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REFERENCE ARCHITECTURE

Nutanix Calm

NUTANIX™
YOUR ENTERPRISE CLOUD

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1. Executive Summary

Enterprises constantly seek to improve their overall IT agility and responsiveness to enable more rapid innovation. However, as application development and delivery grow in complexity, it can be challenging for teams to keep up with expectations to move faster. Siloed organizations and processes disrupt each other, which results in cross-discipline overhead and slower delivery of business value. In response to the slow pace of traditional IT, shadow IT and shadow public cloud providers arise, further fragmenting business processes and creating more inefficiency and waste.

We designed the Nutanix enterprise cloud from the ground up for efficiency and simplicity, integrating server, storage, networking, and virtualization resources into a highly resilient, turn-key appliance. The Nutanix enterprise cloud supports cloud, business-critical applications, generic server workloads, VDI, and big data deployments across multiple virtualized environments, including VMware ESXi, Microsoft Hyper-V, and the native Nutanix hypervisor, AHV.

Nutanix Calm enables organizations to automate IT service delivery to meet their business needs and fully manage the release process. Calm automation lets you run applications on multiple hypervisors and clouds without platform lock-in and adjust workloads according to business priorities. Calm also provides policy-based governance, making it easier to optimize VM utilization and sizing, which leads to significant savings in opex and capex as well as shorter time to value.

In this reference architecture, we make recommendations for designing Calm blueprints on the Nutanix enterprise cloud across a variety of cloud providers. We demonstrate configurations that take advantage of Nutanix scaling, performance, and simplicity, while using Calm's capabilities to provide datacenter infrastructure, applications, and anything as a service (XaaS). We also present deployment scenarios at proof of concept (PoC), small, medium, and large scales, indicating for each the type and amount of hardware, software, and VMs needed for management components.

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2. Introduction

Audience

This reference architecture is part of the Nutanix Solutions Library. We wrote it for individuals responsible for architecting, designing, managing, and supporting Nutanix Calm. Consumers of this document should be familiar with Nutanix Calm, AOS, Prism, and AHV.

The document highlights representative deployment scenarios and addresses key items for successfully designing and implementing Nutanix Calm.

Purpose

This reference architecture focuses on deploying Calm management components on Nutanix and covers the following subject areas:

- Overview of the Nutanix solution.
- Overview of Calm.
- Blueprint best practices for on-premises and public cloud deployments.
- How to deploy Calm on Nutanix.

Table 1: Document Version History

Version Number	Published	Notes
1.0	February 2018	Original publication.
2.0	June 2018	Updated for Prism Central 5.7 and Calm 2.1.
3.0	February 2019	Updated for Prism Central 5.10 and Calm 2.6.
4.0	December 2019	Updated for Calm 2.7 and Calm 2.9.
4.1	July 2021	Updated the Calm Management Components section.

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3. Nutanix Enterprise Cloud Overview

Nutanix delivers a web-scale, hyperconverged infrastructure solution purpose-built for virtualization and both containerized and private cloud environments. This solution brings the scale, resilience, and economic benefits of web-scale architecture to the enterprise through the Nutanix enterprise cloud platform, which combines the core HCI product families—Nutanix AOS and Nutanix Prism management—along with other software products that automate, secure, and back up cost-optimized infrastructure.

Available attributes of the Nutanix enterprise cloud OS stack include:

- Optimized for storage and compute resources.
- Machine learning to plan for and adapt to changing conditions automatically.
- Intrinsic security features and functions for data protection and cyberthreat defense.
- Self-healing to tolerate and adjust to component failures.
- API-based automation and rich analytics.
- Simplified one-click upgrades and software life cycle management.
- Native file services for user and application data.
- Native backup and disaster recovery solutions.
- Powerful and feature-rich virtualization.
- Flexible virtual networking for visualization, automation, and security.
- Cloud automation and life cycle management.

Nutanix provides services and can be broken down into three main components: an HCI-based distributed storage fabric, management and operational intelligence from Prism, and AHV virtualization. Nutanix Prism furnishes one-click infrastructure management for virtual environments running on AOS. AOS is hypervisor agnostic, supporting two third-party hypervisors

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—VMware ESXi and Microsoft Hyper-V—in addition to the native Nutanix hypervisor, AHV.

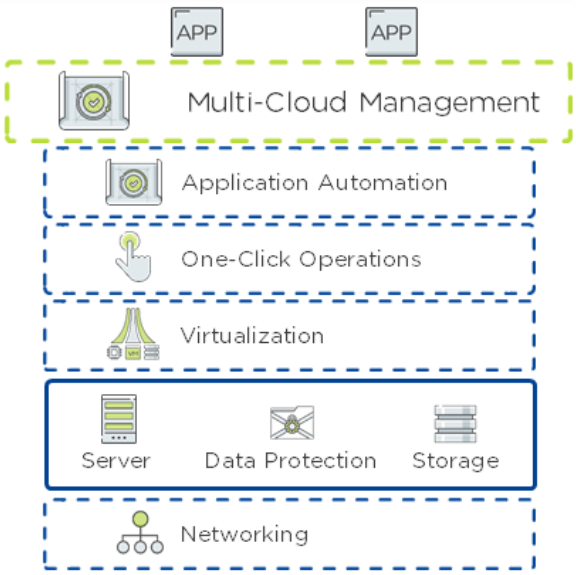

Figure 1: Nutanix Enterprise Cloud OS Stack

Nutanix HCI Architecture

Nutanix does not rely on traditional SAN or network-attached storage (NAS) or expensive storage network interconnects. It combines highly dense storage and server compute (CPU and RAM) into a single platform building block. Each building block delivers a unified, scale-out, shared-nothing architecture with no single points of failure.

The Nutanix solution requires no SAN constructs, such as LUNs, RAID groups, or expensive storage switches. All storage management is VM-centric, and I/O is optimized at the VM virtual disk level. The software solution runs on nodes from a variety of manufacturers that are either entirely solid-state storage with NVMe for optimal performance or a hybrid combination of SSD and HDD storage that provides a combination of performance and additional capacity. The storage fabric automatically tiers data across the cluster to different classes of storage devices using intelligent data placement algorithms. For best

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performance, algorithms make sure the most frequently used data is available in memory or in flash on the node local to the VM.

To learn more about Nutanix enterprise cloud software, visit the Nutanix Bible and Nutanix.com.

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4. Nutanix Calm Overview

What Is Nutanix Calm?

Calm provides infrastructure and application automation and life cycle management for the Nutanix enterprise cloud and public clouds. It provisions, scales, and manages infrastructure and applications across multiple environments to make the entire IT infrastructure more agile and application-centric. Building an enterprise or service provider cloud solution with Nutanix Calm helps organizations with delivery and ongoing management of infrastructure, applications, and custom services, leading to lower opex.

Calm enables organizations to deploy with existing or new business processes and tools and to deliver a very flexible, highly automated, and intuitive self-service experience for the end user. It supports private, public, and hybrid cloud implementations.

Calm defines applications using simple blueprints that administrators can easily create and deploy. IT managers can use preintegrated blueprints or create their own and publish them to the Nutanix Marketplace. IT can empower other teams, such as application developers or lines of business, to set up and manage applications from the Marketplace in a self-service manner, while retaining full control of the infrastructure.

Organizations can now fully automate hybrid cloud architecture deployments, scaling both multitiered and distributed applications across different cloud environments, including Nutanix AHV, VMware ESXi, Amazon Web Services (AWS), AWS GovCloud, Google Cloud Platform (GCP), and Microsoft Azure.

Calm's versatility makes it easy to maintain control over provisioned virtual workloads and applications through its centralized provisioning structure, governance, infrastructure, and application management capabilities. For example, administrators can use Calm to manage applications and associated VM life cycles through built-in processes for:

- Request

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- Approval
- Provisioning
- Management
- Scaling
- Reclamation
- Decommission

Calm Constructs

The following section describes how Calm works and how the constructs relate to the various Calm components.

Calm automates provisioning and deployment steps across multiple resource providers. For example, provisioning a development environment could involve provisioning Amazon EC2 instances, pulling code from GitHub, installing prerequisites, and configuring a deployment. In Calm, you define a blueprint that describes the application services, infrastructure, operations, configuration, and dependencies for the desired environment. When you run the blueprint, Calm deploys an instantiated version referred to as an application. You can also define common recurring tasks, such as taking backups, that are available in each application.

Calm can act as a self-service portal for users or as an orchestration platform. You can integrate it into your existing tools, such as Jenkins and Chef, for higher level automation in continuous integration and delivery pipelines. Calm also provides business monitoring and metrics you can set to trigger operations.

Blueprints

Every application you model using Nutanix Calm has a blueprint as its bare framework. A blueprint is a template that describes all the steps taken to provision, configure, and run tasks on its output. It represents the architecture of an application, which you can run repeatedly to instantiate, provision, and launch multiple applications. The blueprint also defines the application life

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cycle and its underlying infrastructure, from its creation until the end of the deployment.

You can use blueprints to model applications of various complexities, whether you're provisioning a single VM or provisioning, deploying, and managing a multinode, multitier application across hybrid enterprise clouds. For infrastructure-as-a-service (IaaS) use cases, there's also a Single VM blueprint with a streamlined interface.

Blueprint Editor

The Blueprint Editor is a visual method for configuring your architecture components and their dependencies.

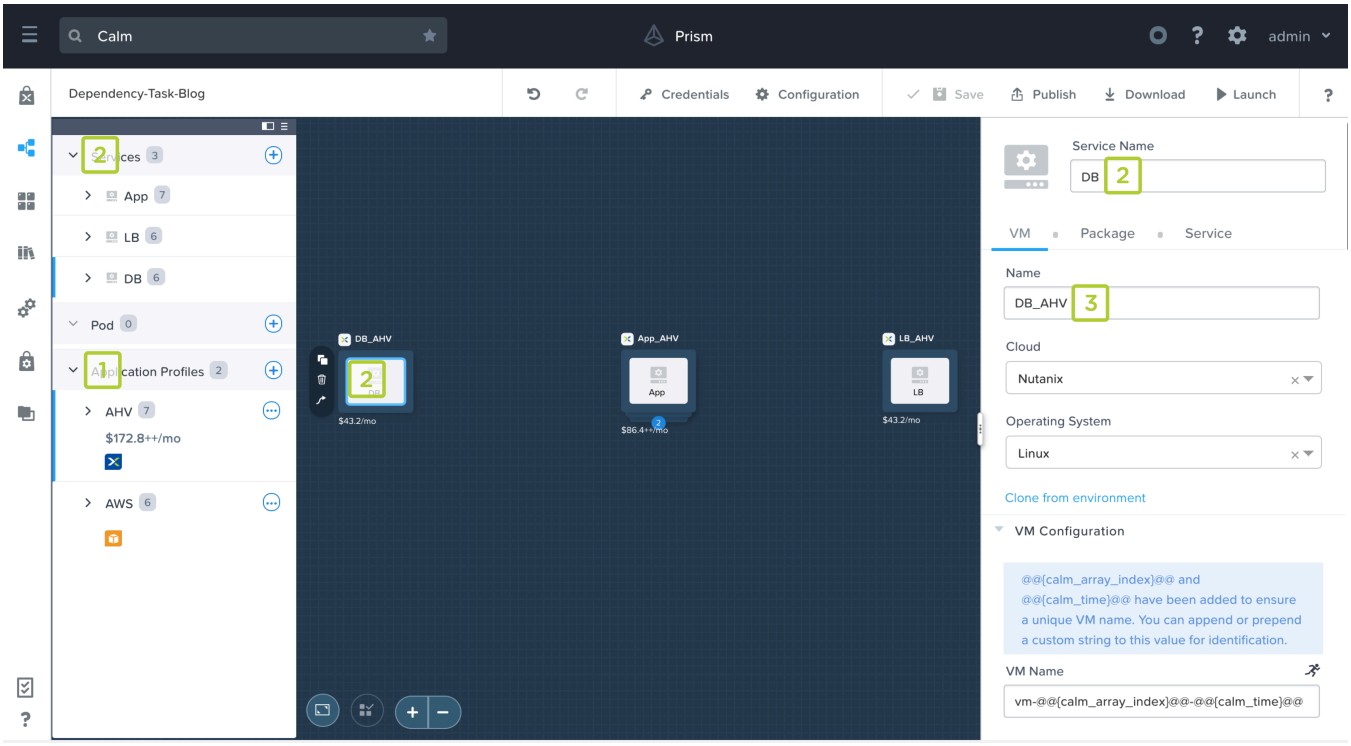

Figure 2: Nutanix Calm Blueprint Editor

Application Profiles

Application profiles (box 1 in the previous figure) expose simple choices to end users. Often these choices are about where an application should run (AHV or AWS), but they can also be about sizing (small or large), or a combination of

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the two (small AHV or large AHV or small AWS). An IT operator or developer should have a good understanding of the underlying differences between these choices, while abstracting that complexity from end users.

> Note: The blue line (to the left of the AHV application profile in the previous image) designates which app profile is currently being worked on.

Services

Services (box 2 in the previous figure) are logical entities exposed by an IP that span all application profiles and are managed by Calm. End users and services communicate with each other over a network using their exposed IPs and ports.

Substrates

Substrates (box 3 in the previous figure) are combinations of the underlying cloud and the VM instance. When you select the desired cloud in the Calm UI, all the fields required to create a VM instance on that cloud are displayed, and the combination of these fields is a substrate. Substrates don't span application profiles, so it's a best practice to name substrates as a combination of the service name and app profile name (DB_AHV or DB_AWS or DB_Small or DB_Large). Nutanix Calm supports the following hypervisors and cloud providers, with additional support options planned for future releases:

- AHV (the native Nutanix hypervisor).
- VMware vSphere (ESXi) on any infrastructure (Nutanix and non-Nutanix).
- Amazon Web Services.
- AWS GovCloud.
- Google Cloud Platform.
- Microsoft Azure.

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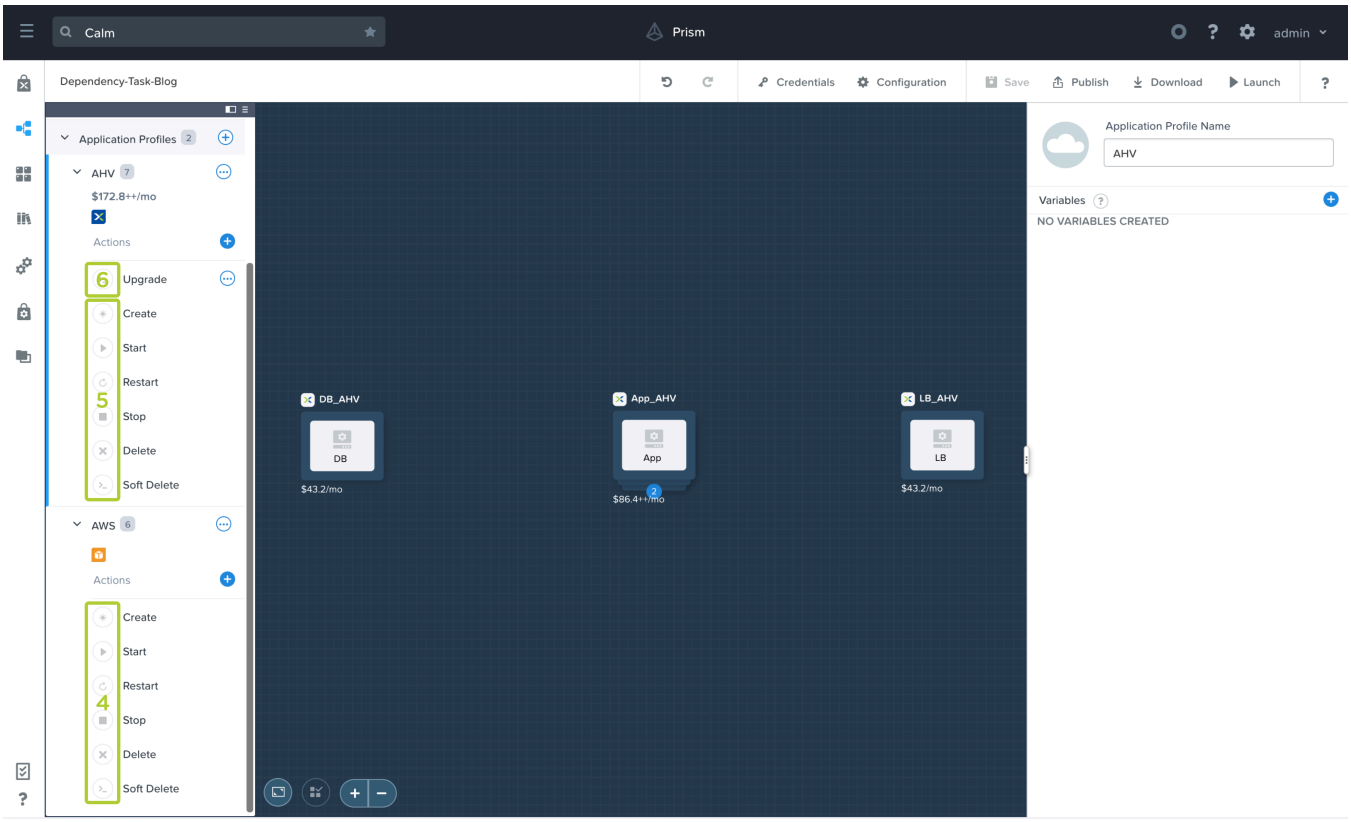

Figure 3: Nutanix Calm Application Profiles and Actions

Application Profile Actions

Application profile actions (or profile actions for short; box 4 in the previous figure) are sets of operations you can run on your application. For example, when you launch a blueprint, you run the Create action. If you don't need your application for a period of time, run the Stop action to gracefully stop your application. When you're ready to resume work, run the Start action to bring the app back. There are two different types of profile actions: system-defined and custom profile actions.

System-Defined Profile Actions

System-defined profile actions (box 5 in the previous figure) are automatically created by Calm in every blueprint and underlying application. The following are the system-defined profile actions.

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- Create-action

  Defines the operation of provisioning the machines that constitute your application architecture and conducts all the operations related to application creation.

- Start-action

  Starts the application by starting all the VM instances associated with the deployment. Typically you run this action after the Stop action.

- Restart-action

  Restarts the application by rebooting all the VM instances associated with the deployment. Use this action for VM changes that require a reboot to take effect.

- Stop-action

  Stops the entire application by powering down all the VM instances associated with the deployment. This action saves resources and associated costs while still allowing you to later restart the application with the Start action.

- Delete-action

  Deletes the entire application and all underlying VM instances at the end of its life cycle. This action occurs either at expiry (as defined in the expiry policy) or when a user runs it manually.

- Soft-Delete-action

  Deletes the application from Calm; however, it does not affect the underlying VM instances. After you run this action, you can't manage your application with Calm, but the application is still running on the cloud provider you deployed it to.

Custom Profile Actions

The blueprint developer creates custom profile actions (box 6 in the previous figure) whenever a set of operations needs to be exposed to the end user. Common custom profile actions are Upgrade, Scale In, and Scale Out.

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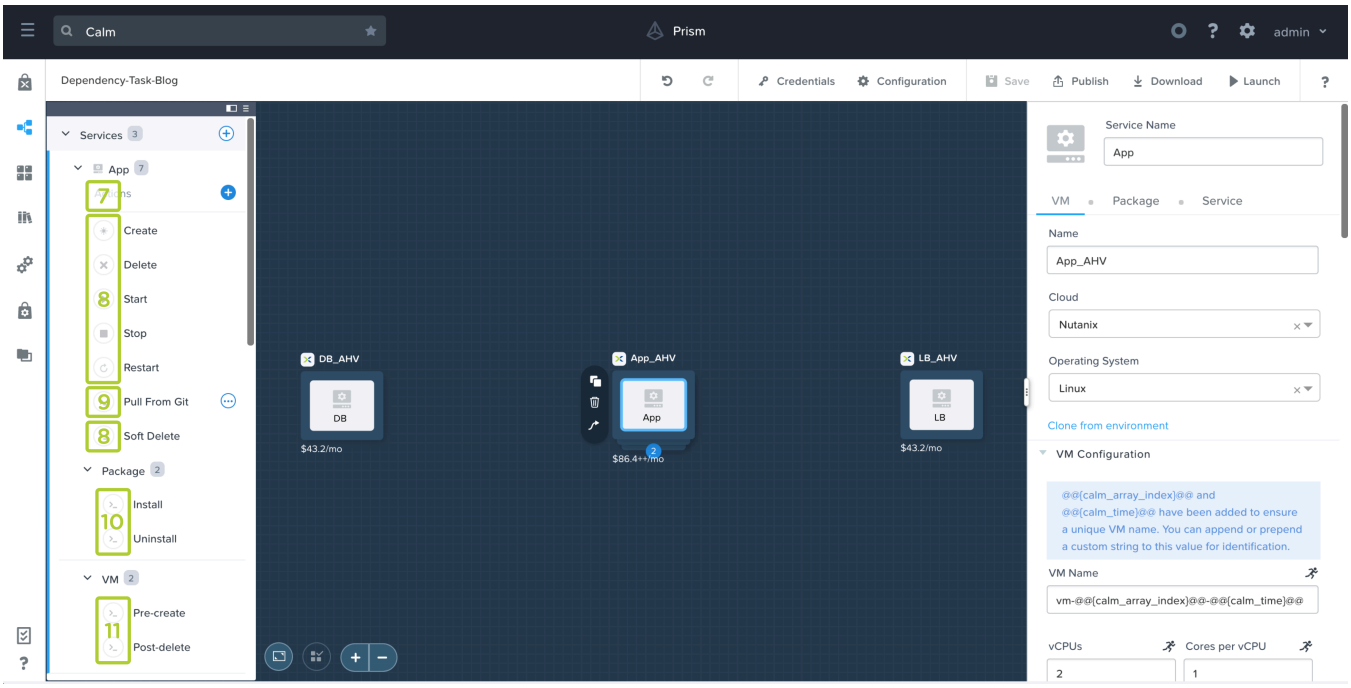

Figure 4: Nutanix Calm Service Actions

Service Actions

Service actions (box 7 in the previous figure) are a set of operations run on an individual service. Currently, the app's end user can't invoke them directly; the end user can invoke them indirectly using either profile actions or package install and uninstall operations (box 10 in the previous figure). As mentioned, services span application profiles, so their actions (and the underlying operations under those actions) do as well. If the blueprint developer creates a service action in the AHV profile, the same service action is available in the AWS profile. There are two different types of service actions: system-defined and custom service actions.

System-Defined Service Actions

System-defined service actions (box 8 in the previous figure) are automatically created by Calm in every blueprint and underlying application. You can't individually invoke these actions; they're only called when you run the corresponding profile action. For instance, any operations under the Stop service action run when the end user invokes the Stop profile action.

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Custom Service Actions

The blueprint developer creates custom service actions (box 9 in the previous figure) for any repeatable operations in the blueprint, like a function definition in a programming language. Say that during both the Create and Upgrade profile actions, the app service pulls new code from git. Rather than maintaining two separate tasks that perform the same set of operations, you could create a single custom service action that you then reference in both the Create and Upgrade actions.

Package Install and Uninstall

Package install and uninstall (box 10 in the previous figure) are run when a user first launches a blueprint (Create profile action) or finally deletes the entire application (Delete profile action). Package install and uninstall are unique to each application profile, which means the tasks or the task content can vary depending on the underlying cloud or the app's size.

VM Pre-Create and Post-Delete

VM pre-create and post-delete (box 11 in the previous figure) are operations run either before you create the substrate or after you delete it. A common use case is to make an API call into an IP Address Management (IPAM) system to get an IP for a to-be-created VM. You run the other operations described so far after the substrate has already been created, so VM pre-create is necessary if a property of your substrate relies on a third-party system.

Variables

Variables are properties associated with the services provisioned in blueprints, such as IP addresses, DNS names, and instance IDs. They can be static, provided at runtime, or generated during blueprint or action runs. Variables can have various data types (strings, integers, dates, or times) and various inputs (generated using single value, single input arrays, multiple input arrays, or an API call), and can be validated through regular expressions (regex). Secret variables allow you to include or create sensitive data in a blueprint without exposing it to end users.

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Macros

Macros enable you to access the value of variables and properties set on entities, and help you make generic scripts and create reusable workflows. For instance, a web server install script could use a macro to reference the IP address of a database. At deployment, the system replaces the macro with the actual IP address. Macros begin with @ @{ and end with }@@.

Dependencies

Dependencies define the reliance of one application service on at least one other service for properties such as IP addresses and DNS names, enabling the specific orchestration of concerns across the entire application state. Dependencies define the order in which the system runs the tasks; Calm visualizes this process in the design phase with arrows indicating the direction of execution. You can manually define dependencies—a web server depends on a database—or automatically define them with the Calm engine when macros are referenced.

Applications

Every blueprint launch results in a unique application you can manage with Calm throughout its entire life cycle. A single blueprint can give rise to dozens of running applications, which can run on a single cloud or multiple clouds. End users or administrators then manage these applications by running profile actions.

Brownfield Applications

Calm offers the ability to create blueprints to use applications already deployed in existing VMs—called brownfield applications—and bring them under Calm management. In a brownfield blueprint, you create dependencies and services just like you do in a freshly instantiated (or greenfield) blueprint, so you maintain the same level of automation along with the ability to scale the application.

Scale In and Scale Out

The scale-in and scale-out functionality lets you decrease or increase the number of service replicas. When you configure the scaling task as part of a

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profile action, you can define the number of instances to add or remove for the service per scale action or choose to define the number at runtime.

Task Library

The global task library allows users to save commonly used scripts and tasks for use in other blueprints. For example, a user commonly configures blueprints with a CentOS cloud image. The first several commands for each blueprint are to update the operating system, and then install basic, commonly used software. Instead of typing in this script manually, a user can publish it to the task library once, then repeatedly import it into any needed blueprints.

Another example is joining a VM instance to a domain. This script could be dozens of lines and contain macros that reference the Active Directory (AD) IP and logon information. You could publish this script to the global task library, with the opportunity to rename macros on both import and export to keep naming conventions consistent.

Projects

Projects are a group of users looking to collaborate. You can assign local users, Active Directory Users, or Active Directory Groups various roles in a project that grant different permissions. These users then collaborate on blueprints, applications, Marketplace items, and their underlying constructs. You can assign a project any number of cloud endpoints, including AHV, VMware, AWS, Azure, GCP, and Kubernetes, which the associated users or groups can then use.

Role-Based Access Control

Role-based access control (RBAC) lets you define different roles in an organization and assign permissions accordingly. RBAC enables organizations to control who can perform specific actions, including:

- Marketplace (publish, clone, provision).
- Blueprint (create, update, clone, delete, launch).
- Applications (manage, edit, create).
- Projects (add, update, assign resources).
- User (add, change, remove, roles).

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Marketplace

The Calm Marketplace provides a one-click deployment experience for requesting applications or services. The Marketplace presents the user with all the applications or services their role has the rights to access. Marketplace's consumer-like setting enables an organization member of any level to select an application and deploy it, enjoying fully automated provisioning and scaling for both traditional multitiered applications and modern distributed services. The Marketplace empowers organizations to consume services in a fully self-service manner at their own speed. It also includes built-in version control to easily track application changes.

From IT's perspective, it's not just about delivering better and faster services; the Marketplace also delivers and runs applications in a repeatable way, eliminating days and months previously devoted to routine application provisioning and management. It logs all user activity for end-to-end traceability, which helps with troubleshooting and addresses compliance needs.

Nutanix designed the Marketplace with our open approach in mind. Users select applications to deploy on-premises, in public clouds, or across both locations. As a result, IT can implement a multicloud strategy, while gaining visibility into the consumption and cost of resources across clouds.

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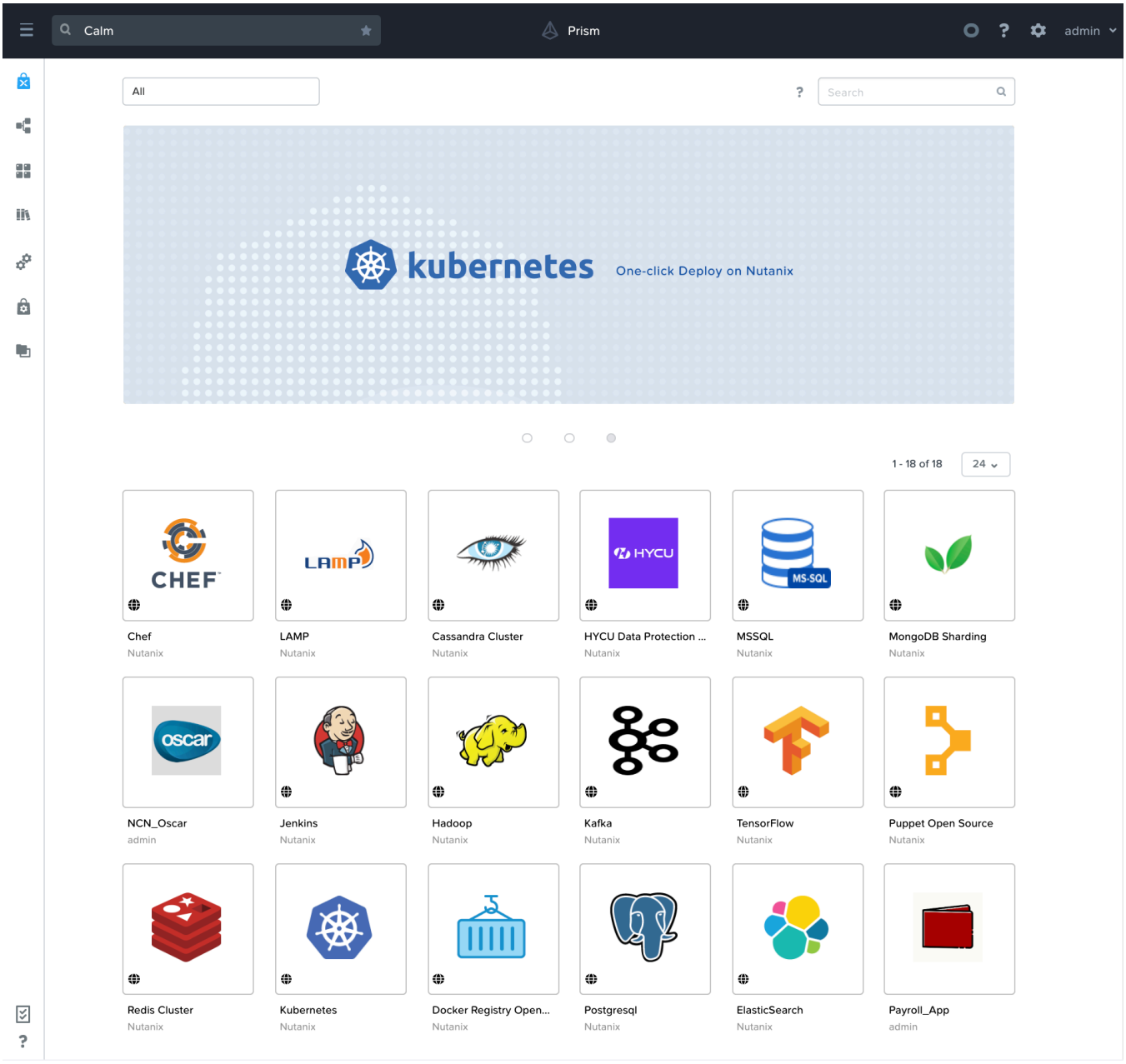

Figure 5: Nutanix Calm Marketplace

Developers constantly seek to improve their development processes by adopting new practices and tools to develop, test, and ship code faster. To that end, Nutanix delivers preintegrated and validated blueprints that enable

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IT teams to quickly introduce new technologies into their environments. With these preintegrated blueprints, IT can pilot new tools with developers and collaboratively decide whether to adopt them. This ability fosters not only experimentation with new tools, but also collaboration between teams.

Nutanix Calm Plugin for ServiceNow

For Nutanix customers who are also ServiceNow customers, the Nutanix Calm Plugin for ServiceNow enables users to publish Calm blueprints as ServiceNow catalog items. With this plugin, end users submit requests for applications that Calm provisions once approved before reporting back to the end user with the relevant details. If they use the Calm plugin, end users can manage their applications through the entire life cycle without ever leaving the ServiceNow UI, because the plugin exposes all application profile actions present in the blueprint to them. In the event of an issue, the plugin automatically creates a ServiceNow incident.

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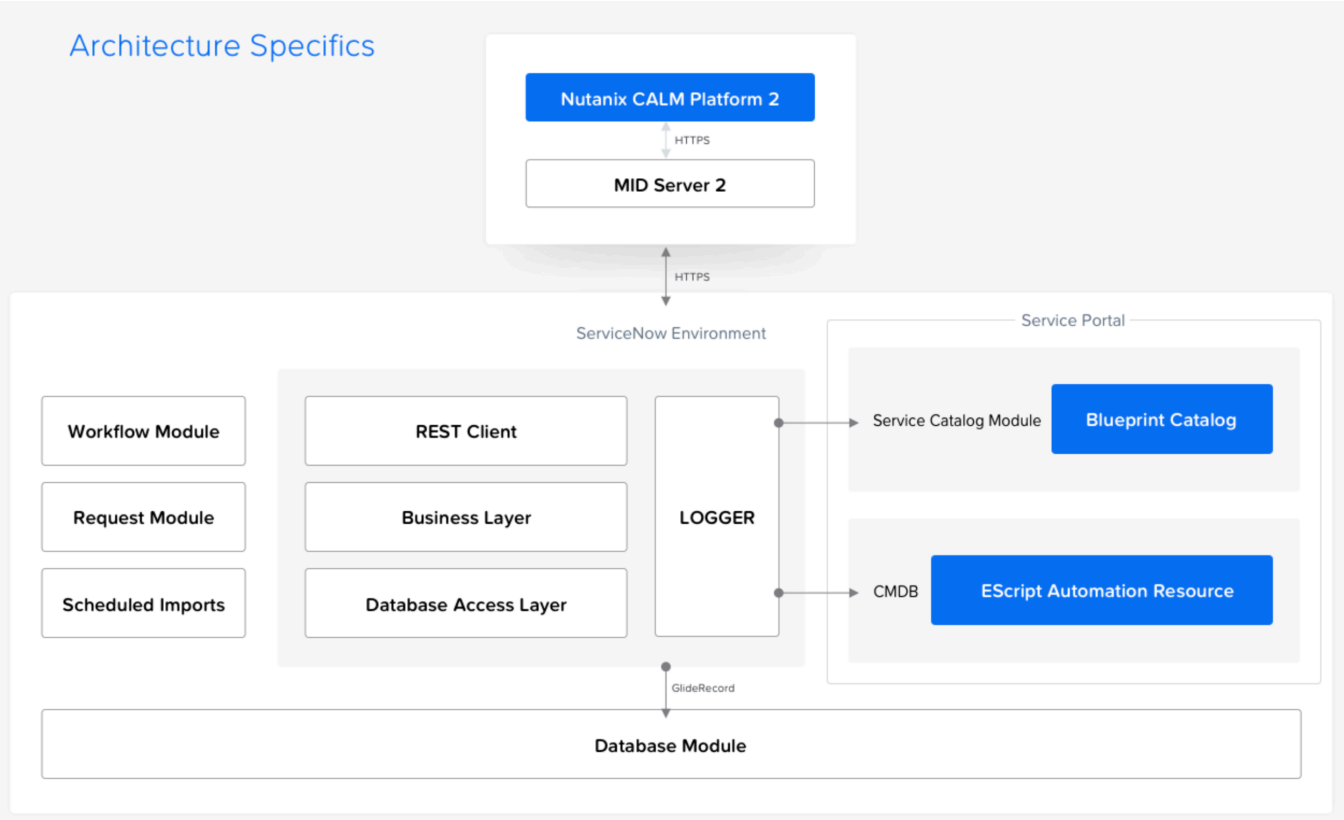

Figure 6: Nutanix Calm Plugin for ServiceNow Architecture

AHV Flow Categories

Calm lets you select an AHV VM category when you define details about VMs for services. This feature means you can assign blueprint entities to existing Flow microsegmentation security policies to precisely control network communications, and to existing Leap protection policies to provide application disaster recovery. Calm pulls a list of available AHV categories from Prism Central and presents the list in a drop-down menu in the Blueprint Editor. VMs deployed with these categories can be secured using Flow and protected using Nutanix Leap disaster recovery.

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5. Calm for Traditional IT

Calm enables infrastructure teams to automate common application-centric activities, streamlining daily operations and empowering self-service without compromising on visibility or control. Users of any level can easily consume these activities, or infrastructure and operations teams can use them internally to achieve improvements before opening them up to the larger organization.

One-Click Application Provisioning

Fully automate the way you provision and scale both traditional multitiered applications and modern distributed services using preintegrated blueprints that make managing applications in private and public clouds extremely simple. For example, IT managers can access the Calm Marketplace, choose a preintegrated application blueprint, and deploy it in single click. Organizations can choose from a growing number of preseeded application blueprints, including blueprints for Microsoft SQL Server, MySQL, Kubernetes, Jenkins, Hadoop, and more. Additionally, developers can publish their custom applications to the Marketplace for end users to quickly deploy. With Calm, infrastructure teams dramatically reduce the time they spend provisioning applications, allowing them to invest more time driving high-value activities.

Customizable Blueprints

Incorporate all elements of each custom enterprise application, including relevant VMs, configurations, and related binaries, into an easy-to-use blueprint that the infrastructure team can easily set up and manage. Automating deployment and life cycle management for common applications makes these tasks easy to repeat, so administrators can eliminate the hours and days they currently devote to routine application management.

You can, for example, create an application blueprint in Calm that orchestrates provisioning and scaling for a custom application and includes key

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dependencies and integration with other configuration tools, such as Puppet or Chef. Once you've defined them in an application blueprint, operations can be repeated and capture the latest organizational knowledge, significantly reducing errors, delays, and downtime.

Infrastructure as a Service

With single-VM blueprints, IT administrators can create basic infrastructure-focused blueprints; for instance, blueprints for Windows Server 2012R2, Windows Server 2016, or CentOS 7 Server. These blueprints might have basic scripts that update the software to latest versions and ensure all security vulnerabilities are patched. End users then provision these infrastructure blueprints on-premises or on public clouds and manage them throughout their entire lifecycle, including updating parameters like vCPU or memory, and snapshotting, cloning, or restoring the application.

Showback

Nutanix Calm natively integrates with Nutanix Beam to provide showback on VMs, applications, and projects for on-premises endpoints. IT departments can use this information to charge other departments or groups, as a form of quotas, or as a way to determine the optimal place to run an application. We're adding public cloud showback in a future release.

Automated Self-Service and Governance

Empower different groups in the organization to provision and manage their own applications, giving application owners and developers an attractive alternative to public cloud services and elevating infrastructure managers to cloud operators. Calm provides powerful, application-centric self-service capabilities, while maintaining control with role-based governance that limits user operations based on role, such as IT operator, developer, or manager. Additionally, Calm logs all critical activities and changes for end-to-end traceability, aiding security teams with key compliance initiatives. For example, you can enable the development team to create, scale, and destroy test and

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development environments without filing IT ticket requests. Development teams benefit from rapid provisioning times, while IT maintains control, traceability of user operations, and visibility into resource consumption.

Microsoft SQL Deployment Example

Microsoft SQL Server is a common application for traditional IT organizations. This use case example looks at the overall experience and behind-the-scenes activity for a one-click mirrored SQL deployment.

The Calm user clicks on a blueprint in the Marketplace, which prompts them to fill in a few fields with runtime variables used in the deployment process. For this example, Calm asks the user to choose the deployment destination, which is either an on-prem cluster or an off-prem cloud instance. Calm may also ask the user to provide IP addresses or instance names if there aren't processes to automate these points.

After the user submits the data, the blueprint begins the automated provisioning. This example is for a mirrored SQL install, in which Calm requests and provisions a pair of VMs. Calm instantiates these VMs based on the template image approved by the blueprint creator. The blueprint names and assigns the VMs an IP address either based on requestor input or using automated methods with callouts that are part of the blueprint.

After Calm prepares the VMs, the blueprint installs Microsoft SQL Server on each VM by accessing install media from a shared repository and configuring per the blueprint specifications. This process includes mirroring the SQL instances, applying best practices for SQL deployments, and assigning administrator rights for default groups and the requestor.

This one-click deployment results in a Microsoft SQL Server installation the requestor can consume without any delay or additional effort from external teams.

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6. Calm for Application and Development Teams

Calm enables teams who have embraced DevOps processes to unify around a single application modeling language for all applications, improving collaboration, providing unified governance, and eliminating IT personnel bottlenecks to achieve even greater agility.

Single Language for Application Modeling

All teams can use a single flexible construct—blueprints—for all applications, fostering collaboration that leads to greater operational efficiency. For example, developers define requirements for a new application in a blueprint. The security team makes changes to the blueprint to satisfy compliance requirements. The operations team updates the blueprint based on their support requirements. The final result is an end-to-end view of the application that eliminates silos, dramatically streamlines collaboration, and reduces errors.

Unified Management and Governance

Calm unifies management of on-prem and public cloud infrastructure (such as AWS), delivering complete visibility into user activity and clearly displaying costs for each workload. When you face a surge in application demand, for example, you can instantly distribute extra copies of a workload to a target cloud, tear them down when the application load subsides, and know the precise overall costs at any point in time.

Democratize Operations

Eliminate IT personnel bottlenecks that slow application deployments and life cycle management by turning specialized operations into repeatable actions that follow the application, not the infrastructure. Build repeatable

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environments anywhere, empowering IT generalists to manage nearly all operations.

Take, for example, a new project with requirements that include urgent requests to provision new servers. Normally, an operations architect manages these requests, but what happens if that person is out of the office or occupied with another project? Because you already coded all requirements into an application blueprint, anyone—including individuals in the development team—can use Calm to instantiate these new environments quickly and easily.

CI/CD Pipeline with Calm and Jenkins

With Calm and the Nutanix Calm plugin for Jenkins, you can create a fully automated continuous integration and delivery (CI/CD) pipeline, resulting in faster application delivery and a more satisfied customer.

For example, a developer runs git push from their developer workstation. The git repository they pushed to has a webhook configured to send the commit info to the company's Jenkins server. This process causes Jenkins to trigger a build, which creates a new Docker image based on the new code. Once the new image passes automated testing, the system pushes it to the company's container repository. Through the Nutanix Calm plugin for Jenkins, Jenkins instructs Calm to deploy a new application or update an existing application. All the developer had to do was run a single git push.

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7. Hybrid Cloud on Nutanix

The simplified operations, application management, and automation capabilities, and the open architecture that supports multiple clouds and hypervisors are key advantages of building your hybrid cloud with Nutanix. Nutanix Calm provides the automation and orchestration expected from an enterprise cloud solution, allowing administrators to:

- Use the same blueprints to provision applications in both the Nutanix and public clouds.
- Provide users with self-service provisioning on-prem or in public clouds from a single control plane, based on groups and roles.
- Gain visibility into the true cost of public cloud use so decisions are based on business needs and budget requirements.
- Consume resources based on project budgets facilitated by easy-to-implement governance for both Nutanix and public clouds.
- Manage VM and application life cycles in a fraction of the time.

In addition to automation and orchestration, Nutanix enables you to run your workload on a scalable platform that provides the following.

- Modular incremental scale

  With the Nutanix converged infrastructure, you can start small and scale. This capability aligns well with cloud deployments, which often start small and scale up on demand.

- Lower operational expense

  Nutanix helps organizations decrease opex by simplifying day-to-day operations and using converged architecture to break down organizational silos.

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- Data efficiency

  Nutanix offers multiple data efficiency features, including in-memory cache, inline and post-process compression, deduplication, and erasure coding (EC-X).

- Effective transparent data tiering

  Nutanix can take advantage of multiple storage tiers (if available) and migrate data based on requirements and access patterns.

- Enterprise-grade system management

  The Nutanix Prism UI gives you a simplified and intuitive way to manage large systems and serves as a single pane of glass for servers, storage, health, capacity management, and alert notifications. Nutanix Prism Central makes it possible to manage multiple Nutanix environments in a single session.

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8. Architecting AHV for Nutanix Calm

Calm provides application automation and life cycle management across your private, public, and hybrid clouds, with one-click simplicity for end users. As an IT administrator or application developer, you need to properly configure your desired cloud providers for Nutanix Calm. In this section, we go over the required settings for Nutanix AHV, walk through creating a 3-tier web application blueprint, and discuss blueprint best practices.

Nutanix AHV and Nutanix Calm Setup

Since AHV is the native Nutanix hypervisor, no configuration is necessary. Simply select the AHV cluster of your choice under Prism Central > Calm > Projects.

Calm Blueprint Creation Using AHV

This section walks you through creating a 3-tier web application blueprint and discusses best practices, what individual fields mean, and why you would select certain options.

- Log on to Prism Central with a local Prism administrator account or an AD account with at least developer credentials, per the Calm Project specifications.
- Select the menu icon in the upper left corner, navigate to the Services section, and select Calm.
- In the Calm UI, select the Blueprints icon on the left, and then the + Create Application Blueprint button.
- In the pop-up field, name your blueprint, and select a project linked to an AHV cluster.
- SSH keys are a more secure way of accessing VM instances. While Calm can authenticate with both password-based and key-based credentials, we

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recommend key-based credentials. To generate an SSH key pair, open a terminal and run the following command (take note of the Linux and MacOS differences), substituting the bracketed text with something appropriate for your environment:

```
linux$ ssh-keygen -t rsa -f ~/[KEY_FILENAME] -C [USERNAME]
macos$ ssh-keygen -m PEM -t rsa -f ~/[KEY_FILENAME] -C [USERNAME]
```

- For example:

```
ssh-keygen -m PEM -t rsa -f ~/calmkey -C centos@nutanix.com
```

- Back in Calm, click Credentials near the top, then Credentials +. Fill out the following fields in the credential box that appears:
  - Credential Name: Any name that makes sense for your environment. You later select this name when tying the credential to a service.
  - Username: The first half of the [USERNAME] field that you specified. In our example, it's centos.
  - Secret: Select Key.
  - Key: Paste in the private RSA key generated in the previous step. In our example, it's the output of cat calmkey. Include the BEGIN and END lines of the key.

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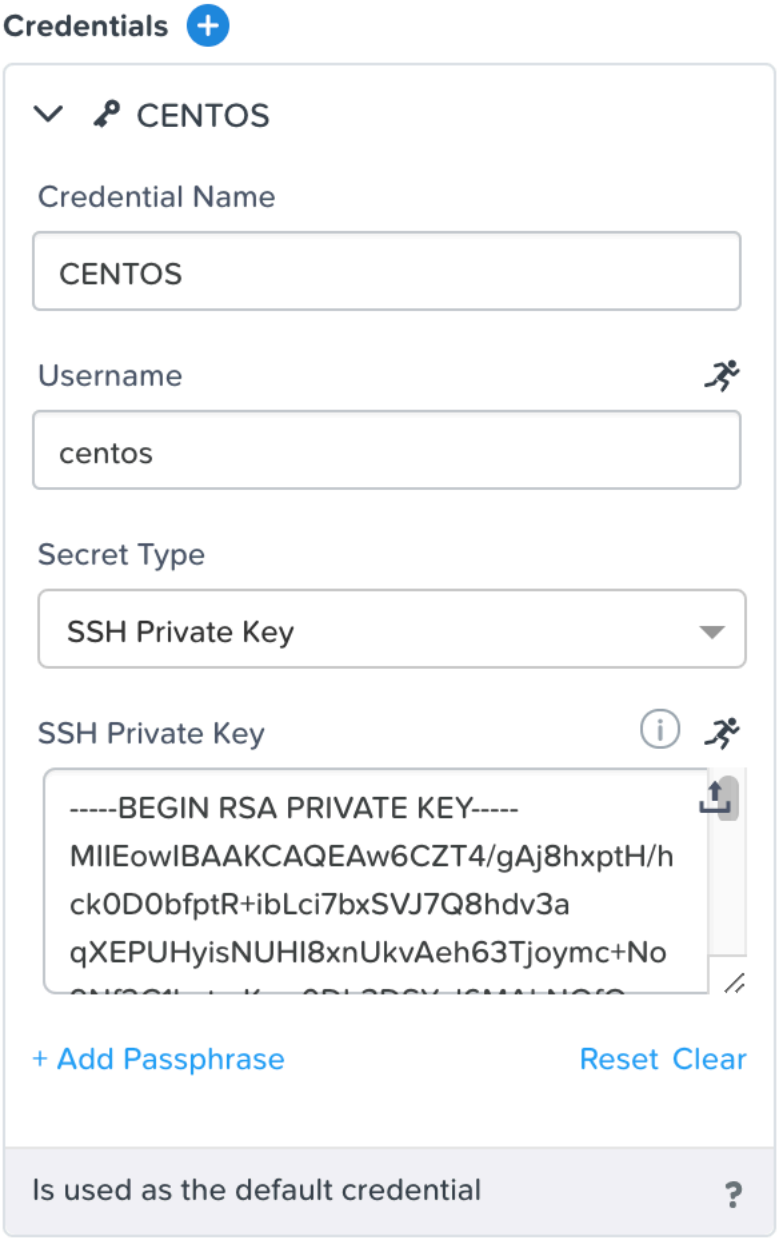

Figure 7: Key-Based Credential

- Click Back in the upper right corner, then click Save. It's a good idea to regularly save your blueprint and ensure that you don't introduce any errors. If you do, resolve the errors and move on.

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- Ensure that you've selected an application profile in the Application Overview pane on the left. You should see the Application Profile Name and a place to enter variables in the configuration pane on the right.
- Either leave the application profile named Default or change it to a more descriptive name. We recommend that you change the name if you have multiple application profiles. The end user selects from this group of application profiles at launch, so use simple yet descriptive names. Typical names include AHV and AWS, or AHV – Small App and AHV – Large App. In this example, we changed the default application profile to AHV.
- Under the variable list, fill out any necessary variables. In our example, you need to fill out the following fields.

Table 2: Variable List

Variable Name	Value	Secret
Mysql_user	root	
Mysql_password	Any value of your choice	X
Database_name	homestead	

Most clouds that Nutanix Calm supports handle VM images based on a disk image. From there you add things like compute and networking to round out the VM. AHV works the same way. In Calm, you can choose any disk or ISO image already present in Image Configuration (Prism Central > Explore > Images). Alternatively, you can specify an image directly in the Calm blueprint using the downloadable image configuration. We recommend this method for blueprint extensibility because it doesn't rely on a preexisting image on the cluster.

- To specify a downloadable image, click Configuration near the top of the screen.

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- On the page that appears, click Downloadable Image Configuration, and fill out the following fields:
  - Package Name: Any descriptive name. In our example, we specified CentOS_7_Cloud.
  - Description: An appropriate description of the image; for instance, CentOS 7 Cloud Image.
  - Image Type: The type of image required. In our example, it was a disk image.
  - Architecture: The image architecture type, which in our case was X86_64.
  - Source URI: The location to download the image. In our example, we specified this publicly available link: http://download.nutanix.com/calm/CentOS-7-x86_64-1810.qcow2
  - Product Name: The name of product this image is based on. In our example, it's CentOS.
  - Product Version: The version of the product the image is based on. In our example, it's 7.

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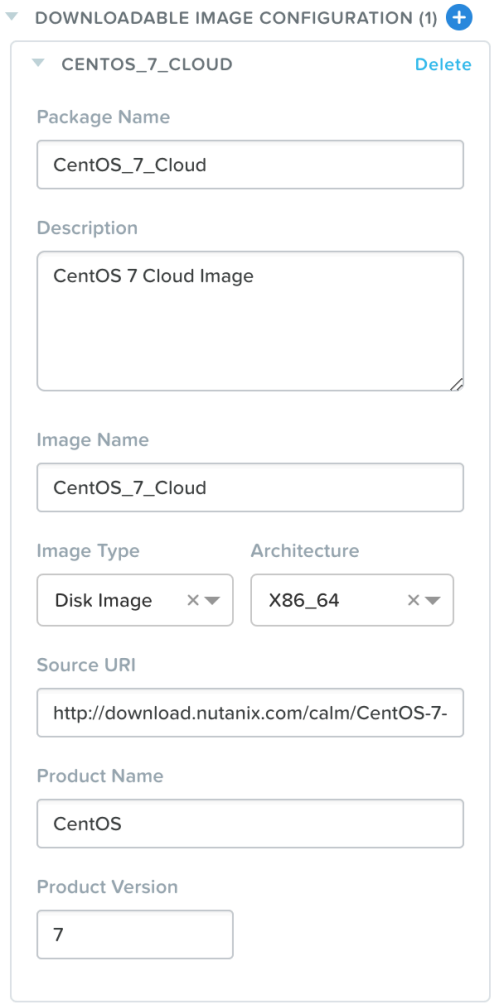

Figure 8: Downloadable Image Configuration

- Click Back and then Save.

Adding Services

Next, add any services you need in your application, anything from a single service to dozens. In our example, there were three services (database, web server, and proxy).

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Configuring MySQL Service

- In the Application Overview pane in the Services section, click the plus icon. You should see a service icon appear on the workspace, and the configuration pane on the right shows the details of the selected service.
- Fill out the fields according to what your application requires:
  - Service Name: The logical name of your service; MySQL in our example.
  - Name: The name of the substrate the service runs on; MySQLAHV in our example.
  - Cloud: The cloud you want your service to run on. Our example used Nutanix AHV, so we selected Nutanix.
  - OS: The operating system of the service, either Linux or Windows. Our example used a Linux OS.
  - VM Name: The name of the VM from the hypervisor's perspective. A default value of -@@{calm_array_index}@@-@@{calm_time}@@ is already present, which represents two macros to help make the VM name unique. In our example, we added MYSQL to the default: MYSQL-@@{calm_array_index}@@-@@{calm_time}@@.
  - Images – Image: The name of the image you based this VM on, which could be a downloadable image specified in the blueprint or an existing image on

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a Nutanix cluster. In our example, we chose the downloadable image we specified in a previous step, CentOS_7_Cloud.

- Images – Device Type: The image type, which in our example was disk.
- Images – Device Bus: The type of bus used for the disk. We used SCSI for our example, which is the recommended type for performance reasons.
- Images – Bootable: Whether the given image is bootable. Our image was bootable, so we checked the Bootable box.
- vCPUs: The quantity of vCPU you need for this VM instance. In our example, we selected 2.
- Cores per vCPU: The number of cores you need per vCPU specified. In our example, we selected 1.
- Memory (GiB): The amount of memory you need for this VM instance. In our example, we selected 4.
- Guest Customization – Checkbox: Whether you need guest customization technology (cloud-init or Sysprep) for this VM instance, which your image source dictates. The image we used does need guest customization, so we checked the box.
- Guest Customization – Type: The source image and its underlying OS dictate whether you need to use cloud-init or Sysprep to customize the guest. For Linux distributions (which our example is), select Cloud- init; for Windows distributions, select Sysprep.
- Guest Customization – Script: The script that performs the guest customization task. In our example, we used the task provided in the image at the end of this sublist.
- vDisks: Any additional virtual disks you need for your service. We didn't add any for this service, as we only needed the image we previously selected.
- vGPUs: If you need any vGPUs for your VM instances, click the plus icon. In our example, we didn't use any vGPUs.
- Categories: Select any Key: Value pair you need for this service, which allows you to specify Flow networking rules to the given VM instances, or

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Leap protection policies. In our example, we left this section blank, as a deep dive into Flow or Leap is beyond the scope of this document.

- Network Adapters: By default, a VM instance only specifies one NIC. If you need more than one NIC for your VM instance, click the plus icon to add as many as you need. In our example, we only need one NIC.
- Network Adapters – NIC 1: Select the network appropriate for this VM instance, which depends on your network configuration and your application's use case. For our example, we chose a network with a DHCP server available on it.
- Connection – Check log-in upon create: Check this box if you want Calm to log on to the VM instance once it's created. Generally, we recommend that you leave this checkbox selected. There are certain workflows, like using an eScript task for API calls on a dummy machine, that don't need Calm to log on. In our example, we left it checked.
- Connection – Credential: Select the appropriate credential for this service from the drop-down menu, or, if you need to create it, click Add New Credential. In our example, we already added it, so we selected CENTOS.
- Connection – Address: If you have multiple NICs, select the appropriate NIC for Calm to connect to. In our example, we left NIC 1 selected, as that's our only NIC.
- Connection – Connection Type: Specify how Calm connects to this service, which is based on the guest operating system: SSH for Linux or Windows (Powershell) for Windows.
- Connection – Connection Port: The port Calm uses to connect to the VM instance. Calm automatically sets it to 22 or 5985 based on the previous selection; however, if your disk image requires a nonstandard port number, change it here. For our example, we left the default of 22.
- Connection – Delay (in seconds): The amount of time Calm waits, after VM creation, before attempting to connect to the machine. This wait period allows the VM to boot, apply any guest customization, and perform any other first-boot tasks before Calm attempts to make a connection. Generally the default of 60 seconds is appropriate; however, there are

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Sysprep tasks for Windows machines that take much longer than a minute. For our example, we selected the default of 60 seconds.

Script

```
#cloud-config
users:
  - name: centos
    ssh-authorized-keys:
      - @@{CENTOS.public_key}@@
    sudo: ['ALL=(ALL) NOPASSWD:ALL']
```

Figure 9: MySQL Service Guest Customization Script

- Click Save and if any errors or warnings occur, resolve the issue, and try saving again.
- Scroll up the configuration panel on the right side and select the Package tab. The package install and package uninstall tasks add or remove any necessary software or configuration settings during VM creation and deletion.
- Change or leave the default name for the package and click Configure Install. On the blueprint canvas, a Package Install box appears.

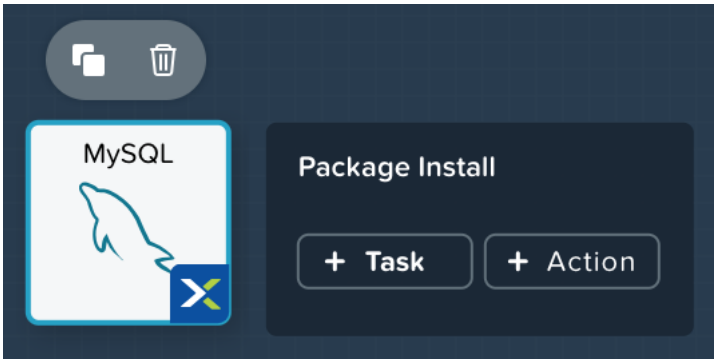

Figure 10: Package Install Section

- Depending on your use case, click either the + Task or + Action button. + Task allows you to run Shell, EScript (sandboxed Python environment), or

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Powershell scripts; scale your service in or out; or set variables you can use in other parts of the blueprint. + Action allows you to run service-level actions, including both system-defined service actions and any custom service actions. In our example, we ran a bash script, so we selected + Task. In the configuration pane that appears, fill out the following fields:

- Change or leave the default name for the new task.
- In the Type drop-down menu, select Execute, Set Variable, Delay, or HTTP Task. The Execute option runs the following script. The Set Variable option runs the following script, and additionally, when print var=value or echo var=value (depending on script type) runs, Calm creates a variable set to value that you can later use in a different section of the blueprint. The Delay option causes the application deployment to sleep for the specified amount of time. The HTTP Task option allows the user to define REST API calls using drop-down fields. In our example, we selected Execute.
- In the Script Type drop-down menu, select the script of your choice. Select Shell for *nix shells, EScript for Python scripts (useful for interacting with APIs), and Powershell for Windows Powershell scripts. In our example, we did a bash script, so we selected Shell.
- In the Credential drop-down menu, select the credential that applies to this service. For our example, we selected CENTOS.
- In the Script field, maximize the text box (optional) and paste in the following script, which installs MySQL, configures the credentials, and creates a database based on the variables specified earlier:

```
#!/bin/bash

set -ex

sudo yum install -y "http://repo.mysql.com/mysql-community-release-
el7-5.noarch.rpm"

sudo yum update -y

sudo setenforce 0

sudo sed -i 's/enforcing/disabled/g' /etc/selinux/config /etc/selinux/config

sudo systemctl stop firewalld || true

sudo systemctl disable firewalld || true

sudo yum install -y mysql-community-server.x86_64
```

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```
sudo /bin/systemctl start mysqld

sudo /bin/systemctl enable mysqld

#Mysql secure installation

mysql -u root<<-EOF

UPDATE mysql.user SET Password=PASSWORD('@@{Mysql_password}@@') WHERE
 User='@@{Mysql_user}@@';

DELETE FROM mysql.user WHERE User='@@{Mysql_user}@@' AND Host NOT IN
 ('localhost', '127.0.0.1', '::1');

DELETE FROM mysql.user WHERE User='';

DELETE FROM mysql.db WHERE Db='test' OR Db='test\_%';

FLUSH PRIVILEGES;

EOF

mysql -u @@{Mysql_user}@@ -p@@{Mysql_password}@@ <<-EOF

CREATE DATABASE @@{Database_name}@@;

GRANT ALL PRIVILEGES ON homestead.* TO '@@{Database_name}@@'@'%' identified by
 'secret';

FLUSH PRIVILEGES;

EOF
```

- Select the MySQL service icon in the workspace window again, scroll to the top of the configuration panel and click Package, then click Configure uninstall. Now you can run scripts that uninstall software prior to deletion.
- In the pane that appears in the workspace, add a task by clicking the + Task button. In the configuration pane that appears, fill out the following fields:
  - Change or leave the default task name.
  - Type: Execute.
  - Script Type: Shell.
  - Credential: CENTOS.
  - Script:

    ```
    #!/bin/bash

    set -ex

    sudo yum remove -y mysql-community-server.x86_64
    ```

- Click Save and if any errors or warnings occur, resolve the issue and try saving again.

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At this point, you've successfully configured the entire MySQL service. If your application is based on a single service, your blueprint is likely complete. Our example required another two services, which we configure below.

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Configuring WebServer Service

- In the Application Overview pane on the left, under the Services section click the plus icon. In the configuration pane that appears, fill out the following fields:
  - Service Name: WebServer
  - Name: WebServer_AHV
  - Cloud: Nutanix
  - OS: Linux
  - VM Name: WebServer-@@{calm_array_index}@@-@@{calm_time}@@
  - Images – Image: CentOS_7_Cloud
  - Images – Device Type: Disk
  - Images – Device Bus: SCSI
  - Images – Bootable: selected
  - vCPUs: 2
  - Cores per vCPU: 1
  - Memory (GiB): 4
  - Guest Customization – Checkbox: selected
  - Guest Customziation – Type: Cloud-init
  - Guest Customization – Script: This script is provided in the image at the end of this sublist.
  - vDisks: no additional
  - vGPUs: none
  - Categories: none
  - Network Adapters: Single NIC
  - Network Adapters – NIC 1: same network as the MySQL service
  - Connection – Check log-in upon create: selected
  - Connection – Credential: CENTOS

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- Connection – Address: NIC 1
- Connection – Connection Type: SSH
- Connection – Connection Port: 22 (Default)
- Connection – Delay (in seconds): 60 (Default)

Figure 11: WebServer Service Guest Customization Script

- Click Save and if any errors or warnings occur, resolve the issue and try saving again.
- Scroll up on the right side of the configuration panel and select the Package tab.
- Change or leave the default name for the package and click Configure Install. On the workspace, click + Task. In the configuration pane that appears, fill out the following fields:
  - Change or leave the default name for the new task.
  - Type: Execute
  - Script Type: Shell
  - Credential: CENTOS
  - Script:

```
#!/bin/bash
set -ex
sudo yum update -y
```

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```
sudo yum -y install epel-release
sudo setenforce 0
sudo sed -i 's/enforcing/disabled/g' /etc/selinux/config /etc/selinux/config
sudo systemctl stop firewalld || true
sudo systemctl disable firewalld || true
sudo rpm -Uvh https://mirror.webtatic.com/yum/el7/webtatic-release.rpm
sudo yum update -y
sudo yum install -y nginx php56w-fpm php56w-cli php56w-mcrypt php56w-mysql
 php56w-mbstring php56w-dom git unzip
sudo mkdir -p /var/www/laravel
echo "server {
 listen 80 default_server;
 listen [::]:80 default_server ipv6only=on;
root /var/www/laravel/public/;
 index index.php index.html index.htm;
location / {
 try_files \$uri \$uri/ /index.php?\$query_string;
 }
 # pass the PHP scripts to FastCGI server listening on /var/run/php5-fpm.sock
 location ~ \.php$ {
 try_files \$uri /index.php =404;
 fastcgi_split_path_info ^(.+\.php)(/.+)\$;
 fastcgi_pass 127.0.0.1:9000;
 fastcgi_index index.php;
 fastcgi_param SCRIPT_FILENAME \$document_root\$fastcgi_script_name;
 include fastcgi_params;
 }
}" | sudo tee /etc/nginx/conf.d/laravel.conf
sudo sed -i 's/80 default_server/80/g' /etc/nginx/nginx.conf
if `grep "cgi.fix_pathinfo" /etc/php.ini` ; then
 sudo sed -i 's/cgi.fix_pathinfo=1/cgi.fix_pathinfo=0/' /etc/php.ini
else
 sudo sed -i 's/;cgi.fix_pathinfo=1/cgi.fix_pathinfo=0/' /etc/php.ini
```

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```
fi
sudo systemctl enable php-fpm
sudo systemctl enable nginx
sudo systemctl restart php-fpm
sudo systemctl restart nginx
if [ ! -e /usr/local/bin/composer ]
then
 curl -sS https://getcomposer.org/installer | php
 sudo mv composer.phar /usr/local/bin/composer
 sudo chmod +x /usr/local/bin/composer
fi
sudo git clone https://github.com/ideadevice/quickstart-basic.git /var/www/
laravel
sudo sed -i 's/DB_HOST=.*/DB_HOST=@@{MySQL.address}@@/' /var/www/laravel/.env
sudo su - -c "cd /var/www/laravel; composer install"
if [ "@@{calm_array_index}@@" == "0" ]; then
 sudo su - -c "cd /var/www/laravel; php artisan migrate"
fi
sudo chown -R nginx:nginx /var/www/laravel
sudo chmod -R 777 /var/www/laravel/
sudo systemctl restart nginx
```

- Select the WebServer service icon in the workspace window again, scroll to the top of the configuration panel and click Package, then click Configure uninstall.
- In the pane that appears in the workspace, add a task by clicking the + Task button. In the configuration pane that appears, fill out the following fields:
  - Change or leave the default task name.
  - Type: Execute
  - Script Type: Shell
  - Credential: CENTOS
  - Script:

```
#!/bin/bash
```

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```
set -ex
sudo rm -rf /var/www/laravel
sudo yum erase -y nginx
```

- Select the WebServer service icon in the workspace window again and scroll to the top of the configuration panel and click the Service tab.
- In this section, you can specify the number of service replicas. There are Min and Max fields that allow a user to scale the number of VMs for the service between those values. For our example, specify at least 2 in the Min field (more if desired) and any number greater than or equal to the Min field for the Max field.
- Click Save and if any errors or warnings occur, resolve the issue and try saving again.

You successfully configured the entire WebServer service.

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Configuring the HAProxy Service

- In the Application Overview pane under the Services section, click the plus icon. In the configuration pane that appears, fill out the following fields:
  - Service Name: HAProxy
  - Name: HAPROXYAHV
  - Cloud: Nutanix
  - OS: Linux
  - VM Name: HAProxy-@@{calm_array_index}@@-@@{calm_time}@@
  - Images – Image: CentOS_7_Cloud
  - Images – Device Type: Disk
  - Images – Device Bus: SCSI
  - Images – Bootable: selected
  - vCPUs: 2
  - Cores per vCPU: 1
  - Memory (GiB): 4
  - Guest Customization – Checkbox: selected
  - Guest Customziation – Type: Cloud-init
  - Guest Customization – Script: This script is provided in the image at the end of this sublist.
  - vDisks: no additional
  - vGPUs: none
  - Categories: none
  - Network Adapters: Single NIC
  - Network Adapters – NIC 1: Same network as the MySQL service
  - Connection – Check log-in upon create: selected
  - Connection – Credential: CENTOS
  - Connection – Address: NIC 1

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- Connection – Connection Type: SSH
- Connection – Connection Port: 22 (Default)
- Connection – Delay (in seconds): 60 (Default)

Figure 12: HAProxy Service Guest Customization Script

- Click Save and if any errors or warnings occur, resolve the issue, and try saving again.
- Scroll up on the Configuration Panel on the right side and click the Package tab.
- Change or leave the default name for the package, and then click Configure Install. On the workspace, click + Task. In the configuration pane that appears, fill out the following fields:
  - Change or leave the default name for the new task.
  - Type: Execute
  - Script Type: Shell
  - Credential: CENTOS
  - Script:

```
#!/bin/bash
set -ex
sudo yum update -y
sudo yum install -y haproxy
sudo setenforce 0
```

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```
sudo sed -i 's/enforcing/disabled/g' /etc/selinux/config /etc/selinux/config
sudo systemctl stop firewalld || true
sudo systemctl disable firewalld || true
echo "global
 log 127.0.0.1 local0
 log 127.0.0.1 local1 notice
 maxconn 4096
 quiet
 user haproxy
 group haproxy
defaults
 log global
 mode http
 retries 3
 timeout client 50s
 timeout connect 5s
 timeout server 50s
 option dontlognull
 option httplog
 option redispatch
 balance roundrobin
# Set up application listeners here.
listen admin
 bind 127.0.0.1:22002
 mode http
 stats uri /
frontend http
 maxconn 2000
 bind 0.0.0.0:80
 default_backend servers-http
backend servers-http" | sudo tee /etc/haproxy/haproxy.cfg
hosts=$(echo "@@{WebServer.address}@@" | tr "," "\n")
port=80
```

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```
for host in $hosts
 do echo " server host-${host} ${host}:${port} weight 1 maxconn 100 check" | sudo
 tee -a /etc/haproxy/haproxy.cfg
done
sudo systemctl daemon-reload
sudo systemctl enable haproxy
sudo systemctl restart haproxy
```

- Select the HAProxy service icon in the workspace window again, scroll to the top of the configuration panel and click Package, then click Configure uninstall.
- In the pane that appears, add a task by clicking + Task. In the configuration pane that appears, fill out the following fields:
  - Change or leave the default task name.
  - Type: Execute
  - Script Type: Shell
  - Credential: CENTOS
  - Script:

```
#!/bin/bash
set -ex
sudo yum -y erase haproxy
```

- Click Save and if any errors or warnings occur, resolve the issue and try saving again.

You successfully configured the entire HAProxy service.

Adding Dependencies

In the final portion of the blueprint, you add dependencies.

- In the Application Overview pane on the left, expand the Application Profile, click the Create profile action, and view the workspace.

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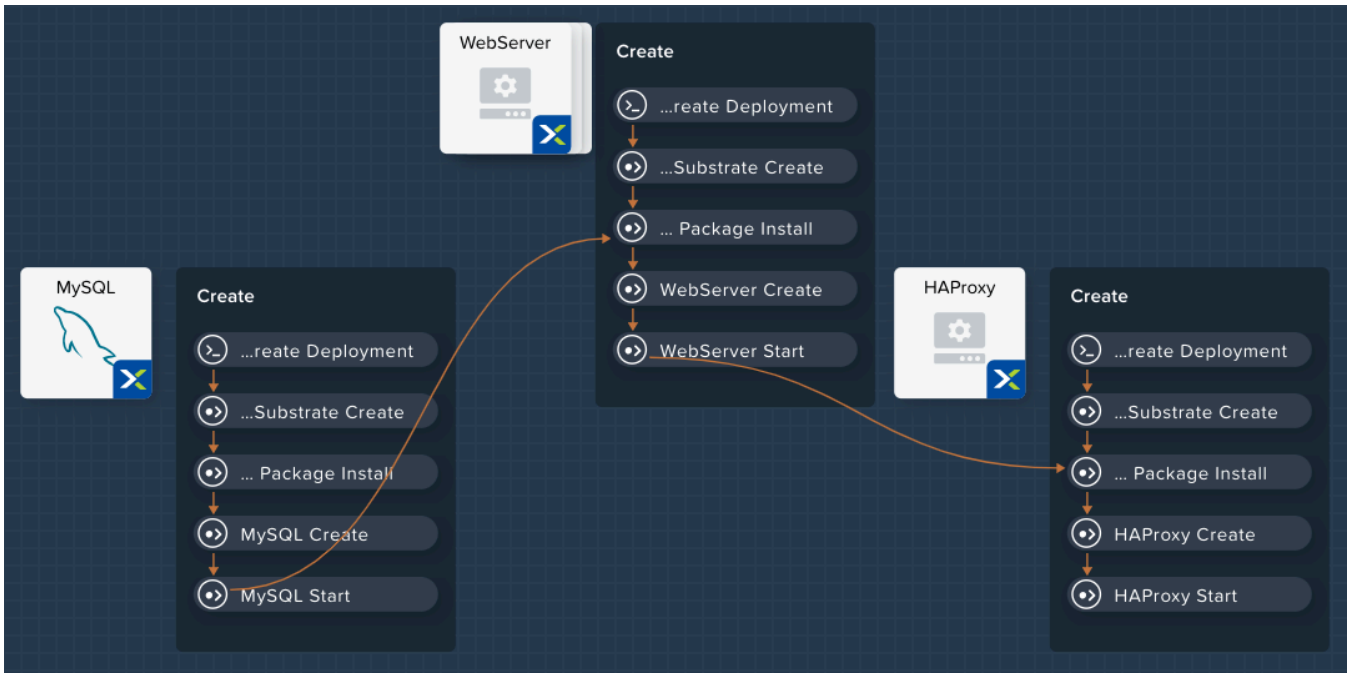

Figure 13: Blueprint Workspace: Create Action with Macro Dependency

Note: The orange arrows on the blueprint workspace represent order of execution. The system automatically generated them guided by macro references. In the Package Install script of the HAProxy, there's the macro @@{WebServer.address}@@. This reference tells the Calm system that the Package Install task of the HAProxy service cannot run until the WebServer is running with an IP address. A similar reference generated the orange orchestration edge between the MySQL and WebServer services.

- Next, select the Stop profile action on the left Application Overview pane, and view the workspace canvas.

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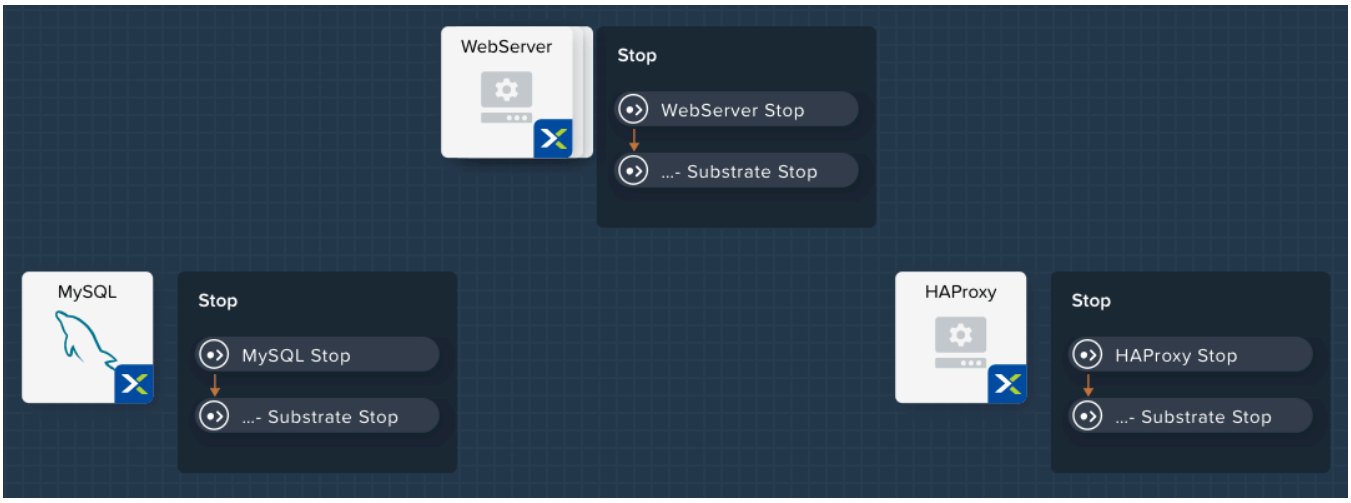

Figure 14: Blueprint Workspace: Stop Action Without Dependency

> Note: Because you didn't specify any scripts under any of the Stop service-level actions, the system didn't generate any orchestration edges, which could be a problem if the database powered down before the WebServer powered down. Manually create a dependency for all system-defined actions to prevent this problem.

- Click the HAProxy service icon, click the Create Dependency arrow icon, then click the WebServer icon. A white arrow should point from the HAProxy service to the WebServer service.
- Repeat the same step, instead drawing the dependency arrow from the WebServer to the MySQL service.
- Save the blueprint so the system can generate new edges, and your workspace should now look like the following image.

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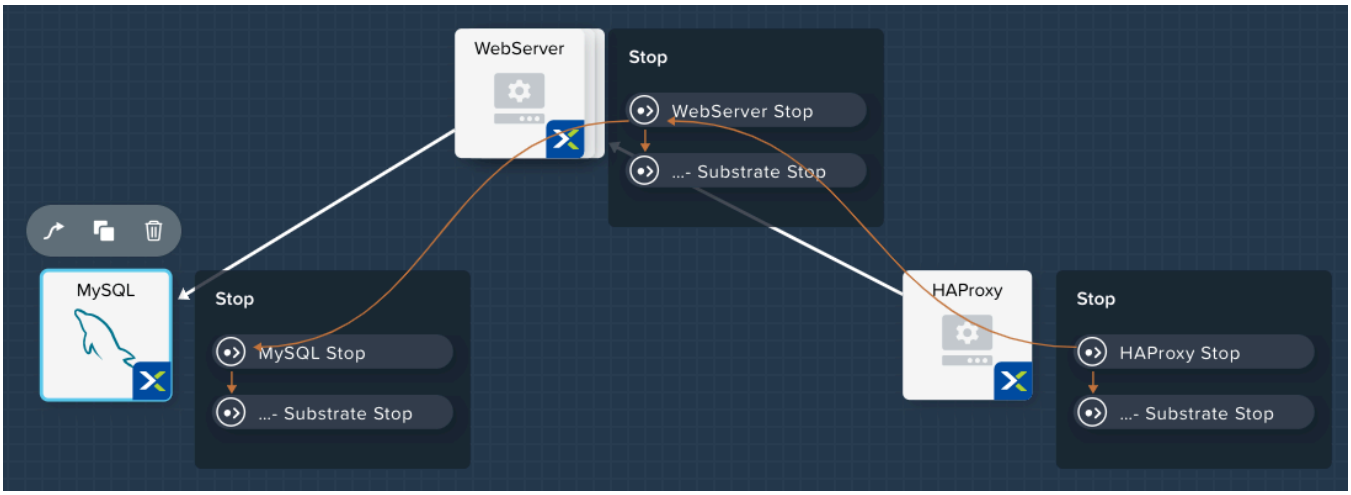

Figure 15: Blueprint Workspace: Stop Action with Dependency

- The system first stops the load balancer or HAProxy service, then the web servers, and finally the database.
- In the Application Overview pane on the left, click the Start profile action. The orange orchestration edges reverse direction, which means the database starts first, then the web servers, and finally the load balancer.
- Click Save, then Launch in the upper-right corner, name the application on the new screen, and hit Create, which redirects you to the Application page, where you can monitor the deployment and, once it's deployed, manage the life cycle of the app.

At this point, you have completed the example blueprint for Calm on AHV.

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9. Architecting AWS for Nutanix Calm

In this section, we go over the required settings for Amazon Web Services, walk through modifying a 3-tier web application blueprint for AWS, and discuss blueprint best practices.

AWS and Nutanix Calm Setup

Prior to creating AWS-based blueprints, an administrator must properly configure AWS for Nutanix Calm. This section covers the minimum steps required; however, it doesn't recommend AWS networking, security, or credential configurations, as business requirements dictate these configurations.

- Log on to the AWS console with your AWS credentials and navigate to the Elastic Compute Cloud (EC2) service.
- In the left column, under Network & Security, click Key Pairs.
- Click Import Key Pair to add our key pair and allow Calm to access AWS VMs using SSH. Name the key pair and paste in the same public key generated in the AHV section.
- Next, navigate to the IAM (Identity and Access Management) service, and select Users from the left column to create a user to allow the Calm API access to AWS. Click the Add user button, and on the next page, give the user a descriptive name.
- Check the Programmatic access box and click Next: Permissions.
- Select Attach existing policies directly, then grant AmazonEC2FullAccess and IAMReadOnlyAccess. Optionally, you can add any additional policies based on business requirements.
- Click Next: Tags, where you can add any tags you need based on your business requirements.

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- Click Next: Review, then Create user. Save the access key ID and secret access key for the end of this section.
- Select Roles in the left column of the IAM section, and then click Create role.
- Select EC2 as the AWS service using this account, select EC2 as the use case, then click the blue Next: Permissions button.
- Select the permission policy that fits your business requirements, but at minimum choose AmazonEC2FullAccess.
- Click Next: Review, review and name the role, then click Create role.
- Navigate back to the EC2 service and under the Create Instance section, click Launch Instance.
- Choose the Amazon Machine Image (AMI) that suits your application needs and click Select. For the example blueprint in this reference architecture, choose a CentOS 7 image.
- Select the instance type, preferably a small instance, as all you're going to use this machine for is to create an image.
- Click Review and Launch and on the next page, Launch.
- In the pop-up window, select Choose an existing key pair for the first drop-down menu and select the key pair you created earlier.
- Check the I acknowledge… box and click Launch Instances.
- Select the instance link in the confirmation message.
- Once the instance changes to a running state, click the gray Actions button, then hover over Image and click Create Image.
- Fill out the image name and image description, then you can add additional volumes if needed. Click the Create Image button.
- Click the View pending image… link. Ensure that after several minutes the image status changes to Available.
- Configure your AWS VPCs according to your business requirements. We recommend that you use either a VPN or Direct Connect between your private datacenter and AWS.

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- Log on to Prism Central, navigate to the Calm tab, select the Settings section, and then the Providers column. Click the + Add Provider button. In the pane that appears, fill out the following fields:
  - Name: enter a descriptive name.
  - Type: Choose AWS.
  - Access Key ID: paste in your access key from earlier.
  - Secret Access Key: paste in your secret access key from earlier.
  - Regions: select the regions based on your business requirements
  - Click Save, then Verify, and ensure that you properly verify your account.
- Navigate to the Projects section of Calm and select the project you want associated with your AWS account:
  - Under Infrastructure, select either Cloud only or Local and Cloud resources.
  - Under the AWS drop-down menu, select your AWS account.

Calm Blueprint Creation Using AWS

This section walks through modifying the 3-tier web application blueprint you created in the AHV section to work with AWS. If you have not already built the AHV blueprint, please start there.

- Log on to Prism Central with a local Prism administrator account, or an AD account with at least developer credentials, per the Calm Project specifications.
- Select the 3-tier web app blueprint you created previously.
- Under the Application Profile section in the left configuration pane, click the three dots next to the AHV application profile, and click Clone.
- In the right configuration pane, change the Application Profile name to AWS.
- In the variable section, fill in the Mysql_password value.

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- For each of the three services (HaProxy, WebServer, and MySQL), perform the following changes:
  - Under the VM section, change the name from [Service]_AHV_cloned_0 to [Service]_AWS, replacing [Service] with the name of the service you are changing.
  - Change the cloud from Nutanix to AWS.
  - Choose an appropriate account ID.
  - Give a descriptive instance name.
  - You can select Associate Public IP Address, if required.
  - Choose instance type based on your application requirements. Here, t2.nano works.
  - Select the AWS region you used in the previous section.
  - Select the availability zone based on your business requirements.
  - Choose the machine image you created in the previous section.
  - You can use the IAM role you created in the previous section or leave it blank.
  - Select the key pair you created in the previous section.
  - Select the VPC, security group, and subnet based on your business requirements.
  - Leave all other fields as the default.
- Click Save, then Launch in the upper-right corner, name the application on the new screen, and hit Create, which redirects you to the Application page, where you can monitor the deployment and, once it's deployed, manage the life cycle of the app.

You've completed the example blueprint for Calm on AWS.

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10. Architecting ESXi for Nutanix Calm

In this section, we go over the required settings for VMware ESXi, walk through modifying a 3-tier web application blueprint for ESXi, and discuss blueprint best practices.

VMware ESXi and Nutanix Calm Setup

Prior to creating ESXi-based blueprints, an administrator must properly configure VMware vCenter for Nutanix Calm. This section walks through the steps required to register vCenter to Nutanix Calm.

- Log on to your vCenter Server and ensure that you have at least one datacenter configured.
- If you plan to deploy on a DRS cluster rather than an individual host, configure a storage pod.
- Ensure that you have a template of each guest OS you want to base your applications on. In our blueprint example, you need a CentOS 7 template. Note the username and password in the template, as the blueprint section uses them.

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- Log on to Prism Central, navigate to the Calm tab, the Settings section, then the Providers column. Click the + Add Provider button. In the configuration pane that appears on the right, fill out the following fields:
  - Name: Give your vCenter account a descriptive name.
  - Type: Select VMware.
  - Server: Enter the resolvable hostname or IP of your vCenter Server.
  - Username: Enter a username that has at least the permissions detailed in the Nutanix Calm Administration and Operations Guide.
  - Password: Enter the password for the above user.
  - Port: By default, vCenter uses port 443, so enter that unless your vCenter Server uses a custom port.
  - Click Save, and an additional field appears.
  - Datacenter: Select the vCenter datacenter you want Calm to deploy to.
  - Click Save, then Verify.
- Navigate to the Projects section of Calm and select the project you want associated with your vCenter account.
  - Under Infrastructure, select either Local only or Local and Cloud resources.
  - Under the VMware drop-down menu, select your vCenter account.

Calm Blueprint Creation Using ESXi

This section walks through modifying the 3-tier web application blueprint you created in the AHV section to work with ESXi. If you have not already built the AHV blueprint, please start there.

- Log on to Prism Central with a local Prism admin account or an AD account with at least developer credentials, per the Calm Project specifications.
- Select the 3-tier web app blueprint you created previously.
- Under the Application Profile section in the left configuration pane, click the three dots next to the AHV application profile, and click Clone.

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- In the right configuration pane, change the Application Profile name to ESXi.
- In the variable section, fill in the Mysql_password value.
- Click the Credentials button and on the screen that opens, click the plus button to add a credential. Use this credential for the VMware template discussed in the previous section.
  - Credential Name: Give the credential a descriptive name (like CentOS_VMware).
  - Username: Enter the template username (like centos or root).
  - Secret Type: Choose whether this template has a password- or key-based credential.
  - Password or Private Key: Enter the password or private key (depending on the previous selection) for this user.
- Click Back, then Save.
- For each of the three services (HaProxy, WebServer, and MySQL), make the following changes:
  - Under the VM section, change the name from [Service]_AHV_cloned_0 to [Service]_ ESXi, replacing [Service] with the name of the service you are changing.
  - Change the cloud from Nutanix to VMware.
  - If your business requires that you deploy in DRS mode, check the DRS Mode box, and select the cluster, template, and storage pod you want to

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deploy to. If you don't have this requirement, leave DRS Mode unchecked, and select the host, template, and datastore you want to deploy to.

  - Provide a descriptive instance name.
  - You can modify any of the template controllers, disks, or network adapters as needed.
  - You can add any controllers, disks, or network adapters you need in addition to those present in the template.
  - Change the credential to the new credential you created in the previous steps.
  - Navigate to the Package heading and change both the Package Install and Package Uninstall tasks to the new credential you created in the previous steps.

- Click Save, then Launch in the upper-right corner, name the application on the new screen, and hit Create, which redirects you to the Application page, where you can monitor the deployment and, once it's deployed, manage the life cycle of the app.

You have completed the example blueprint for Calm on ESXi.

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11. Architecting GCP for Nutanix Calm

In this section, we go over the required settings for Google Cloud Platform (GCP), walk through modifying a 3-tier web application blueprint for GCP, and discuss blueprint best practices.

GCP and Nutanix Calm Setup

Prior to creating GCP-based blueprints, an administrator must properly configure GCP for Nutanix Calm. This section covers the minimum steps required; however, it doesn't recommend GCP networking, security, or credential configurations, as business requirements dictate these configurations.

- Log on to the GCP Console.
- Select or create the project of your choice.
- Locate the Navigation menu in the upper left, click IAM & admin, then click Service accounts.
- Click + Create Service Account and go through the configuration wizard. You need to name the service account, give it an ID, briefly describe it, and give it the necessary roles. At minimum, you need to give it the Service Account User role (under the Service Accounts section) and some role under the Compute Engine section that allows for instance creation, like Compute Instance Admin (v1) or Compute Admin. The last step in the wizard is to create a key. Select JSON as the type, then click Create. This step downloads a JSON file that you upload to Nutanix Calm.
- Navigate to the search bar at the top of the window, enter Compute Engine API, and select the first option. On the page that loads, click the blue Enable button. If the API is already enabled, skip to the next step. If the API isn't already configured, set up GCP billing.

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- Configure your GCP VPCs according to your business requirements. We recommended using either a VPN or Google Cloud Interconnect between your private datacenter and GCP.
- Log on to Prism Central, navigate to the Calm tab, and select the Settings section, then the Providers column. Click + Add Provider. In the configuration pane that appears, fill out the following fields:
  - Name: Give your GCP account a descriptive name.
  - Type: Change to GCP.
  - Click Upload Service Account File and select the JSON you downloaded in the previous step.
  - Regions: Select the regions you want to deploy to.
  - Public Images: Select any images relevant to your blueprint types. For the example blueprint in this reference architecture, select a recent CentOS 7 image.
  - Click Save, then Verify.
- Navigate to the Projects section and select the project you want associated with your GCP account:
  - Under Infrastructure, select either Cloud only or Local and Cloud resources.
  - Under the GCP drop-down menu, select your GCP account.

Calm Blueprint Creation Using GCP

This section walks through modifying the 3-tier web application blueprint you created in the AHV section to work with GCP. If you have not already built the AHV blueprint, please start there.

- Log on to Prism Central with a local Prism admin account, or an AD account with at least developer credentials, per the Calm Project specifications.
- Select the 3-tier web app blueprint you created previously.
- Under the Application Profile section, click the three dots next to the AHV application profile, and click Clone.

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- In the right configuration pane, change the Application Profile name to GCP.
- In the variable section, fill in the Mysql_password value.
- For each of the three services (HaProxy, WebServer, and MySQL), make the following changes:
  - Under the VM section, change the name from [Service]_AHV_cloned_0 to [Service]_GCP, replacing [Service] with the name of the service you are changing.
  - Change the cloud from Nutanix to GCP.
  - Give a descriptive instance name.
  - Select the zone based on your business requirements.
  - Select the machine type based on your application requirements. In this example, g1-small works.
  - Add at least one disk, based on application requirements, with the following configurations: Leave Use existing disk unselected for this example blueprint. For Storage Type, select pd-standard. For Source Image, select a CentOS 7 image (if there isn't one, refer to the section in this document on adding public images). For Size in GB, leave the default for this example blueprint.
  - Add at least one network. The values of the resulting network vary depending on your VPC and networking configuration. In a PoC environment, select the following values: Network: default. Subnetwork: default. Access Configuration Name: anything descriptive. Access Configuration Type: ONE_TO_ONE_NAT.
  - In the SSH Keys section, paste in the public key generated in the AHV section.
  - For the Security Groups field, select the VPC network firewall rules you need for your application. In our example application, the HAProxy and WebServer instances must allow port 80 traffic and the MySQL instance must allow port 3306 traffic.
  - Leave all other fields as default.

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- Click Save, then Launch in the upper-right corner, name the application on the new screen, and hit Create, which redirects you to the Application page, where you can monitor the deployment and, once it's deployed, manage the life cycle of the app.

You completed the example blueprint for Calm on GCP.

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12. Architecting Azure for Nutanix Calm

In this section, we go over the required settings for Microsoft Azure, walk through modifying a 3-tier web application blueprint for Azure, and discuss blueprint best practices.

Microsoft Azure and Nutanix Calm Setup

Prior to creating Azure-based blueprints, an administrator must properly configure Azure for Nutanix Calm. This section covers the minimum steps required; however, it doesn't recommend Azure networking, security, or credential configurations, as business requirements dictate these configurations.

- Log on to the Microsoft Azure dashboard.
- In the left pane, select Azure Active Directory, then Properties. Copy the Directory ID field to use in the Calm Providers section.
- In the Active Directory section, select App registrations, then click New application registration, which allows Calm to make API calls to Azure.
- Give the application a meaningful name (like calm), leave the Application type as Web app / API, and enter any value for the Sign-on URL. Click Create.
- On the next screen, copy the Application ID field to use in the Calm Providers section.
- In the same page, click the Settings button, then Keys.
- Under the Passwords section, add a new key. Give it a description that's relevant to you (like calmkey), select the timeframe for the key to expire, then click Save. Copy the key value that appears after you save to use in the Calm Providers section.
- Next, select Resource groups along the left pane, then the Add button to create a resource group.

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- Name the resource group appropriately (like calmrg), select the appropriate subscription, and select the resource group location that fulfills your business requirements. Click Create.
- Navigate to the newly created resource group and copy the subscription ID on the Overview page to use in the Calm Providers section.
- While still on the Resource Group page, click the Access control (IAM) link, then Role assignment, and finally Add to create new permissions and tie together the resource group and app registration.
- In the pane that appears on the right, select a role that allows for instance creation (like Contributor), leave the Assign access to field as Azure AD user, group, or application, and in the Select field, type in the name of your app registration. Select that app registration once it appears, then click Save.
- In the top search bar, enter Availability Sets, and choose the Availability Sets service. On the page that appears, click Add to create an availability set. Name it something meaningful (like calmas), select the appropriate subscription, select Use existing for the Resource group, and select the same resource group. Choose the domain settings appropriate for your business requirements, then click Create.

  Note: Availability sets allow Azure to restart your machine instances in the event of a failure (high availability).

- In the top search bar, enter Network Security Groups and select Network Security Groups. On the page that appears, click Add, give the network security group a meaningful name (like calmnsg), select your existing resource group, and the same location as your resource group. Click Create.
- Once you've created the Network Security Group, select it, then click Inbound security rules to allow additional traffic into your resource group machines.
- Click Add to add any security rules required by the application in question. All Calm blueprints require SSH access, so add a rule with the destination port ranges set to port 22. Our example blueprint requires HTTP access and MySQL traffic for the database, so add a rule with the destination port ranges set to port 80 and another rule with the destination port ranges set to port 3306. Add any other ports your applications require here.

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- In the left pane, select Virtual networks, then click Add to create an internal network space for the VMs to communicate on.
- Name the virtual network something relevant (like calmvn), fill in the address space for your application (if you're unsure, any 10.0.0.0/24 network should work), and select the existing resource group and the same location as before. Under the Subnet section, choose a subnet in the previously entered address space. Click Create.
- Ensure that you've properly configured the network between your private datacenter and Microsoft Azure. We recommend using either a VPN or Azure ExpressRoute.
- Log on to Prism Central, navigate to the Calm tab, select the Settings section, then the Providers column. Click + Add Provider. In the configuration pane that appears, fill out the following fields:
  - Name: Give your Azure account a descriptive name.
  - Type: Change to Azure.
  - Fill in the four IDs or keys from the previous steps.
  - Cloud Environment: Select the appropriate Azure cloud (if you're unsure, it's likely Public Cloud).
  - Click Save, then Verify.
- Navigate to the Projects section of Calm and select the project you want associated with your Azure account:
  - Under Infrastructure, select either Cloud only or Local and Cloud resources.
  - Under the Azure drop-down menu, select your Azure account.

Calm Blueprint Creation Using Azure

This section walks through modifying the 3-tier web application blueprint you created in the AHV section to work with Azure. If you have not already built the AHV blueprint, please start there.

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- Log on to Prism Central with a local Prism admin account or an AD account with at least developer credentials, per the Calm Project specifications.
- Select the 3-tier web app blueprint you created previously.
- Under the Application Profile section, click the three dots next to the AHV application profile, and click Clone.
- In the right configuration pane, change the Application Profile name to Azure.
- In the variable section below, fill in the Mysql_password value.
- For each of the three services (HaProxy, WebServer, and MySQL), make the following changes:
  - Under the VM section, change the name from [Service]_AHV_cloned_0 to [Service]_Azure, replacing [Service] with the name of the service you are changing.
  - Change the cloud from Nutanix to Azure.
  - Give a descriptive instance name.
  - Select the resource group you configured in the previous section.
  - Select the availability set you configured in the previous section.
  - Select the same location you selected in the previous section.
  - Select the hardware profile appropriate for your application's needs. In our example, Standard_B1s works.
  - Expand the Storage Profile section, then the VM Image Details section.
  - Choose the VM image type your application requires. For your example blueprint, select the following: Publisher: OpenLogic; Offer: CentOS-HPC; SKU: 7.4; Version: 7.4.20180719. In the window that appears, select Confirm Image Change.
- Under OS Disk Details, select the storage type needed for your application. For our example, select Standard.
- In the Network Profiles section, click the plus to add a NIC. Fill in all fields according to your business requirements. In our example blueprint, select the

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security group, virtual network, and subnet you configured in the previous section, and leave the rest of the defaults.

- Click Save, then Launch in the upper-right corner, name the application on the new screen, and hit Create, which redirects you to the Application page, where you can monitor the deployment and, once it's deployed, manage the life cycle of the app.

You have completed the example blueprint for Calm on Azure.

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13. Architecting Calm on Nutanix

This section describes the logical and physical components of a Calm-based infrastructure on Nutanix.

Nutanix Architecture

Table 3: Nutanix Design Elements

Item	Description
Nutanix enterprise cloud	A logical group of Nutanix nodes that provide compute (CPU and RAM) and storage according to availability, capacity, and performance requirements.
Nutanix nodes	Physical servers running AHV as the hypervisor.
Nutanix storage pool	A group of physical storage devices, including SSD and HDD, in the Nutanix nodes that form a Nutanix cluster.
Nutanix container	A logical segmentation of the storage pool that contains one or more VMs or files. You access this logical storage unit through iSCSI for AHV-based VMs, and NFS for ESXi-based VMs.
AHV	The native Nutanix hypervisor where VMs can run. You can have AHV preinstalled on the Nutanix nodes.

Nutanix Storage Pool

Nutanix recommends always using a one-to-one mapping between Nutanix clusters and Nutanix storage pools.

Nutanix Container

You can enable compression, deduplication, and erasure coding (EC-X) on each Nutanix container to increase available storage capacity and, for certain workloads, increase overall performance.

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Compression

Data compression occurs during or after write operations, and the compression ratio varies depending on the customer's use case. Therefore, Nutanix recommends trying compression for your workload to determine the expected storage space savings. Compression also improves performance.

Nutanix offers two types of compression:

- Inline compression: Compress data as users and applications write it.
- Post-process compression: Compress data after users and applications write it based on a delay timer configured per Nutanix container.

Both types of compression are available for most workloads, but you can tie functionality to specific licenses. See application-specific Nutanix best practice guides for recommendations on when to use inline versus post-process compression.

Deduplication

Deduplication is a software-driven, massively scalable, and intelligent data reduction technology. By eliminating duplicate data, the engine increases the effective capacity in the disk tier, as well as in the system's RAM and flash tiers. The larger effective cache capacity in RAM and flash substantially increases storage efficiency, while also improving performance.

Nutanix offers two deduplication options:

- Performance-tier deduplication: Improves caching and achieves faster reads while using less RAM and flash. The cache is per CVM.
- Storage-tier deduplication: Decreases storage utilization by deleting duplicate blocks on the extent store (backed by both SSDs and HDDs). On-disk deduplication is global among all nodes in the Nutanix cluster.

You can use performance-tier deduplication without storage-tier deduplication, but not the other way around.

If guest VMs are mostly similar, enabling deduplication on the performance tier can significantly improve performance, and storage-tier deduplication can increase storage capacity.

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Erasure Coding (EC-X)

EC-X is the native and proprietary Nutanix implementation of erasure coding. With EC-X, Nutanix customers can significantly increase their usable storage capacity.

EC-X overcomes the capacity cost of maintaining a replication factor without losing any of the benefits. Erasure coding creates a mathematical function around a data set such that if a member of the data set is lost, the system can easily recover the lost data from the remaining members of the set.

Use EC-X for data that is not overwritten frequently—for example, services providing archive and log functionality.

Nutanix Replication Factor

Configure the replication factor for Nutanix clusters and Nutanix containers. On the Nutanix container level, the replication factor defines how many identical copies of data are available in the Nutanix cluster. The system stores each data copy on a different Nutanix node to provide data availability in case of node or disk failure. A Nutanix system can have a replication factor of 2 or 3; replication factor 2 keeps two copies of the data and takes less disk space than replication factor 3, which maintains three copies. However, replication factor 3 delivers additional resiliency, because its three separate copies allow the Nutanix cluster to survive two simultaneous Nutanix node failures without impacting data availability.

We include a suggested tunable replication factor for each Nutanix container per deployment profile, but business requirements must be the determining factor when deciding replication factor in your specific design.

AHV Cluster

An AHV cluster is a logical grouping of AHV hosts. This logical component provides availability and resource scheduling for CPU, RAM, storage, and network utilization. Because we built AHV management into the CVMs and made it highly available by default on all Nutanix nodes, you do not need an additional component to manage the AHV cluster.

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Calm Architecture

Think of Nutanix Calm as another service that runs in our full-stack platform for enterprise cloud. The control plane for multicluster, distributed, and hybrid environments is Prism Central. Prism Central is a global control plane that provides management, reporting, automation and orchestration, and many other foundational features in a single consumer-driven HTML5 interface.

Prism Central functions as a virtual appliance available in either a single-node or three-node scale-out architecture. The scale-out architecture ensures that Prism Central is always available to provide platform services, even during maintenance and failure scenarios.

Nutanix Calm runs as a service in the Prism Central architecture. Calm supports both the single-node and three-node scale-out alternatives. In the scale-out architecture, Calm services are part of each Prism Central node. Calm is always available in the Prism Central cluster, even during maintenance and failure scenarios.

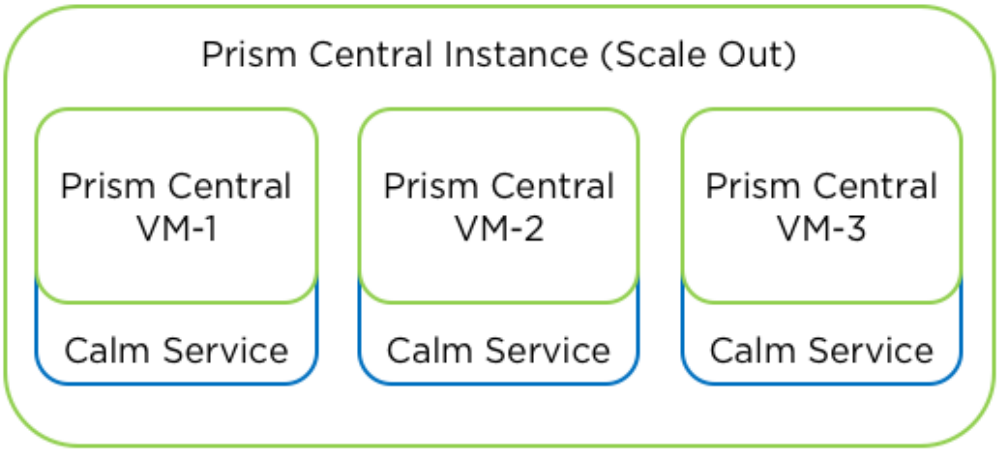

Figure 16: Scale-Out Prism Central

Managing your hybrid cloud deployment with Calm offers the flexibility to use any number of Prism Central instances, depending on your use case. Using a

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single instance is the simplest to configure; however, if there's a disaster in the region hosting the Prism Central instance, you may run into availability issues. If you use multiple Prism Central instances, you can manage Calm separately in each Prism Central instance, which provides different failure domains while also increasing availability and performance. Calm can also register secondary instances of Prism Central as additional availability zones, enabling a single Calm instance to deploy onto any number of clusters managed by any number of Prism Central instances. This deployment model increases failure domains from an application perspective, but not from a management perspective.

Localization

Nutanix Calm now offers Unicode (UFT-8 encoded) support for characters not contained in ASCII. Unicode support allows administrators to use supported characters in names of entities such as containers, VMs, and clusters.

Additional Infrastructure Services

For administrative simplicity and improved availability, you can keep the components described in this section in the management cluster with the Prism Central instance. Nutanix recommends placing at least one Lightweight Directory Access Protocol (LDAP) server in the management cluster for the small, medium, and large deployment profiles.

Table 4: Calm Infrastructure Items and Descriptions

Item	Description
Administration server	Used for cloud platform administrators.
Domain Name Server (DNS)	Provides name resolution functionality for management cluster components. Resource cluster components can also take advantage of this service.
Lightweight Directory Access Protocol (LDAP) server	Used by management cluster components. Resource cluster components can also take advantage of this service.

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Item	Description
Network Time Protocol (NTP)	Used for appropriate time synchronization.
Simple Mail Transport Protocol (SMTP) server	Used by management components. Resource cluster components can also take advantage of this service if needed.
Syslog	Standard for logging system messages.

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14. Deployment Profiles

This section describes the components required and options available for successfully implementing a Calm environment on Nutanix.

PoC or Test Environment

This deployment profile provides a way to quickly implement a Calm environment on Nutanix for evaluation purposes. This profile uses the small Prism Central instance sizing.

- Prism Central VM:
  - Prism Central: One management cluster and resource cluster.
  - Small instance sizing for up to 2,500 VMs (both Calm managed and non-Calm managed), and 2,000 combined Calm applications and blueprints.

The following table outlines the Nutanix-recommended setup for a PoC or test environment deployment profile.

Table 5: Recommended Setup for PoC or Test Deployments

Item	Quantity	Comment
Nutanix clusters	Minimum 1	Use one Nutanix cluster for both Calm management and Calm resource workloads.
Nutanix storage pools	Minimum 1	Use a one-to-one mapping between Nutanix clusters and Nutanix storage pools.
Nutanix containers	Minimum 1	One container with compression enabled for the Calm resource workload using replication factor 2.

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Item	Quantity	Comment
Hypervisor management VMs	Minimum 1	Acceptable to use a single Prism Central instance at small scale and for nonproduction use cases.
Hypervisor clusters	Minimum 1	Optional to split management and resources workloads into separate clusters. Optional for nonproduction and test use cases.
Nutanix nodes	Minimum 3	You need three Nutanix nodes to form a Nutanix cluster.
Nutanix rack units	Minimum 2	
10 GbE ports	Minimum 6	Two NICs per Nutanix node.
100/1000 ports (IPMI)	Minimum 3	One IPMI interface per Nutanix node.
L2 leaf switches	2	

Small Production

This profile does not implement the Prism Central management components in a highly available configuration. Their availability relies on:

- The hypervisor cluster's built-in availability for VMs using hypervisor high availability.
- The availability built into the Nutanix enterprise cloud.

This deployment profile uses the large Prism Central instance sizing.

- Prism Central VM:
  - Prism Central: One management cluster and resource cluster.
  - Large instance sizing for up to 5,000 VMs (both Calm managed and non-Calm managed), and 4,000 combined Calm applications and blueprints.

The following table outlines the Nutanix-recommended setup for a small deployment profile.

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Table 6: Recommended Setup for a Small Deployment

Item	Quantity	Comment
Nutanix clusters	Minimum 1	A small deployment easily fits in a single cluster. As the environment grows to maximum size, there is a natural progression toward multiple resource clusters.
Nutanix storage pools	Minimum 1	Same as above. Use a one-to-one mapping between Nutanix clusters and Nutanix storage pools.
Nutanix containers	Minimum 1	One container for each cluster with compression enabled using replication factor 2.
Hypervisor management VMs	Minimum 1	Acceptable to utilize a single Prism Central instance at small scale and for nonproduction use cases. For small deployments expected to surpass 1,000 managed VMs, we recommend deploying separate Prism Central instances for Calm management and Calm resource workloads.
Hypervisor clusters	Minimum 2	We recommend separating Calm management and Calm resource workloads into different hypervisor clusters. Smaller deployments can use a single cluster if desired. As Calm resource workload VMs increase, you may need more than a single cluster based on workload sizing, requirements, and node models deployed.

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Item	Quantity	Comment
Nutanix nodes	Minimum 3	Initial node count depends on whether the management and resource workloads are divided into separate clusters. The minimum node count for starting a cluster is three hosts.
Nutanix rack units	Minimum 2	
10 GbE ports	Minimum 6	Two NICs per Nutanix node.
100/1000 ports (IPMI)	Minimum 3	One IPMI interface per Nutanix node.
L2 leaf switches	2	

Tip: While it isn't required for starting a small deployment, Nutanix recommends separating Calm management and Calm resource workloads into different Nutanix clusters.

Medium Production

The medium deployment profile provides Calm component high availability for the resource cluster because it uses a Prism Central scale-out cluster. This profile uses both the small and large Prism Central instance sizing.

- Prism Central VMs:
  - Prism Central: One management cluster and resource cluster.
  - Resource instance uses clustered deployment with large instance sizing for up to 15,000 VMs (both Calm managed and non-Calm managed), and 9,000 combined Calm applications and blueprints.
  - Management instance uses non-clustered deployment with small instance sizing for up to 2,500 VMs (both Calm managed and non-Calm managed), and 2,000 combined Calm applications and blueprints.

The following table outlines the Nutanix-recommended setup for a medium deployment profile.

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Table 7: Recommended Setup for a Medium Deployment

Item	Quantity	Comment
Nutanix clusters	Minimum 2	For separation between Calm management and Calm resource workloads.
Nutanix storage pools	Minimum 2	Same as above. Use a one-to-one mapping between Nutanix clusters and Nutanix storage pools.
Nutanix containers	2	One container for each cluster with compression enabled using replication factor 2.
Hypervisor management VMs	Minimum 4	Deploy a three-node scale-out Prism Central cluster for the Calm resource workload cluster, and a single Prism Central VM for the management workload cluster. If the use case warrants additional availability, deploy a scale-out Prism Central cluster for the management cluster.
Hypervisor clusters	Minimum 2	Separate Calm management and Calm resource workloads into different hypervisor clusters.
Nutanix nodes	Minimum 6	
Nutanix rack units	Minimum 4	
10 GbE ports	Minimum 12	Two NICs per Nutanix node.
100/1000 ports (IPMI)	Minimum 6	One IPMI interface per Nutanix node.

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Item	Quantity	Comment
L2 leaf switches	2	

Large Production

The large deployment profile provides Calm management component high availability because it uses a Prism Central scale-out cluster. This profile uses the large Prism Central instance sizing.

- Prism Central VMs:
  - Prism Central: One management cluster and resource cluster.
  - Resource instance uses clustered deployment with large instance sizing for up to 15,000 VMs (both Calm managed and non-Calm managed), and 9,000 combined Calm applications and blueprints.
  - Management instance uses clustered deployment with small instance sizing for up to 5,000 VMs (both Calm managed and non-Calm managed), and 4,000 combined Calm applications and blueprints.

The following table outlines the Nutanix-recommended setup for a large deployment profile.

Table 8: Recommended Setup for a Large Deployment

Item	Quantity	Comment
Nutanix clusters	Minimum 2	For separation between Calm management and Calm resource workloads.
Nutanix storage pools	Minimum 2	Same as above. Use a one-to-one mapping between Nutanix clusters and Nutanix storage pools.
Nutanix containers	2	One container for each cluster with compression enabled using replication factor 2.

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Item	Quantity	Comment
Hypervisor management VMs	Minimum 6	Deploy a three-node scale-out Prism Central cluster for the Calm resource workload cluster and a scale-out Prism Central cluster for the management workload cluster.
Hypervisor clusters	Minimum 2	Separate Calm management and Calm resource workloads into different hypervisor clusters.
Nutanix nodes	Minimum 6	
Nutanix rack units	Minimum 4	
10 GbE ports	Minimum 12	Two NICs per Nutanix node.
100/1000 ports (IPMI)	Minimum 6	One IPMI interface per Nutanix node.
L2 leaf switches	2	

Multiple Datacenters

The multiple-datacenter deployment type derives from the local and remote datacenter construct, in which you can use a centrally located Prism Central deployment with Calm or deploy multiple Prism Central instances with a deployment at each site.

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15. Deployment Profile Hardware Requirements

Calm Management Components

This section outlines the hardware specifications that Calm management components require. These specifications help you calculate what hardware you may need. Refer to the Prism Central Guide for the latest hardware requirements.

- Prism Central VM with Calm (small), 2,500 VMs:
  - 6 vCPU, 30 GB of RAM, 1,000 GiB disk.
  - Scale-out installation is three VMs.

For large Prism Central deployments of 5,000 VMs, adjust memory to 52 GiB and vCPU to 10. Scaling out Prism Central (in either small or large deployments) to three nodes doubles the amount of VMs, applications, and blueprints you can manage.

Additional Components

The following section outlines the additional components that can run in the same hypervisor clusters with the Calm management cluster components to provide additional solution availability:

- LDAP
  - 2 vCPU, 4 GB of RAM, 40 GB disk, 1 Gbps network.
- DNS
  - 1 vCPU, 2 GB of RAM, 40 GB disk, 1 Gbps network.
- Admin VM
  - 2 vCPU, 4 GB of RAM, 100 GB disk, 1 Gbps network.

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- SMTP
  - 1 vCPU, 2 GB of RAM, 40 GB disk, 1 Gbps network.
- NTP
  - 1 vCPU, 2 GB of RAM, 40 GB disk, 1 Gbps network.
- Syslog
  - 2 vCPU, 4 GB of RAM, 100 GB disk, 1 Gbps network.

Nutanix Management Cluster Configuration

The following Nutanix cluster configuration can run the Prism Central (Calm) management VMs required for a large deployment profile as well as the VMs listed in the Additional Components section.

- 3x 1065-G5
  - 2 Intel Broadwell E5-2650v4 CPU (12c/2.2 GHz)
  - 192 GB of RAM
  - 1x 960 GB SSD
  - 2x 2 TB HDD
  - 2x 10 Gbps network cards

Using a vCPU-to-pCPU oversubscription of 4:1 and 20 GB of hot data per VM on average, the Calm management cluster use should look like the following figure.

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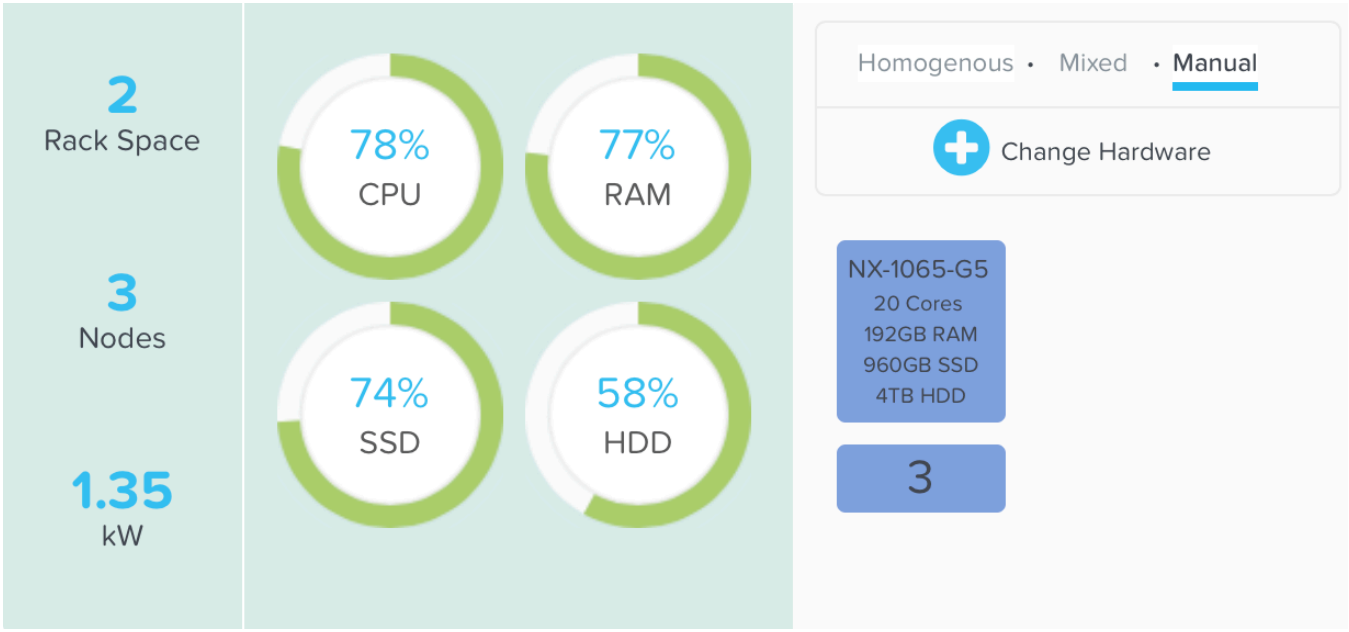

Figure 17: Calm Management Cluster Utilization for a Nutanix Cluster

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16. Network Requirements

Nutanix recommends a leaf-spine network architecture because it is designed for true linear scaling. A leaf-spine architecture consists of two network tiers: an L2 leaf and an L3 spine based on 40 GbE and nonblocking switches. This architecture maintains consistent performance without any throughput reduction because it has a static maximum of three hops between any nodes in the network.

The following figure shows a scale-out leaf-spine network architecture that provides 20 Gbps active throughput from each node to its leaf and scalable 80 Gbps active throughput from each leaf-to-spine switch, providing scale from one Nutanix block to thousands without any impact to available bandwidth.

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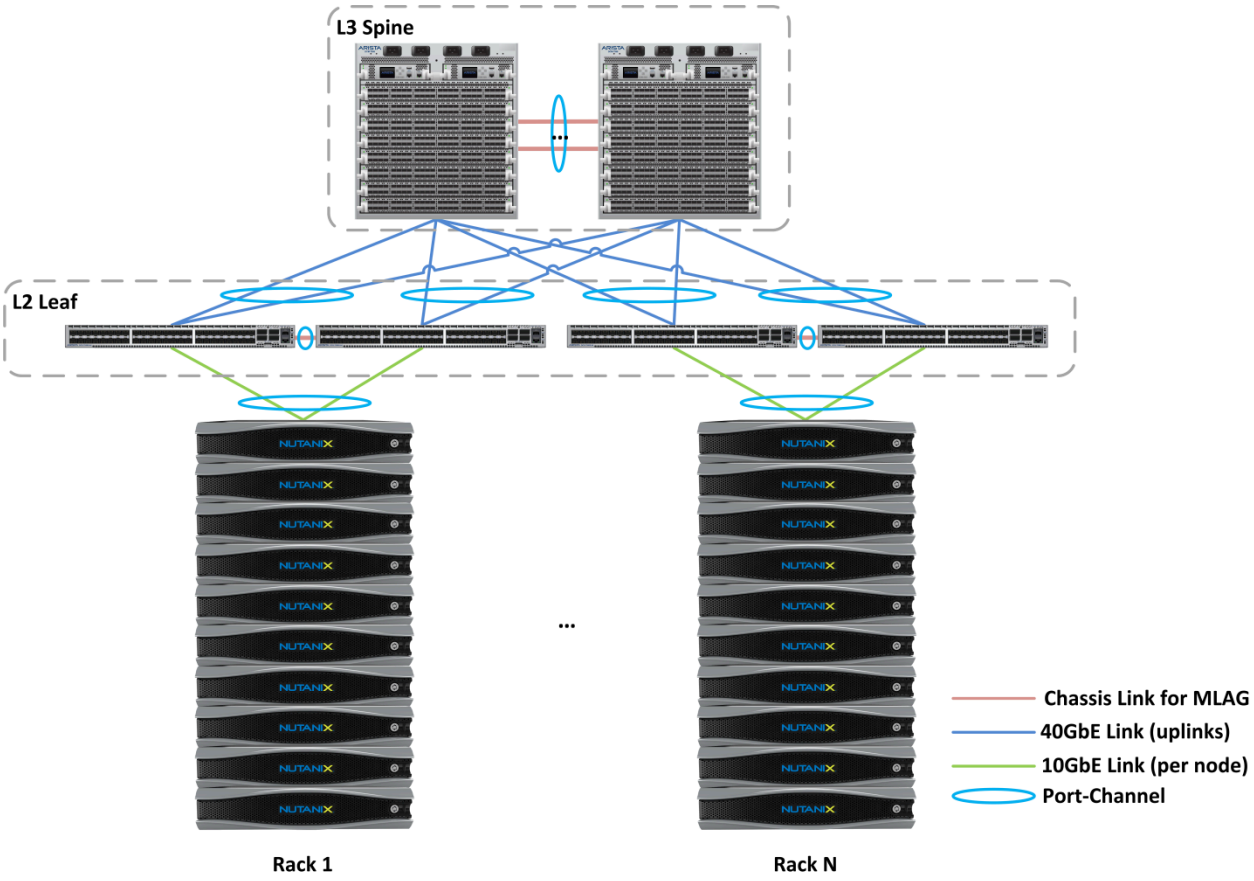

Figure 18: Leaf-Spine Network Architecture

Environments scale by adding more clusters, resulting in new racks; the network scales by adding new leaf switches in pairs to provide the required ports. You can also scale the leaf layer to meet port requirements or bandwidth for very large deployments.

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17. Scalability

This section provides guidance on how to scale the Nutanix solution for the Calm resource workload. Enterprises can scale Nutanix running the Prism Central management component from one deployment profile to another in the existing environment if the Nutanix nodes currently in use provide enough resources. If not, you can scale the Nutanix nodes up with more RAM capacity.

Scalability Example

The following section gives an example of using an existing environment's scalability for a Calm resource workload.

The number of application VMs deployed per Nutanix node varies depending on workload type. Using a 3060-G5 Nutanix node with the following specifications enables you to deploy approximately 40 application VMs.

Nutanix 3060-G5 configuration:

- 2 Intel Broadwell E5-2650v4 CPU (12c/2.2 GHz)
- 384 GB of RAM
- 2x 960 GB SSD
- 4x 2 TB HDD

VM configuration:

- 2 vCPU
- 8 GB of RAM
- 80 GB disk
  - 10 GB classified as hot data.
  - 70 GB classified as cold data.

Consult the Nutanix node hardware specifications for the latest information.

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Scalability Input Parameters

We can divide scalability input parameters into two sections: software-based and company-based.

Software-Based

You can find the software-based scalability limitations and rules in the Nutanix Prism documentation. One key software limitation regarding scalability is that a Prism Central instance can manage no more than 25,000 powered-on VMs.

Company-Based

Some examples of company-based scalability input parameters include:

- Availability domains: You can treat a physical site, a computer room, and a computer rack as an availability domain. Nutanix cannot scale out between sites, but the platform can scale out between computer rooms in the same physical location and between racks.
- Maximum number of Nutanix nodes or hypervisor hosts per Nutanix cluster.
- Maximum number of Nutanix nodes or hypervisor hosts per AHV cluster.
- Maximum number of VMs managed by the same Prism Central instance.

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18. Conclusion

Calm in the Nutanix enterprise cloud is the perfect building block for an enterprise, service provider, or private or public cloud infrastructure. The Nutanix enterprise cloud lets enterprises run both Calm management workloads and Calm resource workloads for the five Calm reference architecture–defined deployment types:

1. PoC and test environments
2. Small deployments
3. Medium deployments
4. Large deployments
5. Multiple datacenter deployments

Calm's native features capitalize on and manage the extended services catalog capabilities Nutanix provides. The design, implementation, and operational benefits of this solution, including consumer-grade simplicity and predictable performance, free IT to focus on high-value tasks, such as perfecting business process integration and innovation.

If you have additional questions on Nutanix or Calm, please continue the conversation on our Nutanix NEXT online community.

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Appendix

References

1. Nutanix Prism Web Console Guide (5.20)
2. Nutanix Calm Administration and Operations Guide (3.2.0)

About Nutanix

Nutanix makes infrastructure invisible, elevating IT to focus on the applications and services that power their business. The Nutanix enterprise cloud software leverages web-scale engineering and consumer-grade design to natively converge compute, virtualization, and storage into a resilient, software-defined solution with rich machine intelligence. The result is predictable performance, cloud-like infrastructure consumption, robust security, and seamless application mobility for a broad range of enterprise applications. Learn more at www.nutanix.com or follow us on Twitter @nutanix.

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