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Scale Your Cloud Operating Model with a Platform Team

Developing shared IT services to accelerate digital transformation

Whitepaper

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Executive Summary

Cloud is now the default choice for organizations delivering new value to their customers. Successful companies use a cloud operating model — a framework for adopting cloud services — to maximize agility, reliability, and security and deliver superior business outcomes.

But that's only the first step. The most mature organizations are further tuning their people, processes, and tools to create centralized platform teams that help scale their cloud adoption enterprise-wide.

Platform teams are instrumental in achieving the maximum benefits from a cloud operating model. The teams' platform engineers deliver shared infrastructure, runtimes, and other services that are consumed by developers across the organization. Effective platform teams enable a cloud operating model that delivers standardized workflows, compliant golden images, and a system of record for cloud adoption. This leads to greater productivity, more frequent releases, increased stability, lower risk, and optimized costs.

This white paper lays out the advantages of implementing a cloud operating model. It will also address important considerations for people, processes, and tools, including solutions developed by HashiCorp and Palo Alto Networks.

Introduction

A cloud operating model is essential for organizations to succeed with cloud adoption and thrive in multi-cloud environments. This white paper explains the components of that approach and the key role of centralized platform teams in industrializing application delivery. It focuses on proven patterns for standardizing how people work, the processes they follow, and the tools they consume.

Platform teams include engineers who provision, run, and manage cloud infrastructure and other shared services. They create and operate highly automated platforms available on-demand across the organization. Developers can access the platform capabilities via self-service processes, making it easy to quickly create new environments and new service instances. The platform team's responsibility is to keep the platform stable, resilient, performant, and secure. Critically, bolstered by a reliable baseline of services from the platform team, application development teams across the organization can create and release new capabilities to users more quickly.

Over time, high-performing platform teams use feedback from developers, security engineers, and business leaders to refine processes, improve reliability, and add desirable new features.

Multi-Cloud Adoption Leads to Platform Teams

According to HashiCorp's 2022 State of Cloud Strategy Survey, 81% of survey respondents choose more than one cloud. And the larger the organization, the more likely they are to use multiple clouds.

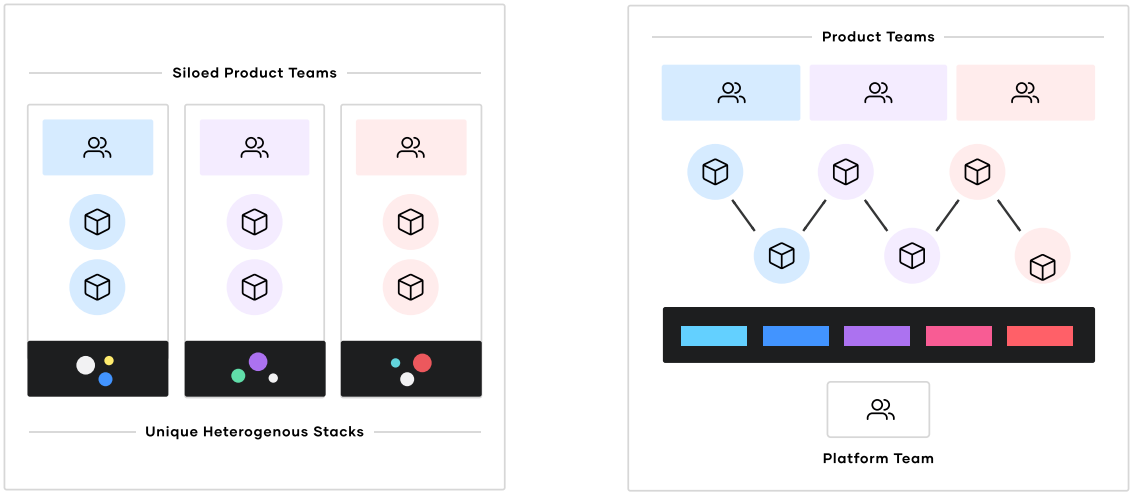
Multiple clouds have become the dominant pattern for many reasons: organic adoption, deliberate diversification, and mergers and acquisitions, to name a few. On the back of the move to multi-cloud, two new motions have become prevalent in large organizations:

1. A shift to platform teams and a platform mindset. This shift standardizes on a set of infrastructure services to reduce friction for developers and operations teams. It empowers a small, centralized group of platform engineers with the right tools to improve the developer experience with APIs, documentation, and advocacy.

2. "Platform-as-a-product" practices. Heritage IT projects have a finite start and end date. That's not the case with your cloud platform; it's a product and never "finished." Ongoing tasks include backlog management, regular feature releases, and roadmap updates to stakeholders.

A Shift to Platform Teams and a Platform Mindset

A platform team abstracts the complexity of multi-cloud architectures away from development teams with a curated set of standardized APIs. This way, each team can "plug in" to the approved services, freeing them to focus their attention on creating custom code. Platform teams can be a significant force multiplier for the organization; the goal is for an organization's collective cloud best practices — including security and compliance requirements — to be "baked in" to the shared platform. This model yields greater operational efficiency and developer productivity.



Organizations often develop silos of cloud usage, shown above at left. Here, each product team uses its own set of processes, tools, and architecture. The ongoing cost and complexity of maintaining unique technology stacks is substantial. In the image on the right, organizations that use a platform team enjoy efficiencies of scale. Product teams can focus on their own applications, while the platform team provides standard services for provisioning, security, networking, and more

Platform-as-a-Product Practices

Organizations should run their cloud platform as a product, a key principle of user-centered design. When building your cloud platform "product," the goal is to understand the needs of the teams that are building services to run atop the platform. A platform needs to have demonstrable value to promote adoption and success.

Building your platform as a product is unlike running a traditional IT project. Rather than discrete project start and end dates, platforms need iterative product development. The platform team should be constantly ingesting feedback from business and technical stakeholders, and regularly shipping new features and improvements based on this feedback.

For maximum impact, platform teams should focus on pragmatic approaches to nine key areas:

1. **Define and measure reliability:** It is crucial for developers to trust the platform team, and trust is built over time. A reliable and predictable set of services gives developers — and executives — confidence that the platform will be reliable and scalable during moments of truth for the business. Desired outcomes include meeting and exceeding application uptime and performance targets. Traditional service level agreements (SLAs) can be a useful measurement. Over time, more advanced site

reliability engineering (SRE) practices such as service level objectives (SLOs)and error budgets can yield even greater benefits.

2 **Continuously reduce toil and increase automation:** Seek to automate as much as possible. Automation increases consistency, reduces toil, and improves developer productivity. The first step to automation is to understand the steps required to complete a given workflow. Discussions with engineering teams can yield the blueprint for a given process. From there, platform teams can proceed to automate the task. The result: increased deployment frequency and faster time-to-market. Each automated workflow reduces the labor needed to achieve a new outcome later.

3 **Enable education and encourage platform adoption:** Successful enterprises tend to build and manage functional platforms that handle networking, security, infrastructure, backing services, and much more. A self-service portal and documentation for the platform and its components are crucial yet overlooked parts of this effort. Platform engineers who provide a thoughtful developer experience will win mindshare and encourage the use of standard patterns that speed the delivery of new applications and services.

4 **Build in security and compliance:** Security, compliance, encryption, auditing, and other InfoSec concerns should be addressed deep within the platform via thoughtful implementation of automation and reference architectures. For example, platform teams can deploy standardized golden images with the latest security patches in response to a critical vulnerability. Engineers can configure secrets management and credential rotation workflows to be performed automatically on behalf of the developer. This empowers individual teams to focus their security and compliance efforts on their particular service, rather than the entire stack. Developer productivity increases as a result.

5 **Build internal communities through advocacy:** It's not enough to mandate the use of a given platform or technology. To be effective in driving a cloud operating model, platform teams need to champion and promote the use of the platform for the right workloads and use cases. What's more, it's important to document new capabilities and share roadmap updates. Internal townhalls and hackathons can help platform teams engage with developers to learn about their goals and challenges. These efforts build empathy and trust between teams, driving platform adoption.

6 **Provide a delightful developer experience:** Developers may need to be coaxed into deploying to your organization's platform instead of competing internal options. Platform teams can attract developers by giving them what they crave most: rapid deployment options with minimal resistance. Teams

can lower the platform's barrier to adoption and create a great developer experience with sensible defaults, prescriptive guidance for common use cases, a paved path to production, tutorials, and code samples. In complex organizations, relief from administrative hurdles is a powerful draw for developers to use approved platform services. Once developers learn the benefits for themselves, they'll help convince other teams around the organization.

7 **Employ pragmatic standardization: T**here are many cloud services your organization can consume. Platform teams should evaluate these products and maintain a pragmatic service catalog exposed to developers. Platform teams can negotiate a reasonable list of supported services with business stakeholders to achieve a balance of innovation and sustainability. Done right, developers get the tools and services they need while platform teams avoid the operational overhead of managing unnecessary services.

8 **Optimize costs with chargebacks and showbacks:** Platform teams help create a more efficient model for cloud consumption. Extensive use of shared resources, automation, and standardization, for example, helps contain server sprawl. Cost optimization comes when individual consumers understand how much they are actually spending. Platform teams can implement resource tagging to associate consumption services with a given team or business unit. This practice can provide cost transparency (showback) or be used to draw down internal budget allocations (chargeback). When platform teams provide clear, transparent usage reports, budget allocation and cost optimization discussions are much easier.

9 **Align goals to business outcomes:** Finally, because a platform team is a service provider, the organization's platform approach should be aligned with business outcomes. Its success or failure should be measured against outcome-oriented metrics such as release frequency, platform stability and reliability, security-workflow efficiency, and cost optimization.

Evolving a Cloud Operating Model with HashiCorp and Palo Alto Networks

The implications of the cloud operating model span infrastructure, security, networking, and applications. As such, enterprise IT is reorganizing around platform teams and centralized shared services. This popular model simplifies the delivery of the dynamic infrastructure and services necessary for modern development teams.

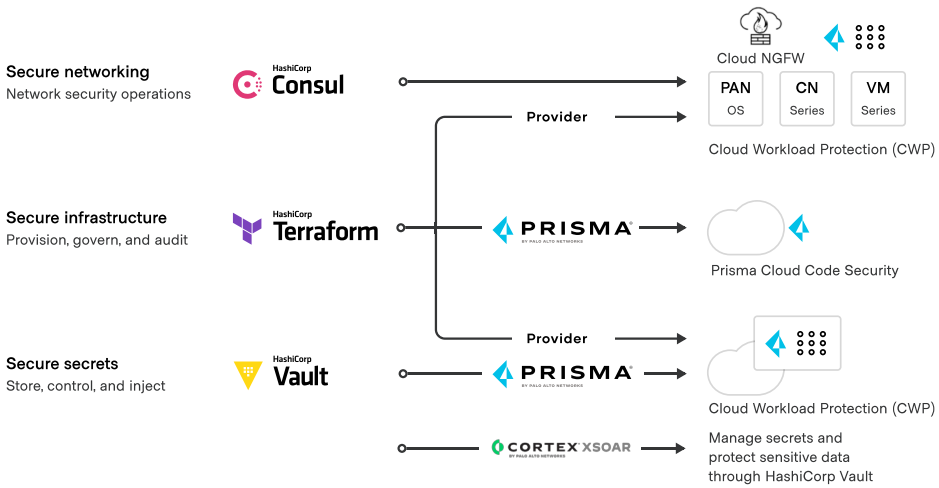
As platform teams deliver each shared service in the cloud operating model, the velocity of innovation increases. In fact, the greater an organization's cloud maturity, the faster its pace of innovation. Central to this velocity increase: security considerations shift left to earlier in the application lifecycle.

In addition to platform teams, security teams and Security Operations Center (SOC) analysts are also looking for automated capabilities to support, secure, and monitor dynamic workloads and environments.

Network security and operations teams can leverage Consul's service discovery capability to continuously monitor ephemeral workloads and update security policies as these environments scale and adapt to new releases.

Platform engineers and developers can use Terraform with the Prisma Cloud Code Security to expand visibility and enhance the organization's security posture.

SOC analysts can use a HashiCorp Vault content pack in Cortex XSOAR to manage credentials for multiple services and systems.



Organizations can extend modern workflows at the infrastructure, security, networking, and runtime layers with capabilities from Prisma Cloud.

IT leaders should keep three major milestones in mind as they adopt the cloud operating model.

1. **Establish the cloud essentials.** Enterprises beginning their cloud journey should address a few immediate requirements. Practitioners often seek to adopt infrastructure as code, establish compliance and governance guardrails, and ensure regular security monitoring. These fundamental building blocks enable teams to accelerate the adoption and deployment of dynamic cloud architectures.

This initial milestone also requires cloud-native security practices. Specifically:

a. **The effective use of modern tools.** Ensure IT and cloud teams can rapidly deliver business value at greater scale with modern CI/CD, security, and DevOps tooling.

b. **The adoption of compliant cloud operations.** Ensure integrations offer comprehensive compliance enforcement across build, deploy, and run phases (DevSecOps) to secure the cloud operating model.

c. **Embrace autoscaling.** Establish automatic scaling rules to ensure application uptime and resiliency. Establish and acknowledge a shared security model. Reinforce integrations with trusted security solutions like HashiCorp Vault and Prisma Cloud that have demonstrated success across industries and across major cloud service providers.

2 **Standardize on a set of shared services.** Enterprises gain efficiencies by standardizing on a common set of shared services in a cloud operating model. The portfolio of shared services should balance developer choice and flexibility with a realistic maintenance burden for operations teams. Similarly, enterprises need to take steps to secure interactions with shared services. Prisma Cloud modules offer capabilities for the following categories:

a. **Cloud Security Posture Management (CSPM).** Identify public cloud misconfigurations, enforce compliance governance policies, and ensure public cloud environments meet internal and external compliance requirements. Provides the ability to detect advanced threats in the public cloud such as crypto-mining or account compromises.

b. **Cloud Workload Protection (CWP).** Ensure host, container, web application, API and serverless operations are monitored and defended for threats and risk in operations, including at runtime.

- **Cloud Native Network Segmentation (CNNS).** Cloud native firewall capabilities for hosts and VMs, mainly focused on east-west segmentation
- **Web Application and API Security (WAAS).** Advanced protection for web applications and API security. Including API discovery, OWASP Top 10, virtual patching, advanced rate limitations, and bot protection.

c. **Cloud Infrastructure Entitlement Management (CIEM).** Ensure identity and access management (IAM) permission enforcement across workloads and clouds. Deep visibility into who has the ability to take what actions on which resources. Automatic detection of overly permissive access and permission rightsizing to achieve least-privileged access.

d. **Code Security (CS).** Ship secure code by default. Identify vulnerabilities, misconfigurations, and compliance violations in IaC templates, container images, open source packages and delivery pipelines. Automated feedback and fix suggestions natively embedded into DevOps workflows and tooling. Supply chain graph visualization.

3 **Innovate using a common logical architecture.** As teams fully embrace the cloud and depend on elastic services and modern applications as the primary systems of engagement, there will be a need to create a common logical architecture. This requires a control plane that connects with an extended ecosystem of popular solutions. Enterprises can also perform advanced cloud security management and orchestration across multiple services and clouds.

To effectively reach this third milestone in the cloud operating model, enterprises must ensure uniform and comprehensive security management and orchestration across hybrid and multi-cloud environments and at every layer. Specifically:

a. **Deep security integration leveraging a unified framework.** Ensure defense-in-depth protection with a uniform platform delivers layered security for multi-cloud workloads within a single pane of glass and with a single agent.

b. **Integrated cloud-automated vulnerability and threat intelligence.** Ensure integrated operational threat intelligence from trusted upstream commercial, open source and proprietary data sources deliver out-of-the-box protection for OWASP Top 10 application and zero-day threats.

c. **Uniform security across multiple clouds and hybrid environments.** Ensure seamless, secure, and uniform communication across adjacent third-party services such as Slack, Jira, and ServiceNow. This way, operators remain productive and InfoSec teams gain visibility into distributed cloud security.

What follows is a review of how to successfully adopt a cloud operating model with solutions from HashiCorp and Palo Alto Networks.

Standardize Platform Team Workflows with a Cloud Operating Model

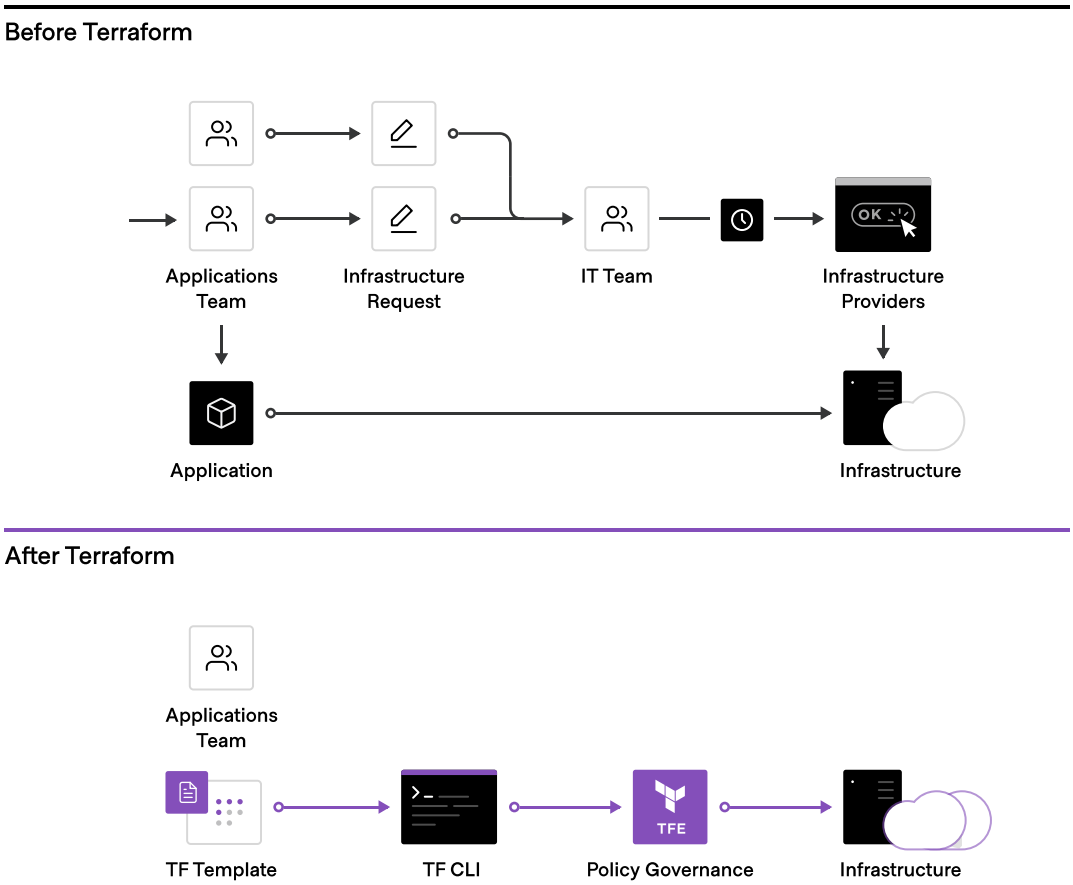
A cloud operating model impacts teams across all layers of the stack: infrastructure, security, networking, and applications. The greater cloud maturity an organization has achieved, the faster its velocity. That's why enterprises are establishing platform teams: to deliver the dynamic services necessary at each layer for rapid application delivery, a strong security posture, and operational efficiency.

Based on what we've seen at successful organizations, here are some best-practice suggestions for adopting a cloud operating model and applying it to your platform at the infrastructure, security, networking, and application layers.

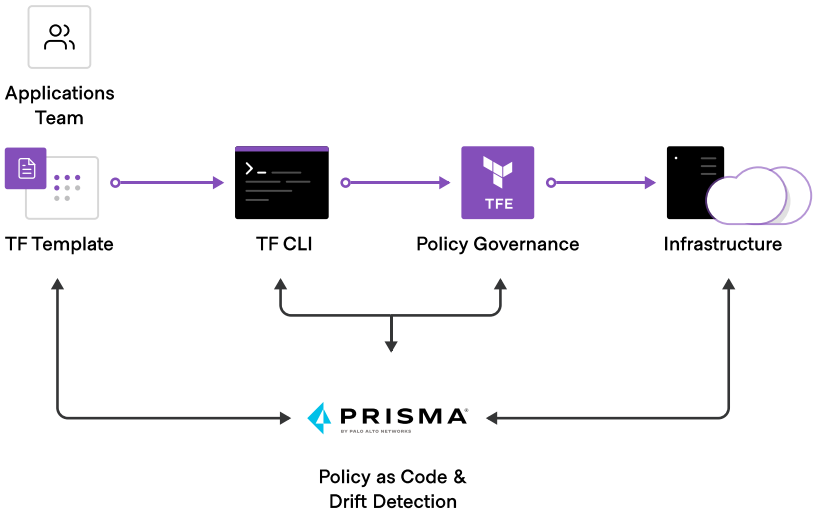
Standardize Infrastructure Provisioning with HashiCorp Terraform

The foundation for running a cloud platform is infrastructure provisioning. HashiCorp Terraform is the world's most popular cloud provisioning product. Terraform is used to provision infrastructure for any service using an array of providers for any target cloud or popular software application.

To build shared services for infrastructure provisioning, platform teams should start by implementing reproducible infrastructure as code practices, and then layering on compliance and governance workflows to ensure appropriate controls.



After Terraform and Prisma Cloud Code Security

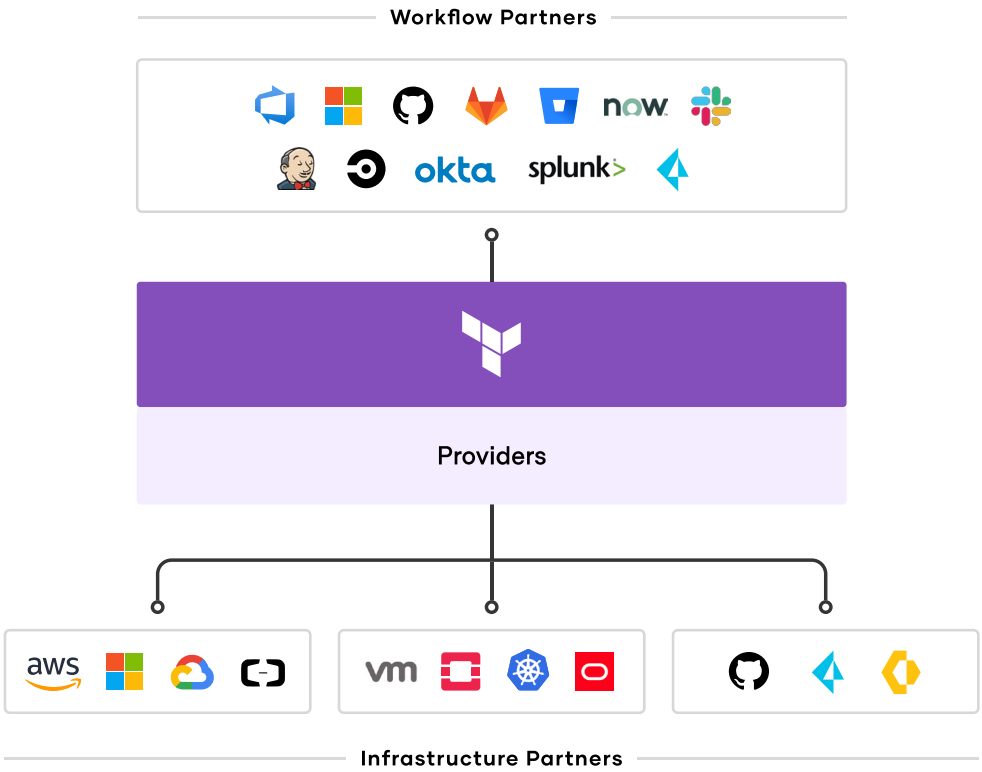


Without an automated provisioning workflow, requests for resources must be reviewed and approved manually. With HashiCorp Terraform, platform teams can automatically route all requests through pre-approved templates to deliver on-demand access to infrastructure for application teams.

Reproducible Infrastructure as Code

The first goal of a shared service for infrastructure provisioning is to enable the delivery of reproducible infrastructure as code, giving product teams a way to plan and provision resources inside CI/CD workflows using familiar tools. Ideally, this provisioning "just works" and is abstracted away from development teams.

Platform teams can create Terraform modules, which act as templates that express the configuration of services from one or more cloud platforms. Terraform integrates with all major configuration-management tools to allow fine-grained provisioning to be handled following the provisioning of the underlying resources. Finally, templates can be extended with services from many other software vendors to include monitoring agents, application performance monitoring (APM) systems, security tooling, DNS, databases, and more. Once defined, the templates can be provisioned as required in an automated way. In doing so, Terraform becomes the lingua franca and common workflow for teams provisioning resources to help the platform scale, and extend the platform's capabilities.



The cloud ecosystem has standardized on HashiCorp Terraform: more than 2,000 Terraform providers help platform teams adopt consistent provisioning workflows.

For platform teams intent on delivering self-service infrastructure, the decoupling of the template-creation process from the provisioning process reduces the time taken for an application to go live, since developers no longer need to wait for operations approval as long as they use a pre-approved template.

Compliance and Management

Most platform teams also need to enforce policies on the type of infrastructure created, how it is used, and which teams get to use it. HashiCorp's Sentinel policy as code framework provides compliance and governance without requiring a shift in the overall team workflow. Sentinel is defined as code too, enabling collaboration and comprehension for the platform model.

Without policy as code, organizations resort to using a ticket-based review process to approve changes. This can become a bottleneck, making developers wait weeks or longer to provision infrastructure. Policy as code allows platform teams to solve this by abstracting the definition of the policy from the execution of the policy.

Platform teams should codify policies enforcing security, compliance, and operational best practices

across all service provisioning. A shift-left approach automates enforcement, assuring that changes are in compliance without creating a manual review bottleneck.

Additional Security Considerations at the Infrastructure Layer

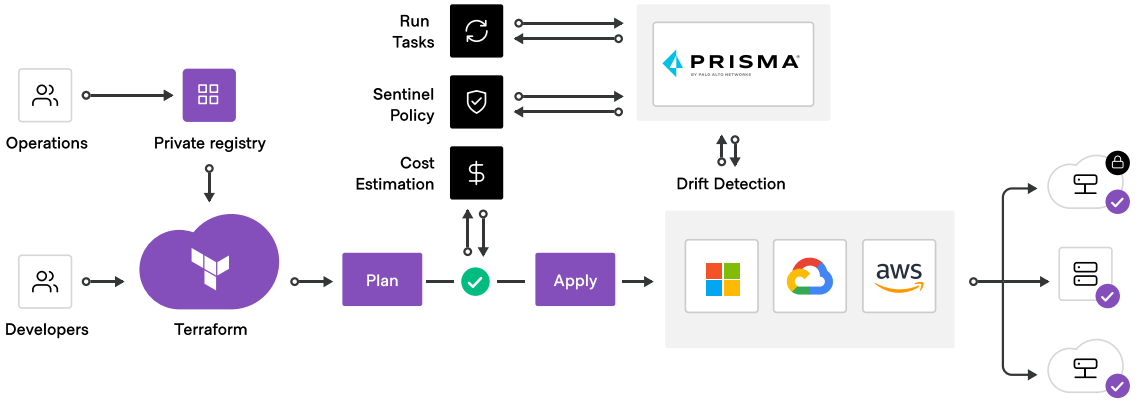
With Terraform, DevOps teams can represent and deploy complex infrastructures at scale and across a multi-cloud environment. However, it is equally important to ensure that the components of the infrastructure definitions in Terraform are appropriately secured to prevent attacks, exploits, and breaches. This can be achieved by adopting purpose-built tools from Palo Alto Networks' Prisma Cloud Code Security to scan the Terraform configurations as they are built, in order to detect security errors arising from misconfigurations or high-risk configurations.

To achieve shared services for infrastructure provisioning, IT and cloud teams should start by implementing reproducible infrastructure as code practices, and then layering security, compliance, and governance workflows to ensure appropriate controls.

Shift Security Left with Secured Infrastructure as Code

Security in the cloud is a shared responsibility. Specifically, the security of the cloud is the responsibility of the cloud provider, while security in the cloud is the customers' responsibility. Cloud providers constantly strengthen their security capabilities, and have a reliable track record of rapid innovation. Consequently, ensuring that the infrastructure that is deployed and the services consumed are strongly secured is the responsibility of the security, cloud, and DevOps teams within an enterprise.

However, it is a challenge for teams to stay abreast of all the best-practice security requirements, guidelines, and configurations. The Bridgecrew by Prisma Cloud infrastructure as code scanning tools can be leveraged to scan IaC configurations and modules for security policy violations and misconfigurations at various stages in the development pipeline: in the IDE, in the pull-request phase, within the CI/CD pipeline, through to runtime. HashiCorp Sentinel, can also be used to embed logic-based policy decisions directly into the Terraform workflow itself. The advantage of this approach is that DevOps teams receive immediate and contextual security telemetry — in languages developers understand — with remediation guidance delivered early in the development phase to significantly improve security posture, reducing out-of-cycle feedback. Terraform's new Run Tasks integration can also be leveraged on a per org basis and then activated per workspace. Enterprises benefit from feedback that integrates seamlessly into the agile methodologies of DevOps teams to compliment speed and agility with security.



Visibility, Compliance, and Governance

Enterprise security practice needs to start with full visibility and assessment of the compliance posture of cloud assets. Sentinel enables the definition of deployment policies in order to establish guardrails to enforce governance on cloud deployments. Prisma Cloud provides out-of-the-box compliance to assess, monitor, and alert on the security posture of assets deployed in cloud environments using comprehensive industry best-practice and compliance standards. Prisma Cloud also enables security teams to shift left and adopt DevSecOps with purpose-built security tools that integrate into developer IDEs and across the CI/CD pipeline to detect violations prior to deployment. These visibility, compliance, and governance capabilities are extended even further with integrated machine-learning -based algorithms that raise cloud configuration and network data flow alerts. Prisma Cloud has also implemented two Terraform providers to help teams automate onboarding and configuring a large number of cloud accounts onto the platform, deploying and managing a large fleet of Defenders or adding and managing users accounts in the platform.

Securing Workloads

Enterprises are leveraging heterogeneous cloud stacks by incorporating workloads that run on VMs, containers, and serverless platforms. These workloads are characterized by scale and high ephemerality, and are treated as immutable infrastructure. Prisma Cloud provides cloud-native protections by moving security closer to the workloads, defining policies based on cloud metadata such as labels and tags, and autoscaling to match the workload lifecycle. Enterprises can leverage Prisma Cloud in order to reach security and compliance outcomes such as:

- **Vulnerability assessment** for hosts, containers, applications, and serverless

- **Runtime protection** embedded into workloads with machine learning for automated real-time response that only allows sanctioned process, file system, and network activity within the runtime
- **Policy definition and governance** using cloud and container tags and labels to deliver a flexible policy framework that scales automatically
- **Intelligence integration** with trusted industry threat feeds to inform and protect against zero-day threats

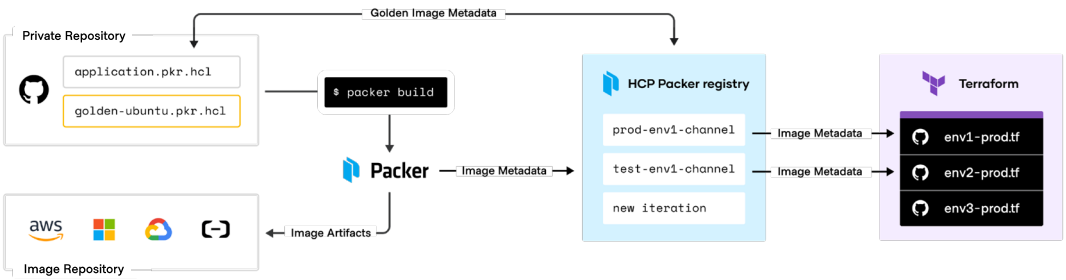
The combination of Sentinel to enforce enterprise wide deployment policies and Bridgecrew by Prisma Cloud to provide hundreds of out-of-the-box policies for cloud providers and Kubernetes gives enterprises the ability to establish cloud security guardrails while not inhibiting operational or DevOps agility. Centralized teams codify policies to enforce security, compliance, and operational best practices across all cloud provisioning. The automated enforcement of policies ensures changes are compliant without creating manual review bottlenecks. Further, drift detection can identify when manual changes are made to cloud workloads so that cloud infrastructure and Terraform templates can be brought back in sync in accordance with GitOps best practices.

Build Automated Images with HashiCorp Packer

HashiCorp Packer is an open source tool that enables platform teams to create identical machine images for multiple clouds from a single source template. A common use case is creating golden images that platforms teams use to help standardize cloud infrastructure.

Packer automates the creation of any type of machine image, including Docker images, and images for use with cloud service providers. Often, images created with Packer are inputs that start a provisioning workflow with Terraform.

Platform teams that desire more automation can use the HCP Packer registry. HCP Packer is a cloud service that bridges the gap between Packer's image factories and Terraform's image deployments. This toolchain lets security and platform teams work together to create, manage, and consume images in a centralized way.



The HCP Packer registry stores metadata about the organization's golden images, including when they were created, where the image exists in the cloud, and what (if any) git commit is associated with the image build. The registry tracks information about the golden images the Packer builds produce, and clearly designates which images are appropriate for test and production environments. From there, the golden images can be used in infrastructure provisioning workflows.

Manage Secrets and Protect Data with HashiCorp Vault

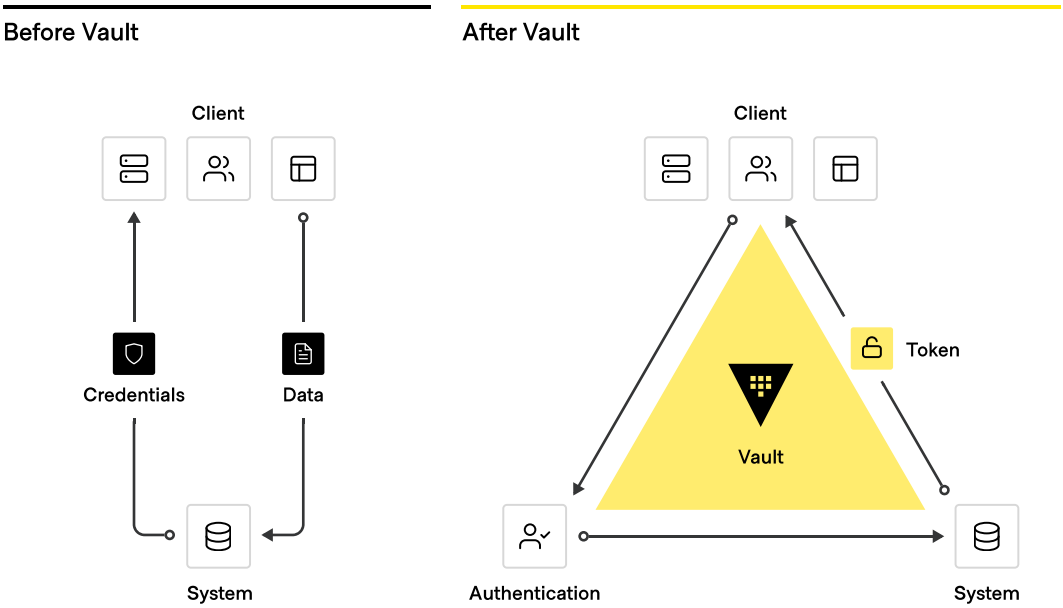
Dynamic cloud infrastructure means a shift from host-based identity to application-based identity, with low trust or zero trust networks across multiple clouds without a clear network perimeter.

In the traditional security world, we assumed high trust internal networks, which resulted in a hard shell and a soft interior. With the modern zero trust approach, we work to harden the inside as well. This requires that both humans and applications be explicitly authenticated, specifically authorized to fetch secrets and perform sensitive operations, and tightly audited.

HashiCorp Vault enables platform teams to securely store and tightly control access to tokens, passwords, certificates, and encryption keys. This provides a comprehensive secrets management solution for machines and applications. Beyond that, Vault helps protect data at rest and data in transit. Vault exposes a high-level API for cryptography for developers to secure sensitive data without exposing encryption keys. Vault also can act as a certificate authority, to provide dynamic, short-lived certificates to secure communications with SSL/TLS. Lastly, Vault enables a brokering of identity between different platforms, such as Microsoft Azure Active Directory (AAD) and AWS Identity and Access Management (AWS IAM) to allow applications to work across platform boundaries.

Vault is widely used by platform teams across industries from stock exchanges to large financial organizations and hotel chains to provide security in a cloud operating model.

To achieve shared services for security, platform teams should enable centralized secrets management services, and then use that foundation to deliver more advanced encryption-as-a-service use cases such as certificate and key rotations, and encryption of data in transit and at rest. This embeds security considerations within the platform, so product teams need only plug in to the provided APIs to ensure their service meets corporate security standards.



Traditional high trust deployments do not have a programmatic way to protect passwords and other sensitive information. With HashiCorp Vault, platform teams implement an automated workflow for both people and machines to centrally manage access to credentials.

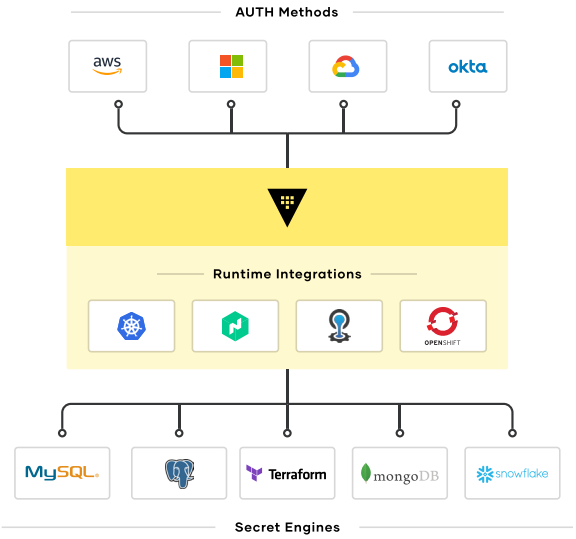
Secrets Management

The first step in cloud security is secrets management: the central storage, access control, and distribution of dynamic secrets. But instead of depending on static IP addresses for this task, it's vital to integrate with identity-based access systems such as AAD and AWS IAM to authenticate and access services and resources.

Vault uses policies to codify how applications authenticate, which credentials they are authorized to use, and how auditing should be performed. It can integrate with an array of trusted identity providers such as cloud identity and access management platforms, Kubernetes, Active Directory, and other SAML-based systems for authentication. Vault then centrally manages and enforces access to secrets and systems based on trusted sources of application and user identity.

Prisma Cloud integrates with HashiCorp Vault in order to facilitate the seamless, just-in-time injection of secrets for cloud and containerized applications. Consequently, developers need only specify a reference to the secrets in the Kubernetes YAML file. Prisma Cloud in turn intercepts the deployment of the container, retrieves the secrets from Vault, and injects them into the container.

With Palo Alto Networks' Cortex XSOAR platform (Security Orchestration, Automation and Response) operators can leverage a Vault content pack that secures, stores and tightly controls access to tokens, passwords, certificates, and encryption keys for protecting secrets and other sensitive data using HashiCorp Vault. This integration fetches credentials to manage multiple solutions that are onboarded into the XSOAR platform, allowing a streamlined and secure process to access these solutions for remediation workflows



HashiCorp Vault works with common sources of identity to be a trusted identity broker at scale.

Platform teams should build a shared service that enables the request of secrets for any system through a consistent, audited, and secured workflow. This kind of shared service not only improves security, it also improves developer productivity. Developers are spared the pain of manually searching for references to a compromised secret. Instead, Vault remediates the secret with an automated workflow of renewal and revocation.

Encryption-as-a-Service

Additionally, enterprises need to encrypt application data at rest and in transit. Vault can provide encryption-as-a-service to create a consistent API for key management and cryptography. This allows platform teams to perform a single integration and then protect data across multiple environments.

Using Vault as a basis for encryption-as-a-service solves complex problems faced by platform teams and security engineers, such as certificate and key rotation. Vault enables centralized key management to simplify encrypting data in transit and at rest across clouds and datacenters. This helps reduce costs around expensive hardware security modules (HSMs) and increases productivity with consistent security workflows and cryptographic standards across consumers of the platform.

While many organizations provide a mandate for developers to encrypt data, they don't often supply the how, which leaves developers to build custom solutions without an adequate understanding of cryptography. Platform teams use Vault to provide developers with a simple API, while adjacent security teams can use policy controls and lifecycle management APIs as needed.

Advanced Data Protection

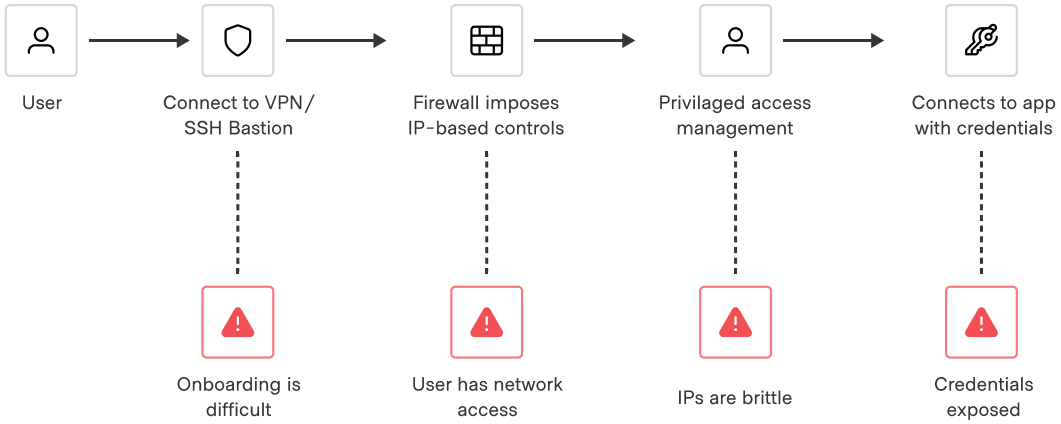
Often, platform teams must still maintain and support on-premises services and applications that need to perform cryptographic operations, such as data encryption for storage at rest. There may not be a business case to improve these applications in this fashion; the custom engineering required to manage these cryptographic keys can be substantial. The solution: delegate the task of key management to external providers. Vault's advanced data protection capability allows organizations to securely connect, control, and integrate advanced encryption keys, operations, and management between infrastructure and Vault, including protecting data in MySQL, MongoDB, PostgreSQL, and other databases using transparent data encryption (TDE).

Advanced data protection provides platform teams with functionality for data tokenization, such as data masking, to protect sensitive data such as credit card numbers and banking details. As such, the capability is popular with organizations that have high security requirements for data compliance (PCI DSS, HIPAA, etc.).

Secure and Manage Access with HashiCorp Boundary

The modern security principle of identity extends beyond the machine-to-machine access workflows addressed by Vault. Identity is equally central to securing human-to-machine interactions.

Traditional solutions for safeguarding user access require distributing and managing SSH keys, VPN credentials, and bastion hosts. This approach creates risks around credential sprawl, and requires substantial manual effort to maintain. For example, it's all too common for organizations to reduce toil by setting their SSH keys to never expire, which gives users access to entire networks and systems indefinitely.



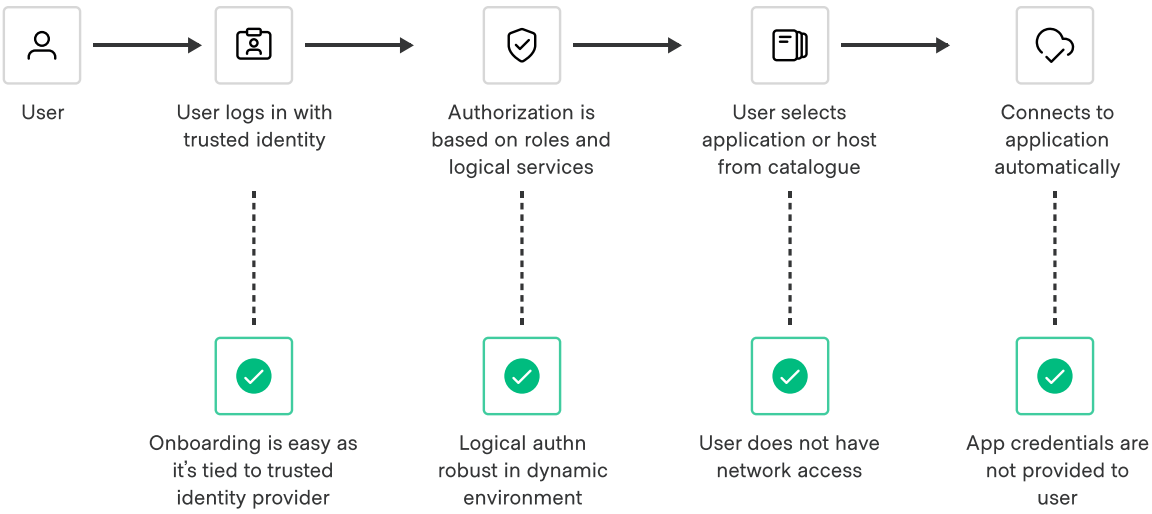
Traditional access workflows are manual and introduce multiple points of vulnerability to the system.

Consider this common scenario: a developer trying to access a production app to troubleshoot an issue. In a traditional access model, the app is likely deployed to a private network (or VPC) on a set of well-known virtual IP addresses. Access is configured at the IP level.

To configure access to the application in question, administrators need to go through many access layers, each requiring its own configuration:

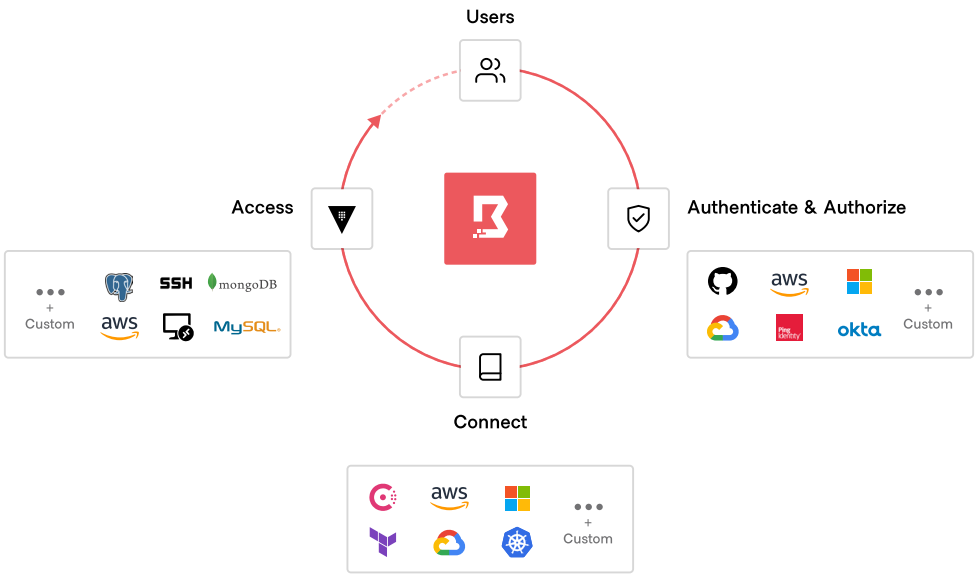
- The corporate VPN/private network layer, which lacks granular access controls
- The bastion host/jumphosts layer that straddles the corporate network and datacenter network
- The network firewall layer (or other location-based controls) that enforces permissions at the client/target IP level, rather than based on logical identity

This philosophy breaks down in the world of cloud infrastructure, due to the nature of ephemeral cloud resources and dynamic IP addresses. A modern approach for human-to-machine access should rely on verifying the identity of the user. Further, access and provisioning of permissions to the end system should be automated.



Modern access workflows are automated and identity based.

HashiCorp Boundary solves modern access challenges in a cloud operating model. Boundary is a secure remote access solution that provides an easy way to safeguard access to applications and critical systems with fine-grained authorizations based on trusted identities. The product governs access across clouds, local datacenters, and low-trust networks, without exposing the underlying network.



HashiCorp Boundary delivers simple and secure remote access to any system anywhere, based on user identity.

Users can authenticate to Boundary using their identity provider of choice (AAD, Okta, AWS IAM, etc.). From there, each user can be tightly authorized to perform actions on a dynamic set of targets, and be granted just-in-time access to connect to those targets via credentials provided by Vault or another credential-management solution.

This model fits the platform team approach of shared services, because it provides secure access to dynamic infrastructure with:

- **Identity-based access controls:** Platform engineers can streamline just-in-time access to privileged sessions (e.g. TCP, SSH, RDP) for users and applications. Teams can control access permissions with extensible role-based access controls.
- **Access automation:** Platform teams can define the perimeter of resources, identities, and access controls as code through Boundary's fully instrumented Terraform provider, REST API, CLI, and SDK. They can automate the discovery of new resources and enforcement of existing policies as resources are provisioned.
- **Session visibility:** Security engineers can monitor and manage each privileged session established with Boundary. Session logs can be exported to a wide variety of analytics tools.

No matter how the platform's capabilities evolve, Boundary can support secure remote access to any number of systems and applications.

IAM Governance with Prisma Cloud

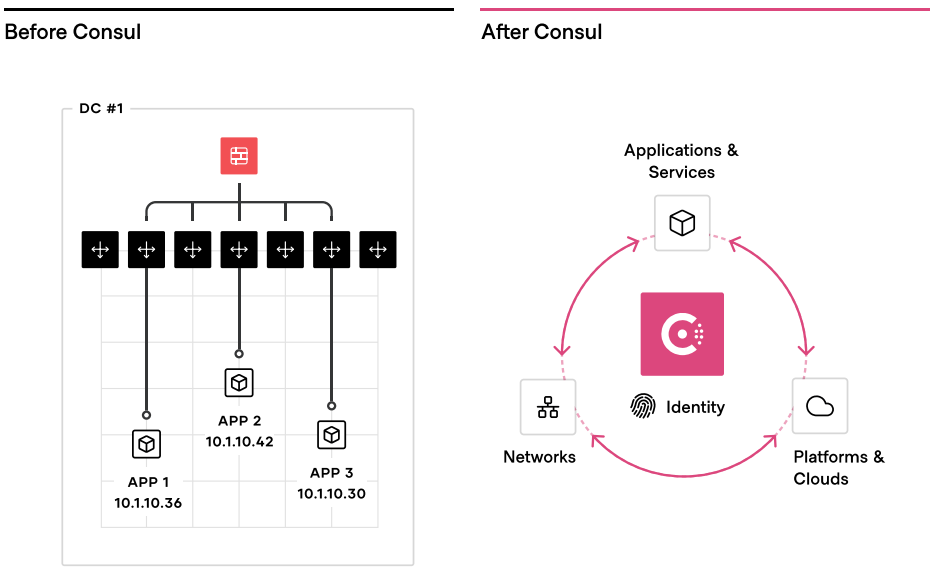
IAM permissions determine the actions that a user or role can perform in the cloud. A number of cloud breaches have been the direct result of adversaries exploiting overly permissive IAM roles. However enterprise security and cloud teams have struggled to identify, remediate, and rectify user roles with excessive permissions. The Prisma Cloud platform enables security teams to address these security concerns by monitoring excessive and unused permissions, through machine language--powered user entity behavior analytics (UEBA), and with least-privilege recommendations and remediation capabilities.

Securely Connect Applications with HashiCorp Consul

Networking in the cloud is one of the most difficult challenges for platform teams adopting a cloud operating model. Engineers must navigate dynamic IP addresses, account for a significant growth in east-west traffic in microservices implementations, and adjust to the lack of a clear network perimeter.

HashiCorp Consul enables platform teams to manage multi-cloud networks by discovering and securely connecting services. Consul is widely deployed to run service networks at a global scale.

Networking services should be based on service identity and provided centrally, allowing platform teams to create a centralized service registry for discovery purposes. The common registry provides a map of what services are running, where they are, and their current health. The registry can be queried programmatically to enable service discovery or drive network automation of API gateways, load balancers, firewalls, and other critical middleware components. Service mesh approaches can simplify the network topology, especially in multi-cloud and multi-datacenter environments.



Historically, networking involved manual activities that connect hosts and static IP addresses. HashiCorp Consul gives modern cloud architectures and platform teams an automated, services-centric approach.

Service Discovery

The starting point for networking in a cloud operating model is a common service registry, which provides a real-time directory of what services are running, where they are on the network, and their current health. Traditional approaches to networking assume a static IP for long-lived applications, using a combination of load balancers and firewalls to regulate communication. Tracking the network location of services often requires disjointed manual processes and tools such as spreadsheets, load balancer dashboards, or configuration files.

With Consul, each service is programmatically registered and DNS and API interfaces are provided to enable any service to be discovered by other services. Consul's integrated health check monitors each service instance's health status so the platform team can triage the availability of each instance and Consul can help avoid routing traffic to unhealthy service instances.

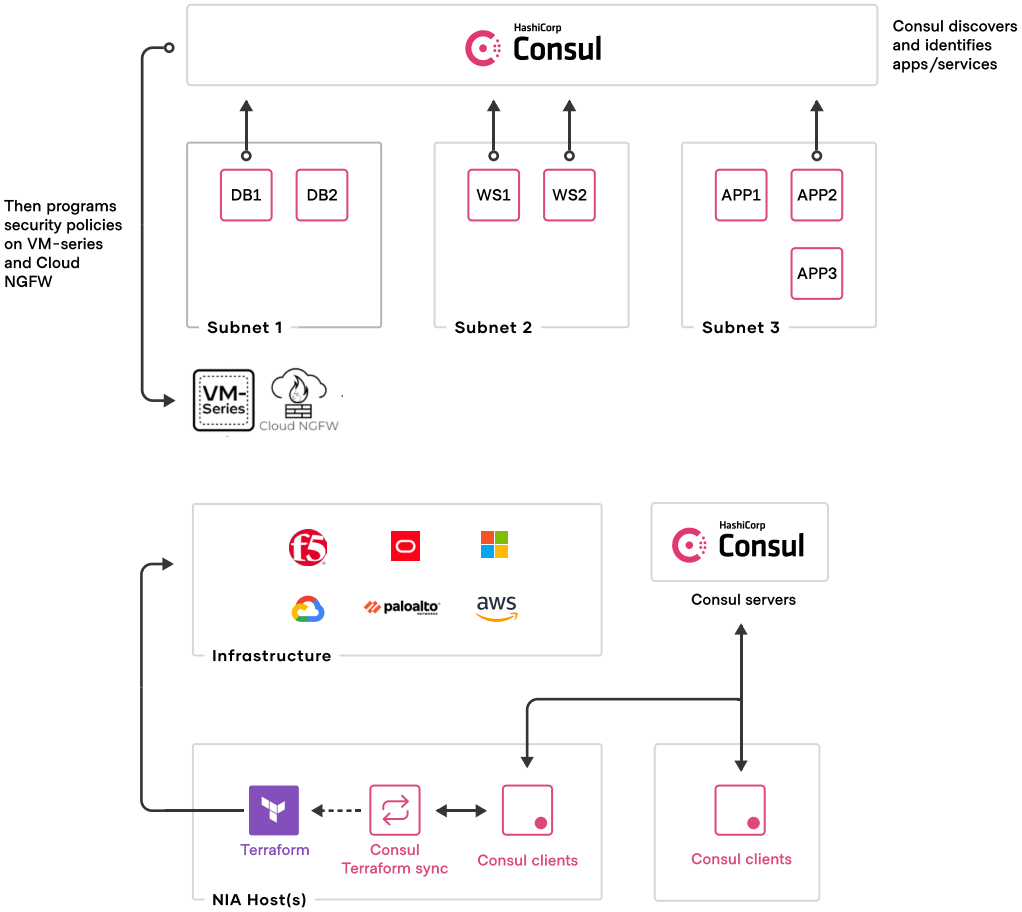
Consul can be integrated with other services that manage existing north-south traffic, such as traditional load balancers, and distributed container orchestrators such as Kubernetes, to provide a consistent registry and discovery service across cloud platforms.

Network Infrastructure Automation

The next step is to reduce operational complexity with existing networking infrastructure through automation. Instead of relying on a manual or ticket-based process to reconfigure load balancers and firewalls every time there is a change in service network locations or configurations — a process that can take days or weeks — Consul can be used to automate these network operations without operator intervention.

The integration between the Palo Alto Networks VM-Series firewall/Cloud NGFWs and HashiCorp Consul demonstrate the ability to seamlessly discover new applications or service deployments and the configuration of security policies to provide in-depth protection from attacks.

For example, when a DevOps team deploys a new service in the cloud, HashiCorp Consul automatically discovers various properties of the application and uses these properties to program dynamic addresses on the VM-Series or Cloud NGFW native firewalls. These dynamic addresses are in turn associated with security policies, which are then automatically applied to protect these new applications from network-based attacks. The integration between a service discovery platform such as Consul and a next-generation firewall such as the VM-Series or Cloud NGFW enables DevOps and network security teams to meet the security needs for highly elastic and dynamic application deployments

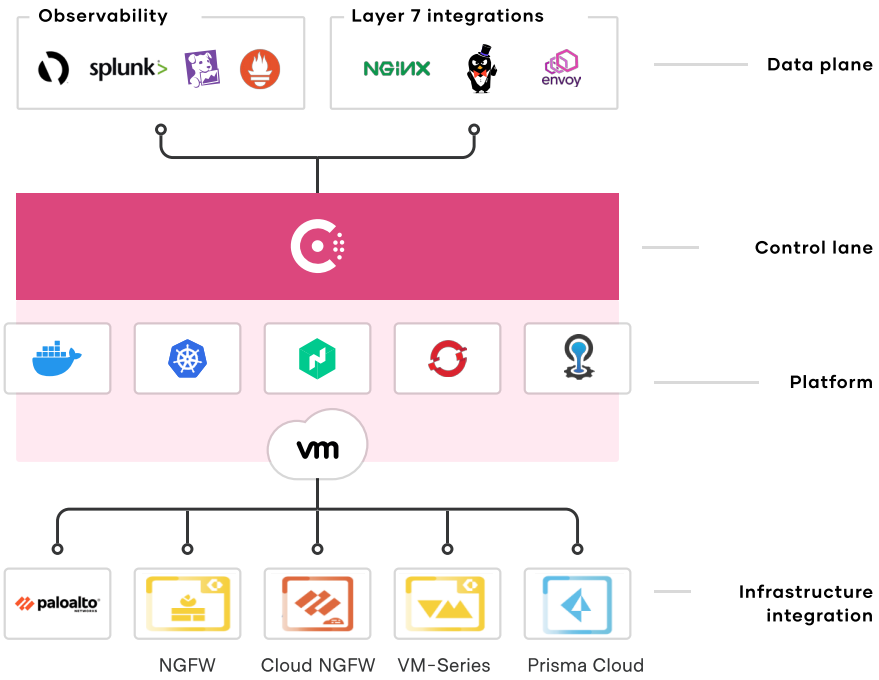


Zero Trust Networking with Service Mesh and API Gateway

As organizations scale with microservices-based and cloud-native applications, the underlying infrastructure becomes larger and more dynamic, with an explosion of east-west traffic. Also, controlling external client access to these microservices ratchets up the volume of north-south traffic. This requires an unwanted proliferation of expensive network middleware devices that bring single points of failure and significant operational overhead for platform teams.

Consul provides a distributed service mesh that pushes routing, authorization, and other networking functions to the endpoints in the network, rather than imposing them through middleware. This makes the network topology simpler and easier to manage, reduces the need for expensive middleware devices within east-west traffic paths, and makes service-to-service communication more reliable and scalable. Adding Consul's API Gateway provides consistent control and security for how north-south traffic is handled through a single, centralized control plane.

Consul is an API-driven control plane that integrates with sidecar proxies alongside each service instance (proxies such as Envoy). These proxies provide the distributed data plane. Together, these two planes enable a zero trust network model that ensures all service-to-service communication is authenticated, authorized, and encrypted. This security posture is achieved with automatic mutual TLS encryption and identity-based authorization. Platform teams can work with the appropriate stakeholders to define security policies with logical services (rather than IP addresses) and provide least-privilege access to developers.



HashiCorp Consul provides a single control plane to enable a broad ecosystem for service networking.

Consul can be integrated with Vault for centralized PKI and certificate management with automatic certificate rotation on both the control plane and data plane. Consul's integration also extends to Kubernetes deployments, including the storage of sensitive data such as keys and tokens in Vault. This approach reduces risk compared to relying on native Kubernetes secrets.

Consul Service Mesh secures service connections across any cloud environment, and on any runtime. This consistent dataplane allows developers and platform teams to connect their services across heterogeneous environments and abstractions. Furthermore, Consul supports multi-tenancy with Administrative Partitions. With this feature, multiple deployments can remain under a single control plane allowing for consistent management and governance while maintaining autonomy and isolation for different tenants.

Additional Considerations for Network Security

Security teams need to extend the zero-trust posture and to secure cloud workloads from a network perspective. This includes protection from network access originating from outside the enterprise network, north-south traffic, as well as traffic originating from workloads within the network, the aforementioned east-west traffic.

The Palo Alto Networks VM-Series virtual firewalls and Cloud NGFWs provide best-in-class, next-generation firewall capabilities to protect cloud networks from malicious attacks. The VM-Series and Cloud NGFWs deliver inline network security that inspects communications for applications, users, content, and threats as well as block malicious attempts over the network. These capabilities allow security teams to deploy fine-grained security policies to permit access based on application and user identifiers and other transport-layer attributes, while all other network access is denied. Additionally, the VM-Series protects workloads from never-before-seen malware and zero-day attacks using inline machine learning and the WildFire service in order to identify and block malware. WildFire® is the industry's largest, most integrated cloud malware protection engine that utilizes patented machine learning models for real-time detection of previously unseen, targeted malware, and advanced persistent threats.

Automation of this deployment and configuration is critical for agility and success in the cloud. Palo Alto Networks has fully automated the deployment of best-practice architectures to the VM-Series to secure all cloud environments using simple infrastructure as code templates such as Terraform, CFTs, ARM templates, and others. The Palo Alto Networks Terraform provider further enables security teams to represent all aspects of their configuration and security policy as structured code. These capabilities provide security teams with unprecedented agility to meet the security needs of highly dynamic cloud applications and environments.

Prisma Cloud Web Application and API Security — With Prisma Cloud's Web Application and API Security (WAAS) enabled defender deployed with a Consul service mesh, you are provided with a comprehensive set of security capabilities and API observability. Providing a deep level of security context in addition to the benefits of running a Consul service mesh for your microservices.

Standardize Application Deployment with HashiCorp Waypoint

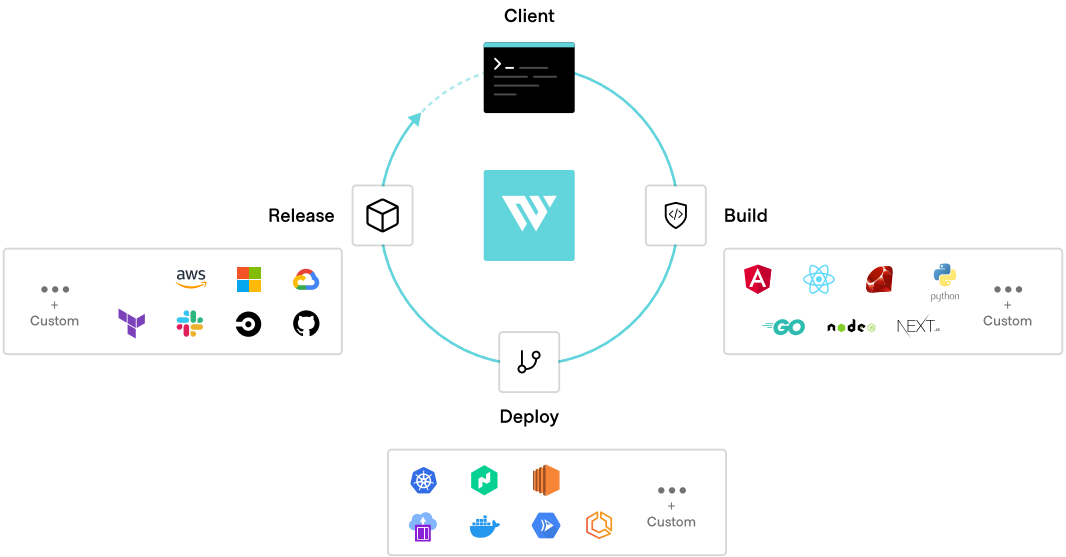
Organizations are creating new systems of engagement and modernizing large swaths of their application estate. Applications slated for modernization span a range of architectural styles, development frameworks, and business importance.

This process can flood developers with complexity: containers, schedulers, YAML files, serverless, and more. This complexity brings some benefits: microservices architectures can yield transformative outcomes. But the cost can be seen in the learning curve required to get a single service deployed to production.

Another challenge common in large organizations is that different tools deploy to different environments. Developers use Docker and kubectl for Kubernetes, HashiCorp Packer and Terraform for VMs, custom CLIs for each serverless platform, and so on. For individual developers and operators, this fragmentation poses a learning curve challenge. For teams, it's a challenge around consistency, complexity, and security.

Build, Deploy, Release

A cloud operating model unifies this fragmentation by establishing a golden workflow for production deployments with HashiCorp Waypoint. Waypoint provides a modern workflow to build, deploy, and release across runtimes.



HashiCorp Waypoint is a centralized developer experience for building, deploying, and releasing applications.

Waypoint provides one easy-to-use command to deploy any application: waypoint up. This workflow is consistent across all platforms, including Kubernetes, HashiCorp Nomad, Amazon EC2, and Google Cloud Run. Waypoint can be extended with plugins to target any build/deploy/release logic. Platform teams can add Waypoint to continuous deployment workflows like GitHub Actions, GitLab CI/CD, Jenkins, and CircleCI.

After deployment, Waypoint provides features such as logs, to validate and debug any deployments.

Waypoint's Implications for Platform Teams

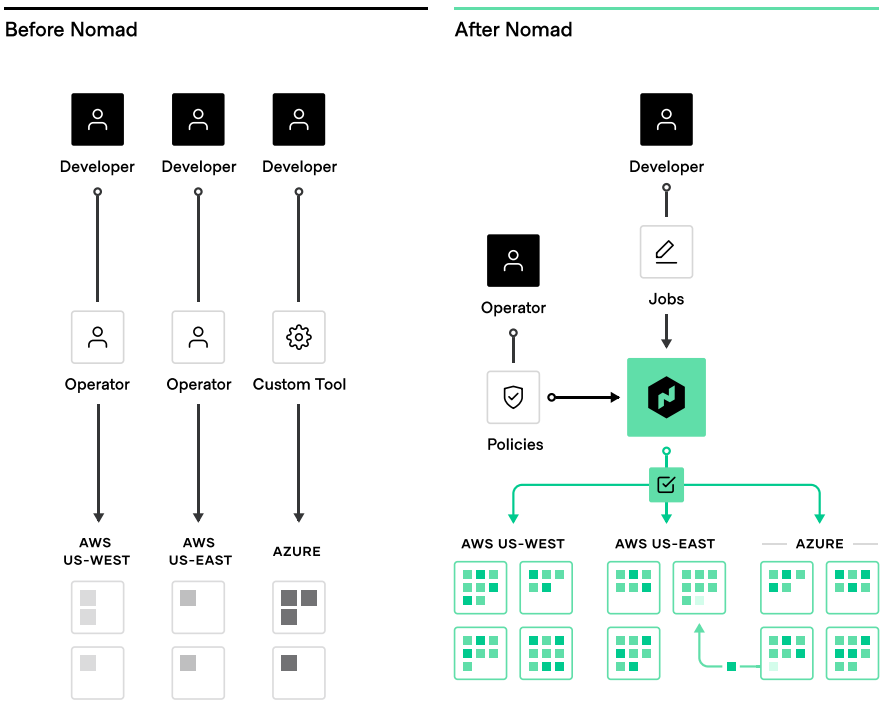
One of the most significant challenges for a platform team is delivering a single path to production that suits the needs of many development teams, InfoSec professionals, and compliance audits. Each development team builds services with a distinct blend of frameworks, backing services, target runtimes, deployment frequencies, and operational considerations. Security and compliance requirements must also be met.

Platform teams can use Waypoint in concert with Terraform, Vault, Boundary, and Consul to enable the consistent delivery of applications on cloud infrastructure, incorporating necessary compliance, security, and networking requirements.

Standardize Workload Orchestration with HashiCorp Nomad

At the application layer, new apps are increasingly distributed while heritage apps still need to be managed more flexibly. HashiCorp Nomad is a flexible orchestrator that can deploy and manage both traditional and modern applications for all types of workloads: from long-running services to short-lived batch jobs to system agents.

To get the benefits of shared services for application delivery, platform teams should use Nomad in concert with Terraform, Vault, and Consul. This combination enables the consistent delivery of applications on cloud infrastructure, while meeting necessary compliance, security, and networking requirements.

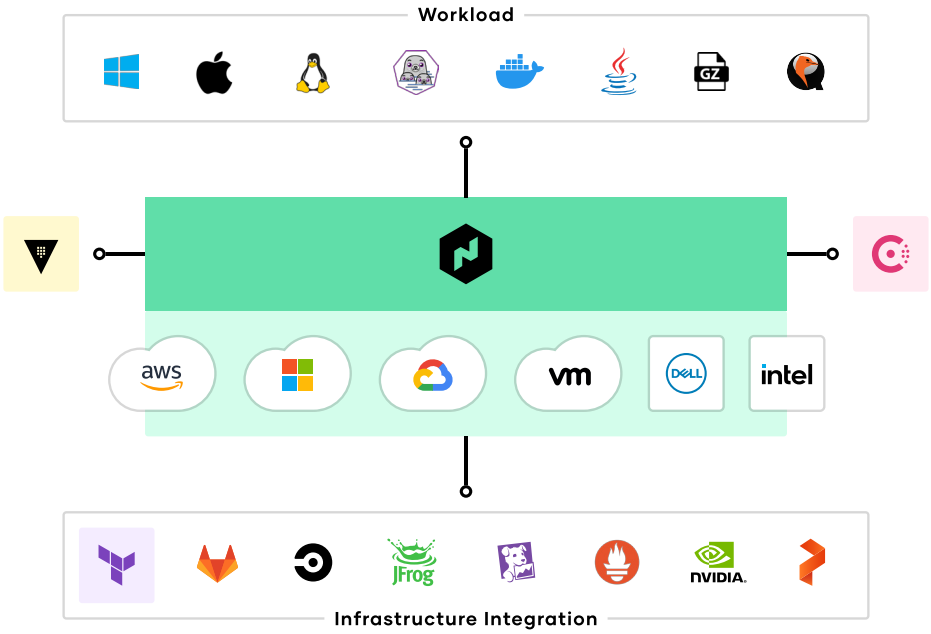


Development teams often build their own toolchain and deployment processes, which can result in operational inefficiencies. With Nomad, organizations can standardize on Nomad's single job spec and use a single workflow to run different types of applications across clouds.

Mixed Workload Orchestration

Today, many new workloads are developed with container packaging to be deployed to Kubernetes or other runtimes. But many legacy workloads will not be moved onto those platforms, nor will future serverless applications. Nomad provides a consistent process for deployment of all workloads from virtual machines through standalone binaries and containers. It provides core orchestration benefits such as release automation, upgrade strategies, bin packing, and resilience across all those workloads.

For modern applications — typically built in containers — Nomad provides a consistent workflow at scale in any environment. Nomad is focused on simplicity and effectiveness at orchestration and scheduling, and avoids the complexity of schedulers such as Kubernetes that require specialized skills to operate and solve only for container workloads.



HashiCorp Nomad integrates with workflows and technologies already in use.

Nomad integrates into existing CI/CD workflows to provide fast, automatic application deployments for heritage and modern workloads.

High-Performance Compute

Nomad is designed to schedule applications with low latency across very large clusters. This is critical for platform teams that process large batch jobs, as is common with high performance computing (HPC) workloads. In the 2 Million Container Challenge, Nomad was able to schedule 2 million Docker containers in 22 minutes across 10 AWS regions globally, at an average rate of nearly 1,500 containers per second. Several enterprise Nomad deployments run at even larger scales.

Nomad makes it easy for high-performance applications to use an API to consume capacity dynamically, enabling efficient sharing of resources for data analytics applications like Apache Spark. The low-latency scheduling ensures results are available quickly and minimizes wasted idle resources.

Multi-Datacenter Workload Orchestration

Nomad is multi-region and hybrid cloud by design, with a consistent workflow for deploying any workload. As platform teams roll out global applications in multiple datacenters or across cloud boundaries, Nomad provides orchestration and scheduling. The product is supported by infrastructure, security, and networking resources to help ensure the application is successfully deployed.

Additional Security Considerations at the Runtime Layer

Modern applications come in many diverse formats, such as containerized microservices and VM-based applications. Cloud-native runtime security supports the entire stack and the customer responsibility as a part of the cloud shared-responsibility model, from infrastructure configurations to application code. Addressing each piece separately or in silos only recreates the challenges of on-premises security where uncorrelated alerts create too much noise and fatigue for security teams.

Effective runtime security requires a defense-in-depth approach to adequately secure running applications in the cloud. It begins with secure cloud infrastructure. Above that, securing the network, as addressed earlier in this paper, protects entrance into and all lateral movement among services. Securing the orchestrator that schedules services creates a safe platform for vetted containers and VMs to run on.

Secure Orchestration

Nomad by default provides a secure orchestration layer for containerized and legacy workloads to provide confidentiality, integrity, and authentication. Nomad deployments can further enhance security with the addition of mTLS, ACLs, and namespaces to segment workloads and provide deep access control. Sentinel policies provide granular control to enforce governance over Nomad orchestration, such as task drivers.

Prisma Cloud secures CI/CD environments and provides Nomad with vetted images. The Prisma Cloud solution identifies vulnerabilities and misconfigurations in container images and offers remediation guidance — Nomad pulls those secured images for safe deployment into the runtime.

Full-Stack Cloud Security

Prisma Cloud delivers full-stack runtime security for containerized and VM-based cloud workloads. Cloud infrastructure including configurations, networking, and IAM layers are secured. Securing scaled cloud workloads requires continuous vulnerability management and compliance monitoring, enhanced with machine learning and modeling that automates governance and control so that malicious or anomalous actions cannot be taken by a container or host. Prisma Cloud provides cloud-native security at all of these layers.

Conclusion: People, Processes, and Tools

Unlocking the fastest path to value in a modern multi-cloud environment requires coupling a common cloud operating model with the power of platform teams across three dimensions — people, processes, and tools. Each dimension requires its own shifts for optimal results:

People: Shift to site reliability engineering (SRE) practices

- Reuse expertise from internal datacenter management and single cloud vendors and apply them consistently in any environment.
- Embrace DevSecOps and other agile practices to continuously deliver increasingly ephemeral and distributed systems.
- Enable IT staff to automate with code and treat operations as if it is a software problem.

Processes: Shift to self-service

- Set up the platform team as an enabling shared service focused on application delivery velocity — shipping software ever more rapidly with minimal risk.
- Establish centers of excellence for infrastructure, security, networking, and other functional areas for self-service delivery of capabilities.
- Standardize on a service catalog with a set of common services for development teams to use, and add new capabilities according to feedback over time.

Tools: Shift to dynamic environments

- Use tools that support the increasing ephemerality and distribution of infrastructure and applications and that support critical workflows rather than being tied to specific technologies.
- Provide policy and governance tooling to match the speed of delivery with compliance to manage risk in a self-service environment.
- Embed security and compliance requirements within the platform itself to accelerate production deployments.

Unlocking the Cloud Operating Model

Put it all together, and it's clear that adopting a common cloud operating model is an inevitable shift for enterprises aiming to maximize their digital transformation efforts. Enterprise IT is evolving away from ITIL-based control points — focused on cost optimization — toward becoming self-service enablers focused on speed optimization.

Platform teams support this by delivering shared services across each layer of the cloud, helping product teams to deliver new business and customer value at speed. The HashiCorp suite of tools provides solutions for each layer of the cloud infrastructure to enable platform teams to successfully lead this shift to a cloud operating model.