MODERNIZATION GUIDE

Data Center

# Modernizing the Enterprise from Proprietary Legacy Systems to Open-Standard Platforms

**Following best practices and established guidelines can improve efficiency and outcomes for organizations as they modernize proprietary infrastructure, moving workloads to a VMware virtualized environment hosted on Intel® architecture.**

## Developing a Modernization Path for Data Center Transformation

Safeguarding competitiveness and profitability requires decision makers to stay abreast of changes to the technology landscape as well as to the business environment. As part of that responsibility, it is vital to replace legacy proprietary systems with more agile, future-ready infrastructure. Older approaches—ranging from mainframes and midframes to smaller systems such as SPARC* and Power*—are costly and inflexible compared to those based on open standards.

Across industries, IT shops are faced with the need to do more with less. The data used to power business decisions is growing exponentially, even as new requirements emerge to generate insights based on that data in real time. This increased scale of computing comes as many IT organizations face stagnant or declining budgets. The lower cost and greater flexibility of open architectures compared to legacy systems make them well suited to enterprise modernization.

The acquisition costs of proprietary systems on a price/performance basis are significantly higher than those for standards-based servers. That factor was simply a cost of doing business when proprietary systems were the standard for mission-critical workloads, but reliability, availability, and scalability (RAS) advances in open, general-purpose architectures now make them a sound choice for the full range of enterprise workloads.

Adding further to the agility and cost effectiveness of modernized infrastructure based on this approach, hardware and software technologies for virtualization have become ubiquitous in the mainstream enterprise. Core virtualization capabilities such as high-density server consolidation and live migration between hosts have evolved to work with advanced techniques and tools for orchestration, automation, and management to enable the software-defined data center.

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## Why Modernize?

Modernization can help dramatically to address escalating data center costs. General-purpose, standards-based servers offer a more cost-effective scale-out strategy to replace the scale-up approach that is typical with legacy proprietary technologies. Rather than buying high-cost, over-provisioned equipment to handle growth, data center operators can procure additional Intel® architecture-based hosts as they are needed. In addition, these systems are available from a large number of manufacturers, providing greater flexibility.

The proprietary storage area networks (SANs) widely used in legacy data centers place particular strain on budgets because of their high expense to acquire and operate. VMware vSAN* provides an alternative by pooling local storage from hosts across the enterprise, decoupling those resources from the underlying hardware. This approach can reduce costs dramatically.

The combination of VMware and Intel technologies enables reduced CAPEX by replacing expensive proprietary infrastructure with lower-cost Intel architecture-based hardware and VMware software. Design approaches based on the software-defined data center automate day-to-day operations, reducing OPEX by decreasing the need for manual administration of the environment as well as improving utilization levels of equipment.

With each generation of technologies, the ongoing collaboration between the two companies adds additional capabilities, further increasing the potential for cost savings. More than a decade of close collaboration between VMware and Intel has led to a high degree of full-stack optimization and integration.

- **VMware Cloud Foundation*** combines software-defined compute, storage, and networking with VMware Software-Defined Data Center* (SDDC*) Manager for full-lifecycle automation, including with the use of cloud-native containerization.
- **Intel architecture** provides a full-stack set of hardware building blocks across compute, storage, and network that deliver industry-leading performance, reliability, and security.

The transition to VMware-virtualized infrastructure on Intel architecture-based systems also opens the door to a vast ecosystem of proven reference architectures and other solutions that enhance interoperability and support innovation. By eliminating the burden of outdated platforms, businesses open themselves to the full potential of current and future technology advantages.

## Core VMware Technologies for the Software-Defined Enterprise

VMware Cloud Foundation is the hybrid cloud platform that underlies the software-defined data center. It provides virtualization capabilities that decouple compute, storage, and networking from the underlying hardware, enabling faster response to changing needs. For example, provisioning a virtual machine (VM) takes seconds, as opposed to the weeks needed for a physical server. VMware software building blocks also provide a transition path to the hybrid cloud, giving enterprises the ability to seamlessly integrate their internal resources with public cloud services, enabling open-ended elasticity without over-provisioning.

- **Compute: vSphere*** is based on a bare-metal hypervisor that runs directly on the bare-metal hardware, delivering high performance along with automated, policy-based provisioning and management.
- **Storage: vSAN** pools local flash-based storage from multiple hosts into a unified, managed data store and then provisions virtual disks for individual VMs as needed from that shared resource.
- **Network: NSX*** spins up virtual networks on demand, providing network services using virtual network functions (VNFs) and protecting traffic by creating isolated logical subnetworks based on microsegmentation.
- **Management: SDDC Manager** automates deployment, configuration, and provisioning, as well as the application of patches and upgrades, all based on user policy.

## Intel® Architecture-Based Hardware Building Blocks

General-purpose servers based on Intel architecture are a compelling alternative to costly legacy proprietary hardware. Open standards-based infrastructure allows for flexibility across a broad range of vendors, in a pay-as-you-grow, scale-out approach that provides ongoing cost benefits. Holistic engineering across the Intel architecture-based solution stack creates synergies among processing, storage, and networking components that further enhance performance, scalability, stability, and security.

- **Compute: Intel® Xeon® Scalable processors** accelerate SDDC workloads with redesigned core and cache architectures, increased memory bandwidth, and more data per instruction using Intel® Advanced Vector Extensions 512 (Intel® AVX-512) technology. Security is enhanced by hardware-accelerated encryption and a trusted execution environment.
- **Storage: Intel® SSDs** include Intel® Optane™ SSDs for extremely high performance and low latency in the caching tier and Intel® 3D NAND SSDs, which deliver data integrity, performance consistency, and reliability for the data tier.
- **Network: Intel® Ethernet** provides reliable, high performance networking with configuration-free migration of virtual servers across the network and intelligent offloads for increased throughput while reducing CPU utilization.

Enterprise customers can accelerate infrastructure deployments using reference architectures, white papers, solution blueprints, and solution briefs provided through Intel® Builders Programs.

### Mapping the Modernization Path

In general, the transition to VMware virtualization on Intel architecture should follow a structured approach that can be broadly defined in terms of three main stages, as introduced in this section and elaborated in the remainder of this document. While each implementation necessarily has its own unique requirements, this structure provides a starting point for conceiving modernization projects.

- **Stage 1 (Planning)** identifies the workloads to be modernized, determining the opportunities and challenges associated with each, and prioritizing them as the basis for an initial project plan.
- **Stage 2 (Infrastructure Development)** involves the selection, acquisition, and configuration of VMware and Intel building blocks to create the target infrastructure.
- **Stage 3 (Workload Deployment)** is the actual implementation of workloads on the new infrastructure. A series of main steps within this stage helps structure the deployment, mitigating risk:
    - 3a: Proof of Concept (PoC)
    - 3b: Pilot Modernization
    - 3c: Rehearsal
    - 3d: Production Launch

Each of these stages will necessarily be more closely tied to some parts of the enterprise than others, and focusing projects accordingly can foster efficiencies. Table 1 suggests how key parts of the environment might be points of focus at the various stages of the process defined above. Here, "General/Line of Business Apps" includes typical software used in the day-to-day productivity operations of the business, whether commercially obtained or internally custom built. "Enterprise Services" refers to support systems such as security, web, file, and print services. "Back-End Systems" house data storage and manipulation resources such as databases, data warehouses, and analytics engines. "Mission-Critical Systems" are those that require high availability and robust data resiliency to maintain and protect core business operations.

This model helps streamline the effort required for the implementation, to help save on the time and cost requirements of the process, while still safeguarding outcomes. Accordingly, the initial and final stages of the modernization address all of the applications, services, and systems included in the modernization equally, while the PoC and pilot phases focus on subsets of the environment for the sake of simplification.

In particular, the PoC is chiefly concerned with back-end and mission-critical systems, under the assumption that those are the most challenging aspects, and the pilot focuses on general and line-of-business apps because their relative simplicity allows project teams to focus on details of the implementation process itself, as opposed to the particulars of more complex systems.

On the other hand, the planning and infrastructure development phases involve all aspects of the environment equally, helping ensure that the specific capacity, access, and other needs of various application types are all accommodated. The rehearsal and production launch phases must naturally include the full environment to be modernized as well, bringing them into eventual production on the new infrastructure.

The bulk of this document considers each of these stages in turn, giving guidance related to the main tasks and considerations involved in each one.

## Stage 1: Planning

The planning stage of a modernization project from legacy hardware to VMware on Intel architecture is often the most complex and longest-duration stage of the entire project. It proceeds from the understanding that it is not necessarily the best approach to modernize all of the legacy systems owned by an enterprise at the same time. Instead, it is desirable to use a methodological approach to identify opportunities, prioritize parts of the enterprise for modernization, and then to define the scope of the project. The main parts of the planning stage, each of which corresponds to a subsection below, include the following:

- **Developing the business case** includes identification of the revenue-generation and cost-reduction opportunities associated with modernizing specific applications, business processes, and systems.

**Table 1.** Mapping parts of the environment to the modernization cycle.

| | 1. PLANNING | 2. INFRASTRUCTURE | 3A. POC | 3B. PILOT | 3C. REHEARSAL | 3D. PRODUCTION |
|---|---|---|---|---|---|---|
| **General/Line of Business Apps** | ★ | ★ | | ★ | ★ | ★ |
| **Enterprise Services** | ★ | ★ | | | ★ | ★ |
| **Back-End Systems** | ★ | ★ | ★ | | ★ | ★ |
| **Mission-Critical Systems** | ★ | ★ | ★ | | ★ | ★ |

- **Assessing the pre-modernization environment** involves inventory of existing hardware and software and identifying good candidates for modernization, as well as risks and special considerations associated with them.
- **Creating the modernization roadmap** consists of the steps to produce a comprehensive plan for the modernization, including priorities, budget and expenditure tracking, and other considerations.

### Developing the Business Case

While the IT value of decommissioning legacy systems may be compelling in its own right, such major changes to the environment must typically be analyzed in terms of their business value to the rest of the organization as well. In other words, while the IT organization may hypothesize that the modernization will be financially successful, the viability of that hypothesis must typically be justified to upper management. Failure to generate a robust business case often creates difficulties and delays in getting the approvals needed to move forward with the project.

In preparing the business case, business analysts should consider the modernization project's potential for both cost reduction and revenue development. Showing benefits in both of these areas provides a more compelling business case than either type of benefit on its own. Moreover, comprehensive models that include both cost reduction and revenue development provide a means of identifying those parts of the project that have especially high ROI potential.

As illustrated in Figure 1, systems and applications that can both reduce costs and generate additional revenue are good candidates for modernization. In addition to being a useful tool for prioritizing systems and applications for modernization, this approach also effectively brings together the technology-oriented benefits that IT may wish to focus on with the financial benefits that are typically front-of-mind for senior management.

The specific opportunities for revenue generation and cost avoidance associated with any given area of operations will necessarily vary according to the specifics of the solution and the organization. At the same time, a relatively small set of generalized considerations apply to a large proportion of real-world scenarios. Analysts taking first steps toward developing the business case for their modernization projects should consider how the items in the following lists pertain to specific systems and applications within their environments. General revenue-generation opportunities that are often relevant to the business case include the following:

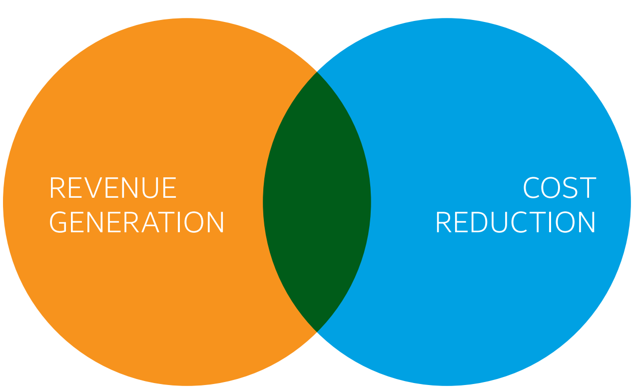


**Figure 1.** Highest-value modernization targets both generate revenue and reduce costs (shown in green).

- **Avoidance of missed opportunities**. Increased performance, stability, and scalability enable the business to grasp new revenue opportunities when they arise that might otherwise pass them by.
- **Accelerated time to market**. The agility benefits of VMware virtualization help bring new products and services to market more quickly, so they can start generating revenue sooner.
- **Improved customer loyalty**. By delivering better customer experiences, businesses are better able to retain hard-won customers, helping ensure that they will remain as ongoing sources of revenue.

A common set of cost-reduction opportunities that can be applicable to a wide variety of business situations and business cases includes the following:

- **Lower equipment costs**. The modernized environment reduces CAPEX using Intel architecture-based servers and VMware vSAN to replace proprietary servers and SANs, respectively.
- **Lower support costs**. Simplifying the environment can reduce the support burden (break-fix, management, and so on), allowing fewer staff to perform the same functions.
- **Faster trouble resolution**. Reducing the mean time to repair (MTTR) from an outage avoids the cost of idle staff as well as potential for lost customers or reputation.
- **Reduced human error**. Centralized management in VMware vSphere automates repetitive manual processes that often lead to costly IT errors.

### Assessing the Pre-Modernization Environment

As an early step in planning the modernization of workloads to VMware on Intel architecture, it is necessary to assess the infrastructure that is currently in place, including its capabilities as well as its shortcomings. This assessment should include both an examination of the environment itself and discussions with the people involved with the workloads it hosts as part of their day-to-day responsibilities.

Consideration of the existing environment should identify any acute issues in areas such as performance, scalability, and reliability. Where possible, those issues should be isolated through root-cause analysis to determine what aspects are caused by hardware issues, such as lack of available resources, and which aspects are due to software issues that might touch on both core functionality and integration with other systems. Based on that research, it should be possible to identify issues that are likely to be resolved by the modernization, as well as issues that are likely to complicate the modernization process.

Research from human sources is equally important to understanding the existing environment. End users typically have important perspectives about what the environment does well and where it falls short, including specific circumstances that may be behind good and bad performance, stability, and availability. For example, there may be recurrent issues associated with foreseeable usage spikes, specific tasks, interactions with other systems, and so on. Business owners and IT personnel may have concerns about issues such as system reliability, availability, and serviceability; ability to scale solutions; system or application support; and licensing issues.

Early in the course of the modernization, project teams should pursue training for staff that will be involved in the migration itself as well as the eventual support of the environment. By starting with basic training and progressing with more advanced courses as the project develops, staff can be more engaged with the modernization process and make more substantial contributions as time goes on. Flexible training options are available from www.vmware.com/education.

### *Identifying Workloads to Be Modernized*

Using the assessment of the pre-modernization environment as a foundation, the next step is to begin identifying workloads that are good candidates for modernization. Because that selection of workloads carries with it an implied selection of hardware that will be decommissioned as well, the suitability of hardware for its current purpose should be considered.

In general, however, decommissioning the oldest and least capable legacy hardware should not be a prime factor in choosing workloads for modernization, because applications that are not moved to the new environment can be moved among the legacy hosts after the modernization is completed.

Determining the priority with which applications should be modernized involves due consideration of a number of factors for various types of workloads. In particular, for the workloads already described in Table 1, each category has specific characteristics that are typical in terms of their sensitivity to downtime and outages, the complexity of replicating them across the environment, and the cost/benefit and risk analysis associated with modernization. A starting point for quantifying these characteristics is summarized in Table 2; project teams may use this information as a starting point for considering the specific workloads in their own organizations.

**Table 2.** Ease of modernization for various parts of the environment.

SIMPLER ⟵ EASE OF MIGRATION ⟶ MORE COMPLEX

| | GENERAL/LINE OF BUSINESS APPS | ENTERPRISE SYSTEMS | BACK-END SYSTEMS | MISSION-CRITICAL SYSTEMS |
|---|---|---|---|---|
| **Downtime/Outage Sensitivity** | Low downtime sensitivity; simple to control or schedule | Moderate downtime sensitivity; complex to control or schedule | High downtime sensitivity; complex to control or schedule | High downtime sensitivity; complex to control or schedule |
| **Replication Across Environment** | Pilot then replicate | Relatively simple to replicate | Low to moderate complexity, depending on specific system | Moderate to high complexity, depending on specific system |
| **Value, Cost, and Risk of Modernization** | High value; low cost and risk | Moderate to high value; low to moderate cost and risk | Moderate to high value; moderate cost and risk | High value; moderate to high cost and risk |
| **Examples of Affected Systems** | Productivity suites, peripheral line-of-business apps | DNS, LDAP, web servers, firewalls, backup and restore, file and print | Enterprise databases, data warehouses, storage area networks, analytics engines | Core business applications, ERP systems, CRM systems |

### *Sizing VMs and Selecting Server Hardware*

The investigation of the existing environment will typically include thorough load assessment of the applications under consideration on their existing servers. This assessment, combined with the specifications of their host servers, will reveal the relative resource requirements for each workload. The information gathered from this process should be used to determine the resource assignments in VMs, including virtual CPUs, RAM, and so on.

A common consideration when sizing server hardware is the balance between the target system's core count versus the robustness of its individual cores. The nature, capabilities, and demands of the most critical workloads to be included in the modernization will typically govern the choice of server hardware.

In some cases, organizations may develop multiple server-hardware specifications, each tailored to a specific type of workload. While this approach introduces a degree of complexity, it also offers flexibility by further tailoring the workload to the capabilities of the host hardware. For example, Intel Xeon Scalable processors are typically the best suited to handling large-scale and mission-critical enterprise workloads, such as enterprise resource planning (ERP) and customer relationship management (CRM) systems, core transactional applications, analytics, and high-performance computing.

The per-core and platform-level advances made in this platform architecture demonstrate the potential for high throughput for demanding workloads. In addition, the Intel Xeon Scalable processor delivers high consolidation ratios for legacy servers, with up to 4x more VMs per host[1] than a predecessor platform.

Despite the compelling capabilities of high-end SKUs in this processor family, certain workloads may deliver favorable cost-benefit characteristics using lower-end SKUs, including the Intel Xeon Bronze, Silver, or Gold processors. The Intel Xeon processor E3 v5 family with Iris® Pro graphics also provides a compelling solution for specialized tasks such as video processing. In addition, hardware acceleration using devices such as Intel® Xeon Phi™ coprocessors may be desirable for some tasks.

## Creating the Modernization Roadmap

The end result of the planning stage is to transform all of the information that has been gathered into a modernization roadmap that will govern the rest of the modernization. Notably, the roadmap must be a living document that is continually updated as the project proceeds, incorporating input from project teams based on lessons learned and other outcomes of the process itself, the shifting demands of the business, and the preferences of stakeholders responsible for the systems and workloads involved in the modernization.

***Note:*** *It is often valuable to break the modernization itself into phases in order to reduce risk. In some cases, however, doing so may be problematic because of high integration among various systems.*

The modernization roadmap acts as a project plan that details how, when, and where the modernization will occur, as well as detailing the responsibilities of team members, documenting approvals by stakeholders, and providing plans to back out modernization steps in the event of unforeseen issues. Prioritization of events in the roadmap include capital budget allocation timing, specific business priorities, and data center constraints. These considerations go to the heart of the business realities that govern the project, and they must be given due weight alongside the relevant technical requirements and processes.

As both a planning tool and a means to gauge project progress, a detailed project timeline is included in the roadmap, showing specific dates and durations of the various tasks involved in the modernization. In addition, the roadmap guides and tracks financial aspects of the modernization process, matching tasks to quarterly budget figures to accurately track progress against projected and actual costs. Key tasks to support the various aspects of preparing the modernization plan include the following:

- **Compiling an inventory of assets** and perform a detailed analysis of existing hardware, as well as the workloads supported by it. Identify relative capabilities and potential value from repurposing retired hardware for non-modernized workloads and applications.
- **Analyzing potential modernization outcomes** to identify potential benefits from modernizing specific workloads and consolidating specific servers onto Intel architecture-based hosts.
- **Identifying and addressing risk potential** based on possible negative outcomes that could arise from modernizing specific workloads and groups of workloads. Develop a risk-benefit analysis and risk-mitigation plan for each.
- **Estimating costs in detail** and map them to organizational and project budgets.

Consolidating the outcomes of each of these steps provides the basis for an aggregate view of project potential and requirements. The remainder of this section details each of these sets of activities and their contributions to the modernization roadmap.

### *Compiling an Inventory of Assets*

This step begins with a conventional inventory of each piece of legacy hardware being considered for inclusion in the modernization project. It should identify groups of servers used for a single workload, including development, test, staging, and production hardware, as well as cluster topologies and other relevant architecture details. For the servers associated with each workload, the following data points should be collected, at a minimum:

- Number of hosts and processor cores per host
- Memory requirements
- Storage and file system requirements
- Network bandwidth and latency requirements

This information should draw from published application system requirements, as well as the actual resources available in the pre-modernization environment. In addition, data should be collected where possible about the actual utilization of these resources in production under load. Note that actual utilization is often far lower than either published system requirements or available resources.

The objective of this process is to determine the level of resources required by each workload, including processing power, memory, storage, and bandwidth. That information can then be used to size individual VMs, as well as to consolidate a view of the resources needed overall.

### *Identifying and Addressing Risk Potential*

While it necessarily requires some degree of speculation, the risk associated with modernizing any individual workload is relatively straightforward to quantify. Estimates of the likely duration of an outage before the modernization can be backed out to its pre-modernization state can be combined with projected costs for each unit of time during the outage. More complex is to quantify the risk associated with modernizing an application group and its associated system of workloads.

The complexity arises from the interrelationships among the applications and workloads themselves. This is in part because those interrelationships increase the scope of an individual component of the modernization. Once an application and all of its dependencies have been migrated, it is a larger undertaking to reverse the process for the entire application group than it would have been for the single application.

In addition, there are typically complex interactions and overlaps among application groups, which makes planning more difficult. Finally, there are interrelationships between the risk factors themselves; a single negative outcome in one workload can cause a cascade effect that impacts others in ways that can be difficult to predict and to quantify.

The analysis in this step identifies the risks associated with modernizing individual workloads and maps the relationships between them, both within and between various application groups. Based on this information, risk-benefit analysis is conducted to ensure that the potential improvement associated with a given part of the modernization is an appropriate tradeoff with the associated risk. Modernization of some workloads may be added or removed from the migration plan based on this analysis. Mitigation measures are specified for each of the risks associated with modernization steps that are retained in the plan.

### *Estimating Costs in Detail*

While cost estimates are typically assembled throughout the planning process, they are necessarily tentative and incomplete until the planning stage is nearly complete. Therefore, the first comprehensive cost estimate for the project is undertaken late in the planning stage. The budget for the modernization as a whole can build from the following set of initial considerations:

- **Hardware costs**, including the acquisition cost of new hardware and associated support agreements, less the cost of support agreements from manufacturers and third parties for hardware that will be decommissioned.
- **Software costs**, consisting primarily of licenses for virtualization platforms, as well as any ancillary test, management, or other requirements.
- **Ancillary personnel and support costs**, such as training fees, transportation requirements, design and implementation consulting, and so on.

Note that this process does not include ongoing cost savings as discussed earlier in this document about developing the project business case, and as such, it is distinct from an overall TCO or ROI analysis. Furthermore, the budget at this stage is simply a preliminary estimate of the costs that the organization will incur to support the modernization project. It should be updated on an ongoing basis as the project progresses.

## Stage 2: Infrastructure Development

The infrastructure development stage involves the design and implementation of the target environment. Infrastructure, in this context, includes both systems hardware and the virtualization environment that runs on it as the substrate for applications. This stage therefore consists largely of determining what VMware building blocks and capabilities will be used in the target environment and then designing a standard operating environment based on those decisions. Key parts of the infrastructure development stage are described in this section:

- **Capabilities of the VMware management tools** describes some capabilities enabled by the VMware environment and how they enable workloads in the modernized context.
- **Building a standard operating environment** discusses the design and development of a modernized infrastructure, including standard host builds and virtualization environment.

## Capabilities of the VMware Management Tools

Management of IT services across private, public, and hybrid clouds is provided by VMware vCenter* Server and VMware vRealize* Suite. Key capabilities of this combination are summarized in Figure 2. Administrators gain deep visibility and extensible control over resources and configurations, enabling them to manage hundreds of workloads while increasing efficiency and reducing problem resolution times.

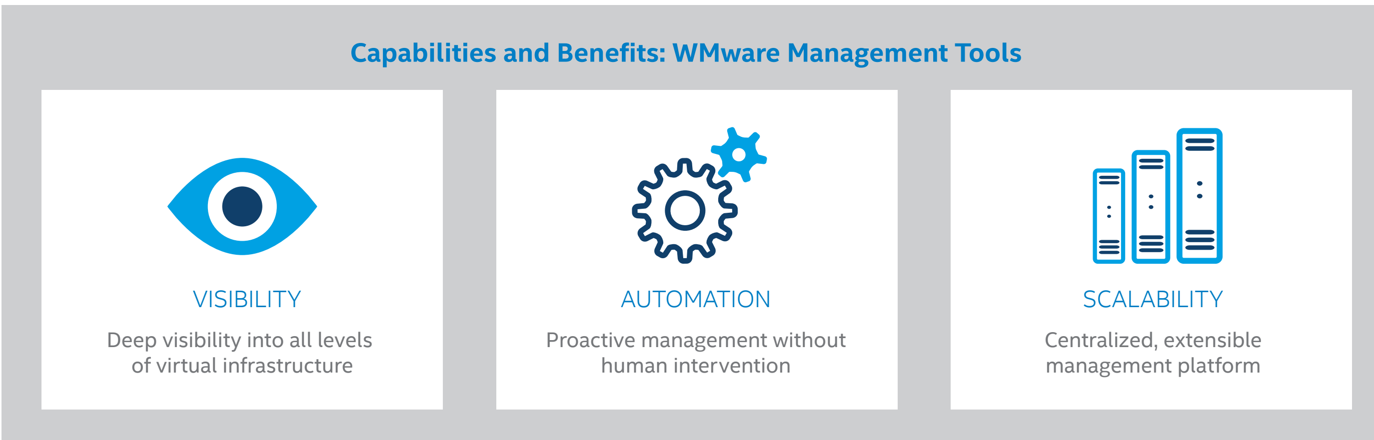


**Figure 2.** Capabilities and benefits of VMware management tools.

Automation enables proactive measures to be taken across the virtual infrastructure, including dynamically provisioning new services, balancing resources, and automating high availability. Scalability of the solution as a whole proceeds from that control over resources, complemented by extensibility using integrated capabilities from a broad ecosystem, including capacity management, compliance management, business continuity, and storage monitoring. APIs extend that flexibility further with the ability to integrate additional physical and virtual management tools.

### *Transitioning from Standalone Utilities to Integrated vSphere* Capabilities*

It may be the case that external utilities that a workload depends on will no longer be required in the modernized environment. For example, the capabilities provided by separate management tools in the legacy environment may be replaced by management using VMware vCenter Server, which is fully integrated with vSphere, as illustrated in Figure 3.

Decommissioning such legacy tools reduces complexity in the target environment. Organizations may also save on licensing costs by decommissioning legacy tools along with the legacy hardware.

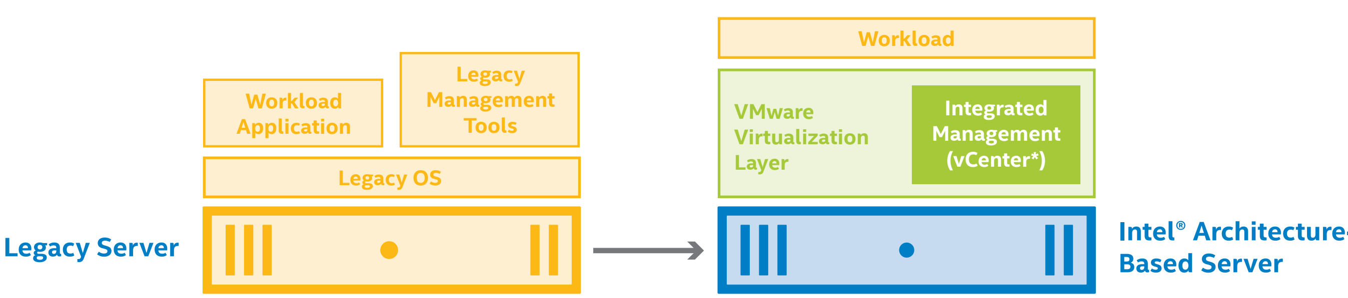


**Figure 3.** Transitioning capabilities from legacy management tools to VMware integrated management.

### *Server Consolidation*

The headroom provided by Intel architecture-based servers provides more compute capacity than typical legacy servers. This relationship means that the workloads from multiple servers can be consolidated onto a single virtualized server, as shown in Figure 4.

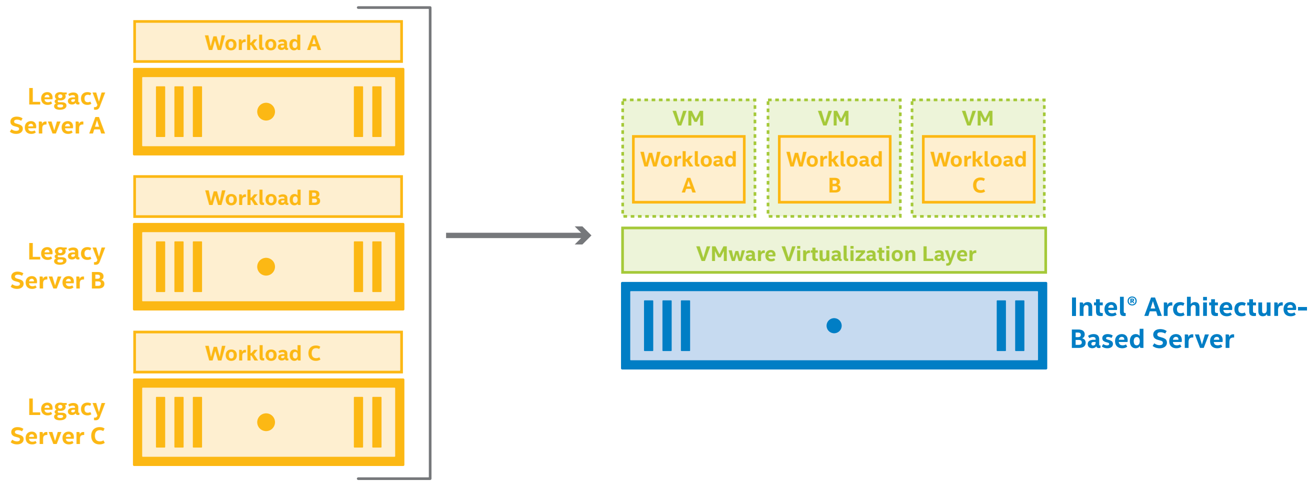


**Figure 4.** Consolidating workloads using VMware virtualization and Intel® architecture.

Consolidating multiple servers onto a smaller number of Intel architecture-based systems can reduce the data center footprint, with the resultant reduction in physical complexity lowering both CAPEX and OPEX. Because the VMs all share the physical host's resources, those resources can be dynamically allocated. Load balancing among VMs is handled by the virtualization software, while each VM operates as if it had sole ownership of the hardware resources. In addition, the virtualization software isolates each VM, preventing data in one VM from being accessed or changed from within any other VM.

Note that each VM contains a full version of the OS, in addition to the workload that runs on top of it. That is particularly beneficial if workloads are running on diverse OSs, sharing physical server resources. On the other hand, cases where multiple workloads each contain a running copy of the same OS can add significant overhead. Containers provide an alternative that allows multiple workloads to share a single version of the OS in a virtualized context. While detailed discussion of containers is beyond the scope of this document, vSphere does support integrated containers; further information is available at https://www.vmware.com/products/vsphere/integrated-containers.html.

### *VM Live Migration*

In addition to resource sharing and load balancing within a single host, vSphere accomplishes similar capabilities among multiple hosts by means of live migration, as illustrated in Figure 5. Here, capacity is scaled up for a given workload by creating duplicate copies of a VM. Those duplicates can be hosted on the same physical host as others, or vSphere can migrate them to a different physical host at the same geographic site or a remote location. Commissioning and decommissioning VMs automatically, on an as-needed basis, provides elasticity for expanding and contracting workload requirements.

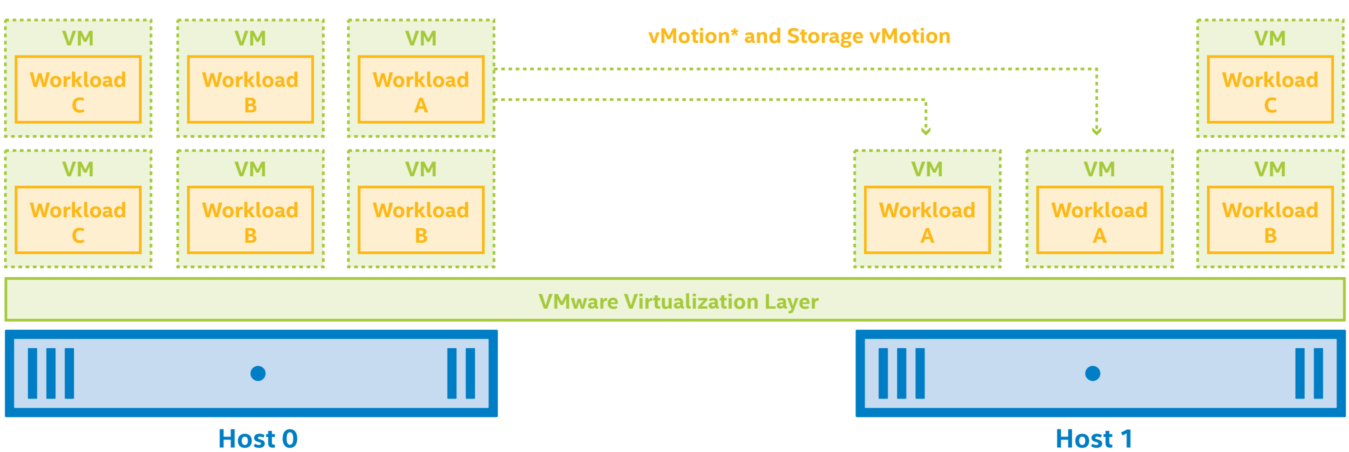


**Figure 4.** Live migration of virtualized workloads.

### Building a Standard Operating Environment

In the context of this document, a standard operating environment (SOE) consists of one or more standardized hardware and software builds for physical servers, as well as the virtualized infrastructure that resides on them. A defined SOE includes the bill of materials including hardware and software components, as well as topologies and configurations. As mentioned above, SOEs should be defined with the goal of supporting any workload in the environment.

Considerations at the host level typically begin with the choice of processors, taking consideration of numbers of cores, size of cores, and special capabilities such as hardware acceleration for video processing. Physical host configuration then proceeds with other components, such as local storage, network adapters, and so on. Designing the broader environment draws on both physical and logical networking, storage area networks, and other components.

In addition, planning the virtualization infrastructure draws on capabilities that include those described in the preceding sections. The complexity of this design makes consulting assistance valuable, and that expertise is readily available from VMware and Intel. See the section of this document titled, "Soliciting External Expertise" for more details. Once SOEs have been defined, workloads should be test-run on SOE-based servers, to help ensure smooth operation in production.

Because of the diversity of workloads and the potential for unforeseen, novel workloads in the future, SOEs often involve multiple types of hosts. The virtualization software can be configured to restrict or prefer hosts for individual VMs.

This approach helps simplify maintenance, increase stability, and reduce support and management costs. After the physical machines are built according to the bill of materials included in the SOE specification, software provisioning is conducted from vSphere. That provisioning includes installation of software packages as well as configuration according to security, authentication, storage, and other requirements.

## Stage 3: Workload Deployment

The workload-deployment stage involves the actual migration of workloads to VMware virtualization on Intel architecture. The discussion in this section begins with guidelines and considerations for various specific types of workloads and then describes a series of tasks that are typically associated with this stage:

- **Accommodating the full range of workloads** outlines modernization considerations associated with specific types of workloads and applications.
- **Stage 3a: Proof of concept** involves testing one or more non-production workloads on the modernized platform to gauge how they perform and to identify general issues.
- **Stage 3b: Pilot modernization** represents a modernization test using production data, but in a non-production context. It has limited scope to reduce resource requirements.
- **Stage 3c: Modernization rehearsal** is a full-scale walk-through of the modernization, again in a non-production context, incorporating lessons learned from the PoC and pilot to refine processes before the actual migration.
- **Stage 3d: Production launch** is the actual cutover of all involved workloads from the legacy environment to the virtualized environment, prior to decommissioning the legacy infrastructure.

### Accommodating the Full Range of Workloads

To successfully modernize enterprise infrastructure, it is valuable to consider applications and services in terms of the characteristics of the categories discussed in this section.

#### *General/Line of Business Apps*

This category typically includes a large set of relatively simple applications. While they may be integrated with on-premises or cloud-based back ends, those integrations are often simpler than in larger-scale enterprise applications. Typical examples of applications in this category may include business applications running at multiple locations, such as remote offices, bank branches, retail stores, and so on. In those cases, IT teams can complete a single pilot modernization, optimize the implementation, and then replicate the modernization process across the enterprise.

Depending on the solution stack complexity, the cost and risk of this process can vary, although when a single piece of software is in use across all locations, economies of scale—which may include server consolidation—are typically possible.

#### *Enterprise Services*

Typical examples of applications in this category include DNS, LDAP, web servers, firewalls, backup and restore utilities, and file-print applications. Downtime is generally not significant because switchover can take place immediately. Following an initial modernization, the process can be replicated across the enterprise, delivering high value with low cost and risk.

#### *Back-End Systems*

Back-end systems, in the context of this document, consist primarily of large-scale data storage and processing systems that are not associated with mission-critical functionality. Common examples include databases, data warehouses, storage area networks, and engines for data analytics or business intelligence.

Virtualizing back-end systems can be relatively simple in many cases, and outside expertise to assist in best practices for the modernization is typically readily available, either from the vendors that supply them or integration partners that are associated with those vendors. On the other hand, back-end systems often share interdependencies with other systems, requiring modernization of multiple applications and data sets at the same time, adding to the complexity of their modernization.

### *Mission-Critical Systems*

Applications in this category are classified as being critical to the operation of the organization, meaning that an outage would create immediate and lasting damage to the business. Typical examples include core business applications, ERP systems, and CRM systems, as well as data stores that underlie them.

The complexity of modernizing these systems can be substantial because of their tendency to span multiple layers, including the database layer, application layer, and web services layer. All three layers, in some scenarios, may be hosted in partitions on a mainframe, midframe, or large legacy server. In other cases, the web or application layers may already be hosted on an Intel-based platform. If multiple layers are involved, the modernization should be performed in stages to reduce risk and to simplify identification and resolution of issues that arise during modernization.

## Stage 3a: Proof of Concept

The first stage of the actual test modernization is the PoC, which serves primary functions both to the project team and to the organization as a whole. For project teams, the PoC provides hands-on experience with the technologies to be used in the new environment, putting their planning and skills into practice. For the broader organization, the PoC demonstrates the viability of the modernization as a whole, building confidence among stakeholders. Both those perspectives are important factors in the planning and execution of the PoC.

Rather than starting with the simplest workloads and applications, many organizations frame the PoC around enterprise back-ends and mission-critical systems. While doing so is by no means a hard and fast rule, success with these most complex workloads clearly demonstrates the viability of the modernization, while also tending to reveal deeper challenges and issues that may arise later. In some cases, organizations choose to stage an early PoC with simpler workloads and systems to work out systemic issues before proceeding to a more comprehensive PoC as described here.

In all cases, project teams should carefully consider and incorporate a wide range of functionality in the PoC environment, including such factors as multiple hosts and other resources needed to accommodate live migration, for example. Doing so is an important factor in ensuring that applications and other functionality run as expected in the new environment under anticipated workloads. The PoC can also help determine the best ways to optimize configurations for maximum performance and to establish the preliminary process for production modernization.

Before conducting the PoC, project teams should ensure that they have made adequate provisions for modernization testing, including assurance that staff from all appropriate business units are involved, to oversee workloads that impact their parts of the organization. Provisions must also be established for testing application performance in the target environment and capturing input on required hardware and software configuration changes. In particular, that evaluation may include the following:

- Initial measured average utilization
- Maximum utilization target
- Peaks in demand
- Workload growth projections
- Relative capacities of differently sized servers
- Consideration of necessary application scaling to conform with SLA requirements
- Advanced considerations, including clustering, disaster recovery, and failover

## Stage 3b: Pilot Modernization

### *Identifying Compelling Pilot Opportunities*

The pilot is a limited modernization in an isolated, non-production environment using production data to simulate production workloads. This process serves the primary purpose of identifying how well production workloads are supported in the virtualized context, as well as identifying systemic issues that may occur. Choosing the workloads to be migrated as part of the pilot requires sufficient complexity to identify concerns that could otherwise cause missteps that could jeopardize operations.

Many project teams wish to choose pilot workloads they feel confident in their ability to virtualize successfully, providing an early "win" in the project's outcome. Such successes can be instrumental in getting buy-in from skeptical stakeholders, solidifying support for the virtualization effort throughout the organization. At the same time, it is necessary to choose workloads that are not too simple, because doing so may not provide the strategic traction required to demonstrate the viability of the undertaking as a whole.

***Note:*** *A business unit with a strong history of adopting modern technology and embracing change—as well as a willingness to share its IT successes across the organization—represents a good partner for a pilot modernization.*

### *Re-Evaluating the Solution Architecture*

During the PoC and pilot phases, project teams ensure that applications and workloads can run efficiently in the modernized environment, taking advantage of intended virtualization capabilities such as server consolidation and live migration, while meeting required SLAs. Where necessary, changes will have been made to accommodate those needs. Broader issues related to the modernization should also be addressed in conjunction with those efforts, including the scalability and availability of the solution.

Migration to VMware virtualization on Intel architecture inherently offers improvements in terms of agility, performance, scalability, and RAS. These benefits can be optimized further by taking full advantage of available building-block features and capabilities within the target environment. For example, consulting with Intel experts to fine-tune the choice of SKU from the full range of Intel Xeon processors, as well as hardware accelerators, local storage, and network connectivity can often improve results dramatically. The choice of processor SKUs in particular can deliver benefits by balancing horizontal versus vertical scaling.

- **Horizontal scaling** (scaling out) handles increased workloads by adding servers rather than increasing the size of individual servers. This approach works well for presentation-layer services, which tend to scale well across multiple servers through workload balancing, which is handled automatically by the VMware environment. Automated provisioning and maintenance keeps overhead management low as the solution expands.
- **Vertical scaling** (scaling up) is based on large compute capacity within individual cores and high-volume servers. This approach is typically reserved for workloads with relatively small groups of tasks that are individually large. For example, vertical scaling may be more appropriate for workloads that demand high throughput, as opposed to the use of horizontal scaling for workloads that support large numbers of relatively simple user sessions.

To drive up reliability, the native RAS and high availability of the Intel Xeon Scalable processor may be augmented where appropriate with redundant components, such as power supplies, disk drives, and fans. In addition, configuration of the virtualization environment with features and capabilities such as automated failover and VMware High Availability (HA) may be valuable, especially for business-critical and mission-critical workloads.

### Stage 3c: Modernization Rehearsal

Rehearsal is vital to the process of finalizing the plans and procedures for the production modernization. Full or partial rehearsals should be repeated as many times as necessary, using the post-migration servers in a non-production context. This process allows project teams to improve processes established in the PoC and pilot stages, streamlining them for maximum efficiency.

Evaluating, modifying, and reordering tasks in the modernization plan, developing scripts to automate necessary processes, and carefully examining data migration steps enables teams to gain knowledge and experience that help to ensure a smooth production launch. Modernization rehearsal must include not only the processes for the modernization itself, but also QA and acceptance testing.

***Note:*** *Back-out planning is essential to the final modernization plan. This aspect of planning dictates the timing for modernization efforts to be aborted if specific success metrics are not reached, as well as detailed steps to be taken to return the environment to its pre-migration state and measures for testing the success of the back-out procedures.*

### Stage 3d: Production Launch

After sufficient rehearsal has been conducted to make the team confident in the modernization plan and their ability to execute on it successfully, the production launch can be undertaken. The initial modernization is made onto the new virtualized environment, but the legacy environment remains the system of record until the post-migration environment is successfully tested and signed off on by stakeholders. A general overview of the primary milestones in the production launch includes the following:

1. **Scheduling**. The modernization should be scheduled within a set window, preferably in an off-peak period when all necessary stakeholders (or their representatives) can be present.
2. **Preparation**. As called for in the modernization plan, all pre-modernization steps should be carried out in advance, including installation of all physical hardware in its production locations.
3. **Modernization**. Following the modernization plan, the actual modernization should be carried out while keeping the operating legacy environment in place to the greatest extent possible.
4. **QA and acceptance**. All required stakeholders must sign off on the success of the modernization, based on success metrics documented in the modernization plan. In the absence of this acceptance, back-out procedures are initiated.
5. **Cut-over**. Production operations are taken over by the new environment and the legacy environment is shut down.
6. **Documentation**. The progress of the modernization is captured for the permanent project record, including all approvals, as well as any unforeseen issues and their resolutions.

## Continuing the Journey of IT Transformation

VMware and Intel enable modernization through co-engineering agreements that span more than a decade. As a result, the software and hardware components of the solution stack are highly optimized for each other, with VMware software deriving early and robust advantages from the latest hardware features in every generation of Intel platforms. Reference architectures and work with the rest of the ecosystem compound these advantages so enterprises can get the full advantage of emerging technologies and usage models.

Moving workloads to infrastructure based on VMware virtualization and Intel architecture sets the stage for additional modernization.

- **Hybrid cloud** combines cloud resources both inside and outside the data center so that private clouds can access resources on public clouds for greater elasticity through capacity on demand.
- **Software-Defined Infrastructure (SDI) and Software-Defined Data Centers (SDDC)** virtualize all resources, including compute, storage, and network, automating their delivery as a service to improve efficiency.

### Optimizing Elasticity with Hybrid Cloud

Resource-constrained workloads are notable candidates to benefit from hybrid-cloud environments. Because hybrid-cloud infrastructure provides elastic compute, storage, and network resources, workloads can potentially overcome performance and scalability limitations, delivering direct business benefits.

In addition to identifying potential benefits to individual workloads, implementing a hybrid-cloud model also has potential benefits to the environment as a whole (or a section of the environment). As such, it must also take into account interdependencies among various applications and workloads. For example, one workload may depend on another for source data as well as processing, I/O, or storage resources.

Those interrelationships often have direct bearing on how multiple workloads should be treated as groups for potential migration to hybrid cloud. For example, a combined view of the larger environment may reveal that moving one workload to a hybrid cloud model to provide additional scale will cause it to be constrained by a separate workload that it depends on, if that workload is not also migrated to the hybrid cloud.

Interrelationships and interdependencies among workloads provide the basis for a framework of application groups that should be considered as part of hybrid-cloud planning. In addition to giving guidance about which workloads should be considered for modernization together, these application groups also offer insight into potential cost requirements and savings, as well as solution benefits.

Equally important is to perform a high-level analysis of the potential benefits of hybrid cloud approaches to each application group. This analysis must examine the following factors for each application in the context of its larger group:

- Application service-level agreements (SLAs)
- Average and peak hardware utilization rates (such as processor cores, memory, disk, and bandwidth)
- Physical location of applications (mapping individual applications to specific data centers)
- Platform limitations (including challenges due to ISV support, regulatory issues, latency, and so on)
- Operational type (including development, testing, staging, and production)
- Security and network segmentation (including security requirements and zones for each application)
- High availability and disaster recovery requirements
- Clustering requirements or limitations
- Specialized hardware requirements (including SANs, InfiniBand, and other hardware)

These factors contribute to an overall view of the viability and challenges associated with moving specific applications (and therefore application groups) to the hybrid cloud. They may also have bearing on issues such as VMs that should not be allowed to reside on the same physical host or that should be restricted from being hosted on public clouds.

### Enabling Software-Defined Infrastructure/Software-Defined Data Centers

The vision of SDI and SDDC is to extend virtualization to embrace a full-service orientation to all data center resources and services. This IT as a Service model draws on physical resources of all types, from inside and outside the data center, as abstracted pools that can be dynamically applied to any workload, on any device, without human involvement. VMware Cloud Foundation extends hybrid cloud models to embrace SDI and SDDC, as illustrated in Figure 6. By treating all resources as applicable to any workload, SDI/SDDC eliminates silos and enables enterprises to operate at full efficiency.

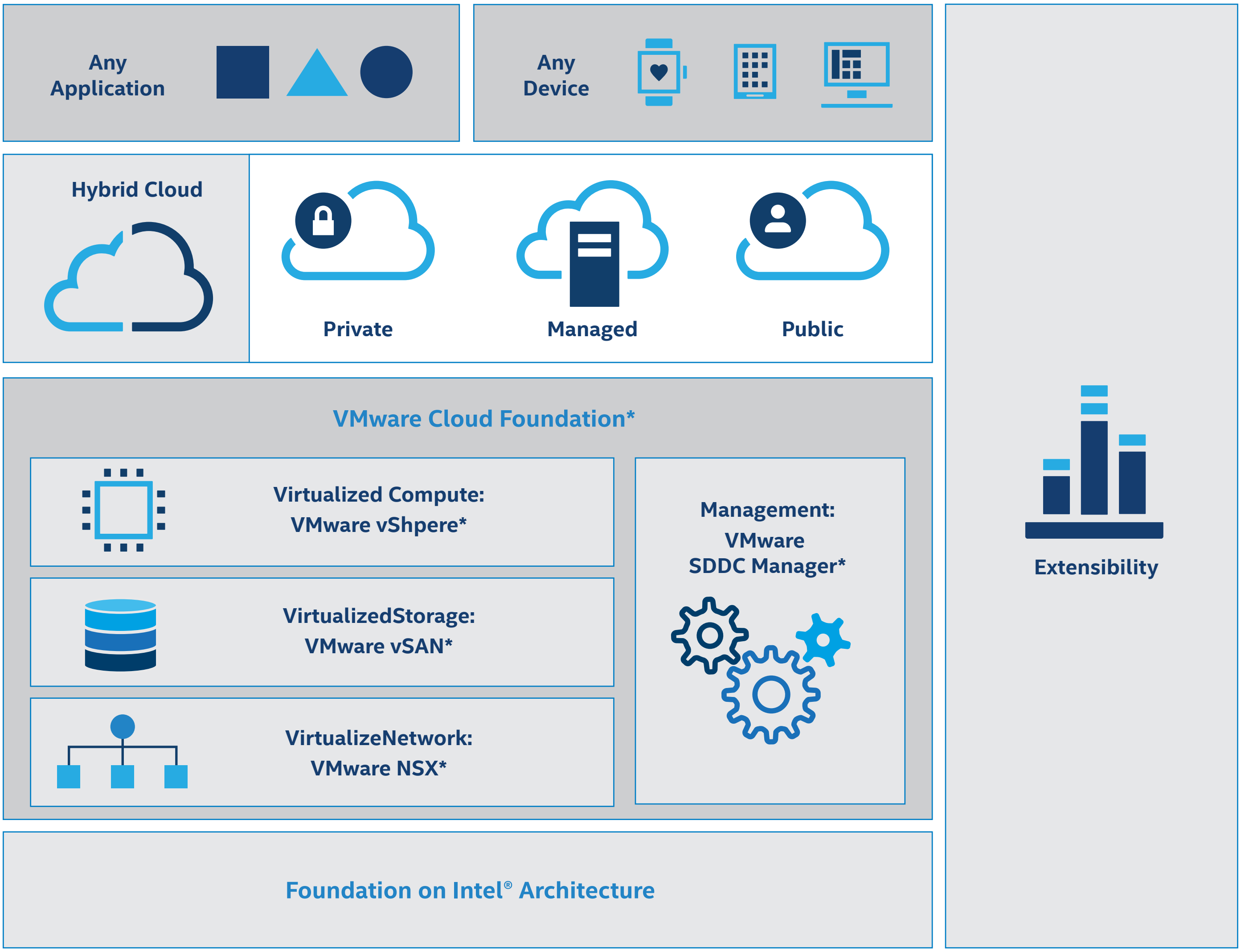


**Figure 6.** Software-defined data centers / software-defined infrastructure based on VMware Cloud Foundation* and Intel® architecture.

VMware Cloud Foundation extends the core hypervisor throughout the stack, beyond compute, to storage and network resources as well. This integrated infrastructure helps ensure interoperability among data center resources, dramatically reducing or eliminating integration burdens from data center operators. Validated and standardized design architectures facilitate repeatability for simplified, predictable implementations. The environment allows applications to run anywhere, on any device, without the added burden and complexity of application rewriting. VMware Cloud Foundation also supports any combination of VMs and containers, for added flexibility.

- **Software-defined compute** is enabled by the Intel Xeon processors working in conjunction with VMware vSphere. It provides automated, policy-based provisioning and management of compute resources, with high performance that is enabled in both hardware and software.
- **Software-defined storage** is implemented using the combination of Intel Xeon processors, Intel® SSDs including Intel Optane SSDs, and VMware vSAN. This approach pools local storage from across the environment into a managed shared data store, with the option of a hybrid or all-flash architecture to tune performance.
- **Software-defined networking** combines Intel Ethernet converged network adapters and VMware NSX to abstract network resources and apply them on demand. It also offers the ability to logically segment traffic, reducing the risk of compromise from inside or outside the network.
- **Cloud management** is provided by VMware SDDC Manager, shown in Figure 7, which is built into VMware Cloud Foundation and automates deployment, configuration, and provisioning based on network policy. Simplified patching and upgrades enable admins to choose the timing and scope of updates.

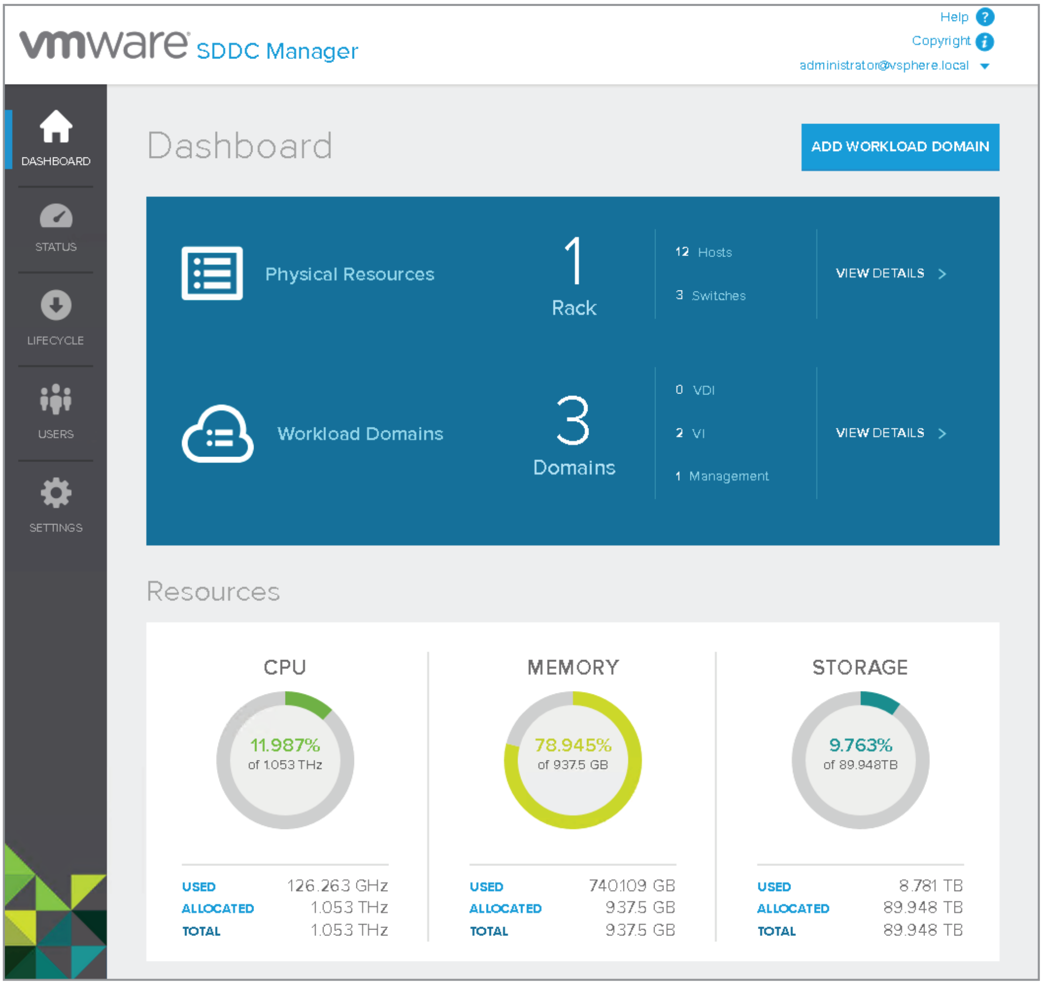


**Figure 7.** Dashboard of VMware SDDC* Manager.

Enterprises can choose to consume VMware Cloud Foundation using their preferred combination of on-premises and cloud models. On-premises options include deployment of VMware Cloud Foundation on pre-certified vSAN ReadyNodes based on Intel architecture or using integrated systems with the software pre-installed at the server point of manufacture by leading OEMs. VMware Cloud Foundation can also be run as a service from VMware public clouds operated by Amazon Web Services, CenturyLink, IBM Cloud, OVH, or Rackspace.

## Soliciting External Expertise

Modernization and long-term planning to take full advantage of its benefits are complex endeavors that require significant planning, expertise, and resources. Both VMware and Intel offer consultants and other experts that can help ensure ongoing success.

### *VMware Professional Services*

VMware Professional Services offers consulting expertise to help plan and execute a modernization based on VMware virtualization. VMware consultants and architects are field-tested veterans with the experience, knowledge, and delivery-oriented intellectual property to accelerate time-to-value with VMware deployments. The VMware approach is to work with clients' entire organizations, including technical and business decision makers, to facilitate a holistic and integrated approach to modernization. VMware Professional services is dedicated to empowering IT organizations with world-class services that enable the business bottom line.

For more information, visit https://www.vmware.com/professional-services.html.

### *VMware System Integrators and System Outsourcers*

VMware partners with a global ecosystem of system integrator and system outsourcer (SISO) partners to provide a worldwide presence of expertise. These providers are validated by VMware to ensure a deep level of vertical market experience and capabilities for business transformation. SISOs can help implement VMware's cross-cloud architecture to enable a robust and flexible multi-cloud strategy. They can also offer the Workspace ONE* platform, which gives customers a digital workspace that accelerates the path to market for mobile apps. Working with SISOs can also offer a dependable path to micro-segmentation, which helps take security to the next level in virtualized networks.

For more information, visit https://www.vmware.com/partners/siso.html.

### *Intel Resources and Services*

Intel, along with its partners, can help enterprises migrate to Intel architecture, reducing TCO and increasing flexibility and agility to respond to changing business needs. Advanced technologies collaboratively developed by VMware and Intel are successfully enabling digital transformation efforts by enterprises seeking the advantages of modern IT infrastructures. Breakthrough developments on SDI and SDDC expand business opportunities into new realms in which efficient resource utilization, demand-driven dynamic reconfiguration, and fluid scalability to accommodate changing workloads are key objectives.

To learn more about resources available to IT leaders, visit https://www.intel.com/content/www/us/en/data-center/new-center-of-possibility.html.

## Conclusion

Decommissioning legacy hardware is a strategic imperative, both to assure long-term viability of a business's infrastructure and to enable the implementation of new business models and capabilities. Implementation of VMware virtualization on Intel architecture is a solid means of attaining both those goals, in a measured fashion that reduces project scope, compared to entirely refreshing hardware and software at once. VMware and Intel provide expertise and assistance that can help enterprises ensure success in this type of modernization, preparing their environments for the future.

Solution provided by:

[1] Configuration details: Intel® Xeon® Scalable processor compared to five-year old system. Example based on estimates as of June 2018 of equivalent rack performance over four-year operation on integer throughput workload (estimate based on SPECrate*2017_int_base on Intel internal platforms) running VMware vSphere* Enterprise Plus on Red Hat Enterprise Linux* Server and comparing 20 installed two-socket servers based on Intel® Xeon® processors E5-2690 (formerly known as "Sandy Bridge-EP") versus five new servers based on Intel® Xeon® Platinum 8180 processors (formerly known as "Skylake"). Assumptions based on https://xeonprocessoradvisor.intel.com, assumptions as of June 6, 2018. For more complete information visit www.intel.com/benchmarks.

The estimated results reported above may need to be revised as additional testing is conducted. The results depend on the specific platform configurations and workloads utilized in the testing, and may not be applicable to any particular user's components, computer system or workloads. The results are not necessarily representative of other benchmarks and other benchmark results may show greater or lesser impact from mitigations.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark* and MobileMark*, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to www.intel.com/benchmarks.

Intel does not control or audit third-party benchmark data or the web sites referenced in this document. You should visit the referenced web site and confirm whether referenced data are accurate.

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