properties of MG pools. They are a great choice for most cases where data is compressible and where space efficiency is more important than raw I/O. This is true especially in use cases where there is heavy snapshot usage, including DevOps and Test/Dev environments. Users might choose FG non-compressed volumes when the data is not compressible (e.g. OS or application-level encryption) but many snapshots are used, and space savings are important, or when persistent checksums are required. Whatever layout is chosen is not a fixed choice, because volumes can be migrated "live" to another pool if the business expectations or requirements change.

Figure 16  VxFlex OS 3.0 dashboard showing capacity utilization compression ratios

### 4.6.2 Non-disruptive volume migration

Prior to VxFlex OS 3.0, a volume was bound to a Storage Pool on creation and the binding could not be changed later. There are several use cases where volume migration would be useful:

- Migrating volumes between different storage performance tiers
- Migrating volumes to a different Storage Pool or Protection Domain (PD) driven by multi-tenancy needs
- Extract volumes from a deprecating Storage Pool or Protection Domain to shrink a system
- Change a volume personality between Thick/Thin or FG/MG
Migrating volumes from one Storage Pool migrates the volume and all its snapshots together (known as V-Tree granularity). Migration is non-disruptive to ongoing I/O and is supported across Storage Pools within the same PD or across PDs.

Figure 17  VxFlex OS non-disruptive V-Tree Migration

4.6.3 Volume snapshot enhancements
Prior to VxFlex OS 3.0 a volume tree (V-Tree) was limited to 32 items, the root volume plus 31 snapshots. In 3.0 the limit is increased to 128, supporting 127 snapshots. Snapshots in FG storage pools are more space efficient and have better performance in comparison to MG snapshots. VxFlex OS 3.0 also added the capability to remove the parent of a snapshot and in-effect promote the child snapshot to parent.

It is also now possible to implement snapshot policies based on a time retention mechanism. Users can define up to 60 policy-managed snapshots per root volume. A snapshot policy defines a cadence and the number of snapshots to keep at each level. For example, Figure 18 illustrates a cadence of hourly backups after which the policy retains an hourly backup from the most recent day, a daily backup for a week, and a weekly backup for 4 weeks.

Figure 18  Snapshot policy example
5 VxFlex integrated rack and VxFlex appliance

5.1 VxFlex integrated rack

Dell EMC VxFlex integrated rack is the most flexible HCI rack-scale system with integrated networking that supports heterogeneous environments.

Figure 19  VxFlex integrated rack

Compelling benefits compared to traditional SAN environment

- 6x faster time to value with 90% lower admin costs
- 82% decrease in time to deploy infrastructure
- 50% less initial purchase cost\(^8\)

Hardware components

- Dell EMC PowerEdge servers (24 1U / 15 2U / any combo)
- Cisco Nexus\(^{®}\) 9K ToR/Aggregation switches (multi-rack)
- Cisco Nexus 9K access switches
- Cisco Nexus 3K management switches
- VxFlex controller (three nodes)
- Intelligent physical infrastructure cabinet with smart Power Distribution Units (PDUs), HID reader and thermal sensors

\(^8\) Wikibon Research- Hyperconverged Infrastructure as a Stepping Stone to True Hybrid Cloud, April 2017

Software components

- VxFlex OS
- Multi-OS/multi-hypervisor (integrated ESXi or RHV with full stack support, others supported using bare metal and require approval)
- Management and support tools: VxFlex Manager, VxFlex OS GUI, VMware vCenter (with VxFlex OS plug-in), Red Hat Virtualization Manager

5.2 VxFlex appliance

VxFlex appliance is an HCI system ideal for high-performing, multi-hypervisor environments that is easy to acquire, own, and scale. VxFlex appliance offers a turnkey experience as the components are validated and tested prior to shipping and allows customers the flexibility/savings to ‘bring your own’ networking.

The VxFlex appliance is available with smaller starting configurations than VxFlex integrated rack. It offers enhanced lifecycle management and automation using VxFlex Manager more than available for VxFlex Ready Nodes. VxFlex Manager provides software alerting, monitoring, reporting and lifecycle management.

Compelling benefits

- Lower admin costs, decreased deployment time, and lower cost compared to traditional SAN
- Economic form factor
- Custom config-to-order with the benefit of pre-configuration in the factory for faster delivery
- Bring your own networking

Hardware components

- Dell EMC PowerEdge servers starting with as few as 3 nodes for test/dev
- Management can run on a VM saving the need for controller nodes

Software components

- VxFlex OS (support starting with version 3.0)
- Multi-OS/multi-hypervisor (integrated ESXi or RHV full stack support, others supported using bare metal and require approval)
- Management and support tools: VxFlex Manager, VxFlex OS GUI, VMware vCenter (with VxFlex OS plug-in), Red Hat Virtualization Manager

---

9 The network switch must be supported by VxFlex Manager
5.3 **VxFlex integrated systems turnkey experience**

Dell EMC HCI is the fastest and least risky way to modernize.

**Engineered**

VxFlex integrated systems are engineered according to strict standards and best practices, lowering cost and risk versus build-your-own.

Deploying VxFlex integrated rack is an easy turnkey experience. Only Dell EMC has hundreds of engineers that are standardizing data center architectural design, system design and complete lifecycle management to take the heavy burden of planning, integrating and sustaining converged infrastructure from the customer and making it simple and low risk for customers to deploy and operate over time.

**Manufactured**

ISO-certified manufacturing for integrating all components provides a faster time-to-value. Each VxFlex integrated rack system is fully tested and pre-configured in Dell EMC’s state of the art manufacturing facilities in the US and EU to build systems to exacting standards so they operate the same everywhere around the world.

**Managed**

VxFlex integrated rack systems are simpler to deploy, scale, upgrade, secure, and monitor. The health and lifecycle of all components are managed together. As an HCI system VxFlex integrated rack provides simplified management, breaking down IT silos by creating a single pool of virtualized resources that can be shared. This leads to faster deployments, simpler upgrades and expansions, and a streamlined support model when issues arise. And because the infrastructure is virtualized and based on software, many traditional management tasks that were manual can be automated, often through a single tool set. This greatly simplifies the ongoing provisioning, troubleshooting, and lifecycle operations in the data center.

**Supported**

Dell Technologies Services help simplify lifecycle operations of VxFlex integrated rack systems. Dell Technologies support teams have expertise in all components of VxFlex integrated rack systems: compute, storage, network and virtualization. This translates into simplified problem resolution with single call support which maintains accountability even through escalations to Cisco or VMware. And with Dell Technologies proactive support tools problems are resolved in a timely manner. Additionally, Dell Technologies hardware expansion services ensure new components integrate efficiently with the overall system, and software expansion services ensure systems are up to date and performing optimally.

**Sustained**

Sustaining VxFlex integrated rack is easy with pre-tested, pre-certified code upgrades for all components, reducing downtime and lowering the cost and risk of upgrades. Full lifecycle for hardware and software is delivered via a comprehensive set of architected, designed, validated, and documented standards called the Release Certification Matrix (RCM). The RCM provides the highest levels of assurance that Dell EMC HCI systems will simply work. Dell EMC has documented processes and procedures for evolving the RCM over time and for updating Dell EMC systems throughout their lifecycle. VxFlex integrated rack offers lifecycle management via pre-tested/pre-validated single-click upgrades.

5.4 **VxFlex integrated rack with integrated networking**

VxFlex integrated rack with integrated networking is designed with sufficient bandwidth capacity to support the system as the number of nodes grow, eliminating the need for complex calculations. VxFlex integrated rack uses a set of Top of Rack (ToR) switches for 25GbE connections to the nodes, providing plenty of
bandwidth as capacity is pooled. Once the first rack is filled, a set of aggregation switches provides 10/40 or 100GbE IP uplink connectivity to the external network for superior performance.

When the number of expected nodes is anticipated to scale beyond ToR aggregation limits, Dell EMC Vscale spine and leaf architecture is used and able to support configurations that can scale above 1000 nodes.

Each VxFlex integrated rack node contains:

- 4*25GB connections for data traffic
- 1*1Gbps for Management (IPMI)
- Link connections are aggregate bandwidth
- Traffic separation and QOS/COS is pre-configured to maintain systems availability and performance

Each VxFlex integrated rack node connects to dedicated data path switches with redundant switch paths that enable maximum systems bandwidth with fault tolerance.

Figure 21  VxFlex integrated rack high level rack components

5.5  VxFlex appliance “bring your own” networking

VxFlex appliance provides greater network flexibility than the VxFlex integrated rack as a result of not offering a turnkey networking solution. It is required for the network switch to be in the support list for VxFlex Manager.
5.6 Scale compute and storage together or separately

VxFlex systems enable an organization to get started with an HCI infrastructure while maintaining a similar structure to traditional SAN. Organizations that prefer separation between storage and application teams are supported. VxFlex integrated systems allow scaling of storage needs separately from the application servers, so financial resources can be spent only on needed resources. Similarly, compute can be scaled independently providing flexibility for applications with specific CPU requirements (Oracle, Splunk, SAP HANA).

Figure 22  VxFlex integrated rack flexible scaling of compute and storage

With VxFlex integrated systems there is an ability to start small with a lower capital expense investment. Additionally, nodes can be scaled in smaller increments, adding smaller amounts of compute or storage capacity as required versus the traditional larger bundles of servers or storage arrays.

Figure 23  Start small and scale efficiently
5.7 **Use cases for shared infrastructure**

Both VxFlex integrated systems support any high-performance database and application at any scale. It supports, Red Hat Virtualization (RHV) by itself, VMware by itself or a combination of both. It is a best practice to run the hypervisors in separate clusters, but for maximum flexibility they can be run from the same cluster. VxFlex integrated rack can support bare metal nodes enabling the running of any hypervisor\(^\text{10}\) and support any application. VxFlex integrated systems rack can start small and grow to support an organization’s many applications with up to 1024 nodes per cluster.

Figure 24  VxFlex integrated rack use cases for shared infrastructure

5.8 **VxFlex Manager**

VxFlex Manager is a unified management and automation solution for the VxFlex integrated rack and the VxFlex appliance that enables template-based provisioning of infrastructure and workloads. It provides monitoring, alerting and health status of hardware and services. It simplifies and automates lifecycle management of diverse and heterogeneous IT resources. It enables users to respond rapidly and reliably to dynamic business needs.

VxFlex Manager is a comprehensive IT Operations Management (ITOM) software purpose built for VxFlex to automate and simplify implementation, expansion and lifecycle management.

VxFlex Manager brings together multiple management consoles, workflow automation and an intuitive interface that allows customers to monitor, manage, deploy and maintain physical and virtual resources with the click of a button. Key tenets of the VxFlex Manager architecture include:

- System assurance: compliance and non-disruptive remediation
- Insights: monitoring, alerting, and health checks
- Implementation simplification: simplified and automated system deployment and workflows
- Node serviceability: single-button take node out of and back into service
- Hypervisor update: single-button upgrade of hypervisor

---

\(^{10}\) Preapproval required for bare metal and other hypervisors
VxFlex Manager provides alerting and monitoring on node hardware (Dell EMC PowerEdge servers powered by Intel® Xeon® Scalable Processors). These monitoring capabilities proactively detect errors and when connected to Dell EMC Secure Remote Support (SRS), provide remote alerting and protection for system nodes. Remote monitoring enables you to easily establish a stateless compute environment, so you can achieve greater agility and control of your server node resources. When node maintenance operations are required, or in the case of a disaster recovery incident, failures are quickly identified, and Dell EMC Support is informed immediately for speedy resolutions. This proactive alerting and automated technical support mean less time is spent troubleshooting so more time can be spent addressing business priorities.

By leveraging a powerful reporting engine, customized reports are also available and provide easy access to specific node information as needed.

The VxFlex Manager architecture delivers a wide range of services to support VxFlex integrated rack including nodes, switches, VxFlex OS, and other hypervisors. It also supports the latest 14th generation node configurations.
5.9 Data protection for VxFlex integrated systems

Dell EMC’s approach is to deliver data protection everywhere it is needed. Data protection is available where needed from traditional on-premises to virtualized infrastructure, to converged infrastructure, to cloud. Regardless of Recovery Point Objectives (RPO) and Recovery Time Objectives (RTO) requirements Dell EMC solutions cover the continuum of data protection requirements from continuous availability all the way to archiving. Dell EMC data protection offers complete choice and flexibility in deploying solutions from traditional best-of-breed hardware and software to converged applications to software defined and As-a-Service.

Figure 26  Dell EMC data protection continuum

VxFlex integrated rack can be purchased with factory-integrated data protection which has many benefits:

- Faster deployment, less risk, optimized performance at any scale
- Data protection backed by Dell EMC RCM
- Fully assembled at factory
- Architected for the VxFlex integrated rack
- 70% of implementation/config performed at factory
- Single-call support
5.9.1 Dell EMC Data Protection Suite for Backup

Data Protection Suite for Backup is an industry-leading backup and recovery software solution. It delivers data protection to a variety of enterprise organizations by providing the flexibility to mix and match components to quickly optimize performance and data protection today and in the future. Data Protection Suite for Backup supports many different deployment models, including deduplication backup, backup to disk, snapshot-based backup, and backup to tape. Offering centralized data protection management with comprehensive reporting, monitoring, and analysis for physical and virtual environments, the Suite for Backup provides reduced management time and lower overall TCO. This cloud enabled offering enables backups of data and applications within the public cloud, as well as secure long-term retention of backups to the cloud.

VxFlex integrated rack customers with the integrated backup system receive support for all components of the Data Protection Suite for Backup with an integrated support experience for:

- RecoverPoint for VMs
- Avamar
- Avamar + Data Domain
- Avamar Virtual Edition (AVE) + Data Domain
- NetWorker + Data Domain
- Data Protection Suite (DPS)

**RecoverPoint For Virtual Machines**

Dell EMC RecoverPoint™ for Virtual Machines redefines data protection for VMware virtualized environments. It protects Virtual Machines (VMs) at VM-level granularity with local or remote replication for recovery to any Point-in-Time (PiT), and synchronous or asynchronous replication over any distance with efficient WAN bandwidth utilization. With near-zero RPO to ensure business continuity, RecoverPoint for VMs simplifies disaster recovery with built-in orchestration and automation capabilities directly accessible from VMware vCenter.

**Avamar**

Dell EMC Avamar enables fast, efficient backup and recovery through its integration with Data Domain as well as its integrated variable-length deduplication technology. Avamar is optimized for fast, daily full backups for cloud, virtual and physical environments, network-attached storage (NAS), enterprise applications remote offices and desktops/laptops. By deduplicating data with Data Domain backup storage is reduced by up to 36x, backup times by 50% and network bandwidth consumption can be reduced by up to 99%. All data is always encrypted and compressed in-flight to meet security and compliance regulations. With Dell EMC Data Domain Cloud Tier, Avamar delivers highly efficient and secure long-term retention (LTR) of backups to the cloud. Avamar Virtual Edition (AVE) can simplify deployment of data protection within a VxFlex integrated rack system.

**NetWorker**

With enterprise-level performance and flexibility, Dell EMC NetWorker backup and recovery software centralizes, automates and accelerates data backup and recovery across the customer IT environment to protect critical business data in a fast, secure and easy to manage way. By deduplicating data with Data Domain backup storage is reduced by up to 36x, backup times by 50% and network bandwidth consumption can be reduced by up to 99%. With Data Domain Cloud Tier, NetWorker delivers highly efficient and secure long-term retention (LTR) to the cloud.
VxFlex Ready Nodes

Dell EMC VxFlex Ready Nodes combine Dell EMC PowerEdge servers powered by Intel® Xeon® Scalable Processors and VxFlex OS software to create scalable, reliable and easy-to-deploy building blocks for hyperconverged or server SAN architecture, multi-hypervisor or bare metal environments, and high-performance databases.

Dell EMC VxFlex Ready Nodes scale from as few as three up to thousands of nodes while providing one large pool of storage and eliminating “islands of SANs” from the data center. They also optimize storage and compute resources to reduce capacity planning and enable a “pay-as-you-grow” buying model.

Each VxFlex Ready Node consists of a full production version of the latest VxFlex OS software and pre-configured Dell EMC PowerEdge servers. Both storage-only or hyperconverged configuration options are supported. Dell EMC PowerEdge servers are tuned and optimized for the configuration.

Systems built with VxFlex Ready Nodes consist of a minimum of three nodes per cluster, with an ability to increase in single-node increments. The maximum node count supported is 1,024 nodes per cluster.

VxFlex Ready Nodes customer benefits

Quick and easy deployment
Dell EMC VxFlex Ready Nodes reduce the time IT spends planning and deploying new architectures. Dell EMC VxFlex Ready Nodes are configured, tuned and optimized to simplify deployment and ease scaling projects. Ready nodes are built on validated and tested PowerEdge Servers, with components that follow Dell EMC approved manufacturers’ lists (AMLs) for firmware, BIOS versions and more. Ready nodes are delivered with the complex configuration steps completed and tested in a known good configuration, including hardware compatibility list (HCL) lookup, HCL driver downloads, VMware® ESXi install, and driver installs. Ready nodes are easy to deploy, operate and manage with VxFlex OS GUI, iDRAC, and OME. Ready Nodes are fully supported by a single vendor, Dell EMC, for streamlined, collaborative support from the first call.

Enterprise-grade resilience
Designed for extensive fault tolerance and availability, Dell EMC VxFlex Ready Nodes handle failures of media, connectivity and nodes, software interruptions and more. No single point of failure can interrupt the I/O service. In many cases, the solution can overcome multiple points of failure as well. Dell EMC PowerEdge R640, R740xd, and R840 servers are a perfect foundation, with automated management and high-availability features, such as redundant power-supply units (PSUs), hot-pluggable and hot-swappable PSUs, hard disk drives (HDDs) and fans, and a dual SD card option for fail-safe hypervisors. In addition, Dell EMC VxFlex Ready Nodes support and integrate with the Dell EMC data protection services that organizations are accustomed to when protecting traditional database applications, such as Oracle, SQL Server, and SAP.

Scalable performance
Dell EMC VxFlex Ready Nodes are designed to massively scale from three to thousands of nodes. Unlike most traditional storage systems, as the number of storage devices grows, so do throughput and IOPS. The scalability of performance is linear with the number of deployed nodes. Storage and compute resources (such as servers and drives) can be added modularly so that resources can grow individually or together to maintain balance. Every server in the cluster is used in the processing of I/O operations, making I/O and throughput accessible to any application within the cluster. Throughput and IOPS scale in direct proportion to the number of servers and local storage devices added, improving cost/performance rates with growth. Plus, Dell EMC VxFlex Ready Nodes are based on Dell EMC PowerEdge servers, which deliver higher core counts for I/O intensive applications, reducing bottlenecks and further improving performance.
Workloads

VxFlex systems handle a wide variety of production workloads. VxFlex can support a wide variety of traditional and cloud-native workloads, and many customers are increasing the number of production workloads they run on their HCI infrastructure. In fact, according to ESG, most HCI customers run anywhere between 10% - 40% of their production workloads on HCI. This rapid rate of adoption is likely to grow even more in the next few years.

Table 1 lists examples of the sheer performance of VxFlex integrated rack evident in actual customer usage in verticals across the board. From a large healthcare in the northeast using it for a data warehouse project, to a financial firm looking to increase I/O performance to a large multinational organization running SAP with ultra-low latency and reduced reporting from 6 days to 2 hours. The performance from VxFlex OS can be incredible.

Table 1  Key workloads where VxFlex integrated rack performance matters

<table>
<thead>
<tr>
<th>Workload</th>
<th>Tech value prop</th>
<th>Customer example</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Warehouse</td>
<td>High bandwidth for large write I/O ingestion</td>
<td>Large healthcare in Northeast</td>
<td>Scientists analyzing 8x more data per day than before, reducing time to value for disease prognosis and cures</td>
</tr>
<tr>
<td>Splunk</td>
<td>High bandwidth in small footprint, start small/grow big</td>
<td>Large bank holding company in Columbus, Ohio</td>
<td>12x increase in I/O performance during heavy data ingestion for faster data analysis</td>
</tr>
<tr>
<td>Oracle</td>
<td>Low latency for transactional I/O</td>
<td>Healthcare data services company</td>
<td>Eliminated $2m/year penalties being paid for missed latency SLA’s</td>
</tr>
<tr>
<td>Epic</td>
<td>Approved for Epic VDI and Database</td>
<td>Healthcare data services</td>
<td>Support for full Epic stack (front and back-end) with high performance</td>
</tr>
<tr>
<td>SAS</td>
<td>High bandwidth in small footprint, start small/grow big</td>
<td>Pharmaceutical company</td>
<td>1/5th the time required to process pharmaceutical trial data</td>
</tr>
<tr>
<td>SAP</td>
<td>Ultra-low latency for High I/O</td>
<td>Multinational commercial and consumer conglomerate company</td>
<td>Reduce end of month ERP Reporting from 6 days to 2 hours</td>
</tr>
</tbody>
</table>

VxFlex integrated rack can run applications together. Customers that start with generic general VMware workloads move more workloads over as they discover that they run well together.
Figure 27 lists more of the workloads that VxFlex integrated rack are running sorted by industries. There is wide variance including mission critical, investment firm applications, SQL on VMware, big data and analytics, one of the largest hotel chains runs their reservation system, one of the biggest grocery stores runs their warehouse robotic application.

Figure 27  VxFlex integrated rack workload industry examples

IDC interviewed 10 organizations to quantify the business value of VxFlex integrated rack\(^\text{11}\) as seen in Figure 28. A core benefit of the VxFlex integrated rack agility, scalability, and flexibility is improved productivity of application development teams. Dynamically provisioning storage resources means that application developers have real-time access to testing environments resulting in business applications delivered in 32% faster, and the time between requests for applications/services being made and delivery is shortened by 26%. The ease of provisioning storage enables application developers to do more, while automation, streamlined provisioning, and higher reliability save IT infrastructure staff time on activities such as data migrations and capacity planning. IDC projects that interviewed organizations will achieve IT staff productivity gains worth an average of $259,900 per 100TB per year.

Figure 28  Business Value of VxFlex integrated rack

---

\(^{11}\) IDC White Paper | Business Value of VxRack
Dell Technologies Services for VxFlex portfolio

In today's highly competitive market and rapidly evolving advances in digital technologies, businesses face many IT staffing challenges. Companies that strive to remain competitive not only need to deploy, maintain and continually update and expand their IT infrastructure, they also need to develop and execute digital strategies that can truly transform their business. However, a recently commissioned study conducted by Forrester Consulting on behalf of Dell EMC confirms that 48% of companies do not believe they have the right expertise to deploy new CI/HCI infrastructure; 47% believe deployment creates a disruption in processes or operations; and 46% believe ongoing support functions take too much of their IT staff’s time.¹²

Dell Technologies Services cover a wide range of business needs. Whether companies need a little or a lot of help some or all the time, locally or on a global scale, or from the datacenter to the edge, Dell Technologies Services are built on best practices that can fit the bill. The Forrester study found that companies that supplemented their IT departments with their IT partner’s services benefited in several ways as shown in Figure 29.

Figure 29  Benefits to IT departments supplementing with their IT partner’s services

With Dell Technologies Services, companies can quickly integrate hyperconverged infrastructure into their IT environment and simplify lifecycle operations of their virtualized systems:

- **Deployment**: In-region project management, in-factory logical configuration, onsite implementation and validation
- **Residency Services**: accelerated technology transitions and optimized data centers
- **Single point of contact**: for cross-vendor server, storage and networking support
- **Hardware Expansions**: proven process to install and configure new components
- **Software Upgrades**: pre-tested software upgrades to keep systems performing optimally
- **Proactive support**: Support Assist and Secure Remote Services enable proactive maintenance

¹² 2019 Forrester Thought Leadership Paper commissioned by Dell EMC
## Table 2  Dell EMC Support and Offerings

<table>
<thead>
<tr>
<th>VxFlex Ready Node</th>
<th>ProDeploy and ProDeploy Plus</th>
<th>ProSupport and ProSupport Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>VxFlex appliance</td>
<td>ProDeploy Plus</td>
<td>ProSupport and ProSupport Plus</td>
</tr>
<tr>
<td>VxFlex integrated rack</td>
<td>Deployment services</td>
<td>Core, Plus and Premier Support</td>
</tr>
</tbody>
</table>

As shown in Figure 30, ProDeploy Enterprise Suite helps companies get more out of technology starting on day one. Trust Dell EMC experts to lead deployments from basic hardware installations through planning, configuration and complex integrations.

**Figure 30  Dell EMC ProDeploy Enterprise Suite**

<table>
<thead>
<tr>
<th>Pre-deployment</th>
<th>Deployment</th>
<th>Post-deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single point of contact for project management</td>
<td>Deployment service hours</td>
<td>Deployment verification</td>
</tr>
<tr>
<td>Site readiness review</td>
<td>Onsite hardware installation*</td>
<td>Configuration data transfer to Dell EMC technical support</td>
</tr>
<tr>
<td>Implementation planning</td>
<td>Packaging materials disposal</td>
<td>30-days of post-deployment configuration assistance</td>
</tr>
<tr>
<td>Technology Service Manager (TSM) engagement for ProSupport Plus entitled devices</td>
<td>Install and configure system software</td>
<td>Training credits for Dell EMC Education Services</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ProDeploy</th>
<th>ProDeploy Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-region</td>
<td></td>
</tr>
<tr>
<td>24x7</td>
<td>24x7</td>
</tr>
<tr>
<td>Remote</td>
<td>Onsite</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13 The VxFlex integrated rack currently falls under Core, Plus and Premier brands and will soon migrate to the ProSupport and ProDeploy brand offers.
As shown in Figure 31, ProSupport Enterprise Suite is designed to help you get the most out of your investment with the support technologies and expertise Dell EMC is known for across the globe. The ProSupport Enterprise Suite doesn’t just extend your IT team, it ensures you’ll be able to resolve IT questions and problems in less time.

**Figure 31  Dell EMC ProSupport Enterprise Suite**

<table>
<thead>
<tr>
<th></th>
<th>ProSupport</th>
<th>ProSupport Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote technical support</td>
<td>24x7</td>
<td>24x7</td>
</tr>
<tr>
<td>Covered components</td>
<td>Hardware and Software</td>
<td>Hardware and Software</td>
</tr>
<tr>
<td>Onsite parts &amp; labor</td>
<td>Next business day or Mission Critical</td>
<td>Next business day or Mission Critical</td>
</tr>
<tr>
<td>Automated issue detection and case creation</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Self-service case initiation and management</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Hypervisor, Operating Environment Software and OS support</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Priority access to senior support experts</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>An assigned Technology Service Manager</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Personalized assessments and recommendations</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Support and utilization reports</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Systems Maintenance</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
Conclusion

VxFlex systems powered by VxFlex OS make transforming from a traditional three-tier architecture to a modern data center without any trade-offs between performance, resilience or flexibility. VxFlex systems handle a wide variety of production workloads, and customers are steadily increasing the number and range of production workloads run on their VxFlex systems. VxFlex systems provide workload, deployment and operational flexibility, linear scalability, and predictable high performance and enterprise-grade resilience. VxFlex provides high performance for applications and databases, multi-hypervisor and bare metal support. VxFlex supports traditional two-layer, HCI one-layer (fully converged), or a mix of both configurations. VxFlex empowers adding and removing storage and compute resources on-the-fly and provides simple non-disruptive migration.

Dell EMC VxFlex integrated rack is the most flexible HCI rack-scale system with integrated networking that supports heterogeneous environments. The Dell EMC VxFlex appliance is a turnkey system available with smaller starting configurations and is easy to acquire, own, and scale. Dell EMC VxFlex Ready Nodes are scalable, reliable and easy-to-deploy building blocks for organizations wanting a full build experience. VxFlex Manager automates and simplifies implementation, expansion and lifecycle management for the VxFlex integrated rack and the VxFlex appliance.
A References

- Dell EMC VxFlex integrated systems
  http://www.dellemc.com/vxflex

- Dell EMC VxFlex Ready Nodes

- Dell EMC Hyperconverged Infrastructure
  http://www.dellemc.com/hci

- Dell EMC Data Protection

- Dell EMC Online Support site (registration required)
  https://support.emc.com.