Fairwinds

WHITE PAPER

Kubernetes Best Practices for Platform Teams

2023

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INTRODUCTION

In the ever-expanding cloud native ecosystem, often organizations embark on their Kubernetes journey unsure as to what path to follow. Covering all your bases and avoiding common pitfalls and mistakes are worthy goals. No one wants to make the wrong decision and pay for it in the future.

THERE IS NO ONE "RIGHT" PATH TO KUBERNETES SUCCESS; INSTEAD, PLATFORM TEAMS NEED TO BUILD THEIR "GOLDEN PATH" OR INTERNAL DEVELOPER PLATFORM (IDP). YOUR IDP WILL NEED TO BEST ADDRESS; THE NEEDS AND PRIORITIES OF YOUR BUSINESS. FOR EXAMPLE, HERE ARE SOME QUESTIONS YOU SHOULD CONSIDER AS YOU BUILD YOUR PLATFORM:

Are you in the finance or healthcare sector where security is non-negotiable?

Do you have a team of busy data scientists or machine learning workloads that require your business to operate with the utmost resource efficiency?

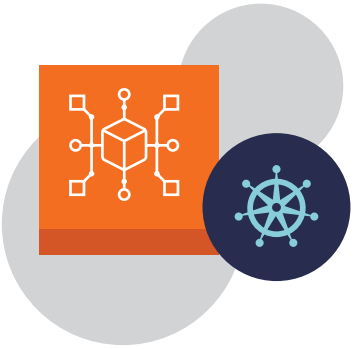
Can your applications and services tolerate downtime, or is 99.99% (or higher) reliability paramount?

Answering these questions (and dozens more) will help you decide how to implement Kubernetes, create processes and clarify tasks and priorities. After you have a handle on the bigger picture in your Kubernetes journey, you'll be better prepared to dig into the inventory of choices and best practices available to you.

Since Fairwinds' inception, we've helped our clients adopt cloud native infrastructure in a secure, efficient and reliable fashion. We've seen hundreds of different use cases and transformations and used that experience to guide our clients on their journey to production.

Fairwinds provides software for platform teams that need to enable developers on Kubernetes. Fairwinds Insights is software that uniquely solves this problem by implementing policies across the development lifecycle to standardize Kubernetes. It saves time, resources and frustration by enabling developers to create secure, cloud efficient and reliable applications.

This paper provides hard won Kubernetes expertise. We dive into the core areas of Kubernetes: security, efficiency and reliability. Our goal is to provide you with Kubernetes best practices for adoption and implementation so you can realize long-term value across your entire organization.



Kubernetes is becoming a **mainstream solution for managing how stateless microservices run in a cluster** because the technology enables teams to strike a balance between velocity and resilience.

SECURITY BEST PRACTICES

Integrate Security Guardrails into the Development Lifecycle

Security teams' interest in Kubernetes is only increasing in line with adoption. The challenge is that many of the security strategies put in place need to be implemented in code and/or manually audited to ensure security best practices are followed.

The challenge here is who owns security? Most certainly the security team, but the platform team plays a big role in enabling developers to use it securely. This requires platform teams to understand security requirements, put guardrails in place and enforce them, and demonstrate an audit trail.

As organizations transition to cloud native technologies, including containers and Kubernetes, the core business challenge remains the same: figuring out how to accelerate development velocity while maintaining security.

Kubernetes is becoming a mainstream solution for managing how stateless microservices run in a cluster because the technology enables teams to strike a balance between velocity and resilience. It abstracts away just enough of the infrastructure layer to enable developers to deploy freely without heavy reliance on operations teams.

All too often, the governance and risk controls available in Kubernetes go underutilized. Since everything is working, it's easy to think that there aren't any problems. It's not until you get hit with a denial-of-service (DoS) attack or a security breach that you realize a Kubernetes deployment was misconfigured or that access control wasn't properly scoped. Running Kubernetes securely is quite complicated which means platform teams need to provide an IDP that has security baked in so that dev, sec and ops can use it properly.

KUBERNETES SECURITY CHALLENGES AND BENEFITS

Development teams new to Kubernetes may neglect some critical pieces of deployment configuration. For example, deployments may seem to work just fine without readiness and liveness probes in place or without resource requests and limits, but neglecting these pieces will almost certainly cause headaches down the line. And from a security perspective, it's not always obvious when a Kubernetes deployment is over-permissioned—often the easiest way to get something working is to give it root access. Platform teams need to arm development teams with the help via guardrails so that they do not neglect those critical pieces.

Security will always make life a bit harder before it makes it easier. Organizations tend to do things in an insecure way at the beginning, because they don't know what they don't know, and Kubernetes is full of these unknown unknowns. It's easy to think your job is done because the site is up and working. But if you haven't tightened up the security posture in a way that adheres to best practices, it's only a matter of time before you start learning lessons the hard way.

Fortunately, Kubernetes comes with some great built-in security tooling, as well as a robust ecosystem of open source and commercial solutions for hardening your clusters. A well-thought-out security strategy can enable development teams to move fast while maintaining a strong security profile. Getting this strategy right is why DevSecOps is so important for cloud native application development.

Furthermore, Kubernetes puts many pieces of computing infrastructure in one place, which helps security teams formulate a coherent strategy. This makes it much easier for security teams to conceptualize and address potential attack vectors. The pre-Kubernetes attack surface—the number of different ways to break into your infrastructure—is substantially larger than the Kubernetes attack surface. With Kubernetes, everything is under one hood.

Optimizing Kubernetes security, however, is no easy feat, as there's not one single way to handle security in Kubernetes. While it's best to keep people out of the cluster altogether, that goal is hard to achieve since your engineers need to be able to interact with the cluster itself, and your customers need to be able to interact with the applications the cluster is running.

Kubernetes can't secure your application code. It wonw't prevent your developers from introducing bugs that result in code injection or a leaked secret. But Kubernetes can limit the blast radius of an attack: proper security controls will restrict how far someone can get once they're inside your cluster. For instance, say an outside attacker has found a vulnerability in your application and gained shell access to its container. If you have a tight security policy, they'll be stuck—unable to access other containers, applications, or the cluster at large. But if the container is running as root, has access to the host's filesystem, or has some other security flaw, the attack will quickly spread throughout the cluster. In essence, a well-configured Kubernetes deployment provides an extra layer of security.

BELOW, WE HIGHLIGHT THE FOLLOWING KEY KUBERNETES BEST PRACTICES RELATED TO SECURITY:

- DoS protection
- Updates and patches
- Role-based access control (RBAC)
- Network policy
- Workload identity
- Secrets

DoS Protection

With Kubernetes you can make sure your applications respond well to bursts in traffic, both legitimate and nefarious. The easiest way to take down a site is to overload it with traffic until it goes down—an attack known as denial-of-service. Of course, if you see a giant burst of traffic coming from one user, you could just shut off their access. But with a distributed-denial-of-service (DDoS) attack, an attacker who has access to many different machines (which they've probably broken into) can bombard a website with seemingly legitimate traffic. Sometimes these "attacks" aren't even nefarious—it might just be one of your customers trying to use your API with a buggy script.

Kubernetes allows applications to scale up and down in response to increases in traffic. That's a huge benefit as increases in traffic won't result in end-users experiencing any degradation of performance. But, if you are attacked, your application will consume more resources in your cluster and you'll get the bill.

While services like Cloudflare and Cloudfront serve as a good first line of defense against DoS attacks, a well designed Kubernetes ingress policy can add a second layer of protection. To help mitigate a DDoS threat, you can configure an ingress policy that sets limits on how much traffic a particular user can consume before they get shut off. You can also set limits on the number of concurrent connections; the number of requests per second, minute, or hour; the size of request bodies; and even tune these limits for particular hostnames or paths.

tl:dr: set limits!

As painful as upgrading can be, **keeping your Kubernetes version up to date is essential.** Old versions quickly become stale, and new security holes are being announced all the time.

Updates and Patches

Kubernetes comes out with a few releases a year, each of which fixes bugs and security holes. As painful as upgrading can be, keeping your Kubernetes version up to date is essential. Old versions quickly become stale, and new security holes are being announced all the time.

On top of that, it's common to have several add-ons installed in your cluster to enhance the functionality Kubernetes provides out of the box. For instance, you might use cert-manager to help keep your site's external certificates up to date, Istio to handle mutual TLS encryption inside your cluster, or metrics-server and Prometheus to gather metrics about how applications are running. With each of these add-ons, your attack surface and your risks increase. Staying up to date on bug fixes and new releases is important.

Each time a new release comes out, you'll need to test those updates to make sure they don't break anything. Where possible, test on internal and staging clusters and roll updates out slowly, monitoring possible problems and making course corrections along the way.

Finally, be sure to keep the underlying Docker image up to date for each of your applications. The base image you're using can go stale quickly, and new Common Vulnerabilities and Exposures (CVEs) are always being announced. To fight back, you can use container scanning tools like Trivy to check every image for vulnerabilities. But making sure the base operating system and any installed libraries are up-to-date is the safest policy.

tl:dr base operating systems and any install libraries need to be up-to-date and tested thoroughly.

RBAC

The easiest way to deploy a new application or provision a new user is to give away admin permissions. A person or application with admin permissions has free range to do whatever they want—create resources in the cluster, view application secrets, or delete an entire Kubernetes deployment. The problem is that if an attacker gains access to that account, they too can do anything they want. They could spin up new workloads that mine bitcoin, access your database credentials or delete everything in the cluster.

If you've got an application that doesn't need extensive control over the cluster, giving it admin-level access is quite dangerous. If all it needs to do is view logs, you can pare down its access so that an attacker can't do anything more than that—no mining bitcoin, viewing secrets, or deleting resources.

To manage access, Kubernetes provides role-based access control (RBAC). RBAC is used to grant fine-grained permissions to access different resources in the cluster. Setting up thoughtful Kubernetes RBAC rules according to the principle of least privilege is important for reducing the potential for splash damage when an account is compromised.

It's a delicate balance, as you might end up withholding necessary permissions. But it's worth that minor inconvenience to avoid the major headaches that come from a security breach.

While RBAC configuration can be confusing and verbose, tools like rbac-manager can help simplify the syntax. This helps prevent mistakes and provides a clearer sense for who has access to what.

tl:dr set up RBAC according to the principle of least privilege.

Network Policy

Network policy is similar to RBAC, but instead of deciding who has access to which resources in your cluster, network policy focuses on who can talk to who inside your cluster. In a large enterprise, dozens of applications may run inside the same Kubernetes cluster, and by default every application has network access to everything else running inside the cluster. Of course, some network access is usually necessary. But while a given workload might need to talk to a database and a handful of microservices, that workload probably won't need access to every other application inside the cluster.

It's up to you to write a network policy that cuts off communications to unnecessary parts of the cluster. Without a strict network policy, an attacker will be able to probe the network and spread throughout the cluster. With proper network policies in place, however, an attacker who gains access to a particular workload will be restricted to that one workload and its dependencies.

Network policy can also be used to manage cluster ingress and egress—where incoming traffic can come from and where outgoing traffic can go. You can make sure internal-only applications only accept traffic from IP addresses inside your firewall and make sure all partner IP addresses are whitelisted for partner-driven applications. For outgoing traffic, you may also want to whitelist allowed domains. This way, if a hacker gains access to the cluster and tries to push data out to an external URL, they'll be stopped by your network policy. With strict ingress and egress rules, you can limit the potential attack surface of your applications.

With workload identity, Google handles all the permissioning under the hood using short-lived credentials, so you don't need to manage and possibly expose your access keys.

Network policy is easy to neglect, especially as you're building out a Kubernetes cluster for the first time. But it's a good way to harden your cluster from a security standpoint and limit the extent of damage after attackers find a security hole. As with RBAC, there's a tradeoff between over-permissioning to make sure everything works properly versus limiting permissions and making sure any problems are contained. Again, you're sacrificing short-term convenience to avoid the fallout from a major security breach.

tl:dr write a network policy that cuts off communications to unnecessary parts of the cluster. Manage cluster ingress and egress based on IP addresses.

Workload Identity

Workload identity is a way to tie RBAC, the cluster's authentication mechanism, to the cloud provider's authentication mechanism, like Identity and Access Management (IAM) on Google Cloud or AWS. In this way, you can use Kubernetes' built-in authentication mechanisms to manage access to resources that live outside the cluster. For example, databases typically live outside of the Kubernetes cluster in a managed service like AWS's Relational Database Service (RDS). Workload identity allows a workload in your EKS cluster to connect to your RDS instance without you having to provision and manage the credentials yourself.

Without workload identity, you'd have two options, both of which have security concerns. First, you could use IAM to grant the necessary permissions to entire nodes, but this effectively grants those permissions to every workload on the node, not just the workload that needs them. Alternatively, you could generate a long-lived access key for your database, turn that key into a Kubernetes secret, and attach that secret to the workload. But each step in this process opens up the potential for leakage, and because the key is long-lived, anyone with access to that key would be able to access your database in perpetuity.

With workload identity, Google handles all the permissioning under the hood using short-lived credentials, so you don't need to manage and possibly expose your access keys.

tl:dr: Employ workload identity to tie RBAC to the cloud provider's authentication mechanism.

One caution: workload identity works only within a particular cloud provider. For instance, Google Kubernetes Engine can use workload identity to authenticate databases on Google Cloud but not on AWS; Amazon EKS, in turn, can use workload identity to authenticate AWS databases but not Google Cloud databases.

By encrypting all of your secrets, you can safely check them into your repository without fear of exposing them.

Secrets

Kubernetes empowers Infrastructure as Code (IaC) workflows more than any other platform. By encoding all of your infrastructure choices in YAML, Terraform, and other configuration formats, you ensure your infrastructure is 100% reproducible. Even if your cluster disappeared overnight, you'd be able to recreate it in a matter of hours or minutes so long as you're utilizing IaC.

But there's one catch: your applications need access to secrets. Database credentials, API keys, admin passwords and other bits of sensitive information are required for most applications to function properly. You may be tempted to check these credentials into your IaC repository, so that your builds are 100% reproducible. But once they're checked in, they're permanently exposed to anyone with access to your Git repository. If you care about security, it's imperative to avoid this temptation.

The solution is to split the difference: by encrypting all of your secrets, you can safely check them into your repository without fear of exposing them. Then you'll just need access to a single encryption key to "unlock" your IaC repository and have perfectly reproducible infrastructure. Tools like Mozilla's SOPS make this easy. Simply create a single encryption key using Google's or Amazon's key management stores, and any YAML file can be fully encrypted and checked in to your Git repository.

tl:dr encrypt all your secrets. You'll then only need a single encryption key to unlock your IaC repository.

FINAL THOUGHTS ON KUBERNETES SECURITY

Applications change constantly, and there's no way to ensure that your application code is bulletproof. What Kubernetes does really well is mitigate the severity of attacks and contain splash damage. When someone penetrates your application and makes it through that first layer, they won't get much (or any) farther if you've optimized security settings in accordance with the Kubernetes best practices described here.

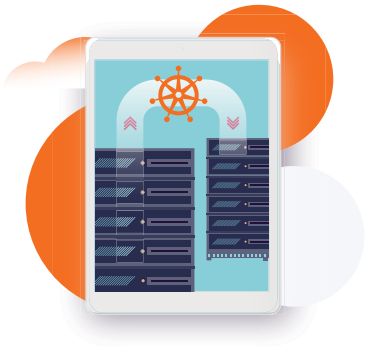
With the proper knowhow and attention, a Kubernetes implementation will be more secure and easier to maintain than other systems, specifically because it provides a single platform for everything related to cloud computing. Kubernetes has strong built-in security features, as well as a massive ecosystem of third-party security tooling. Setting these features correctly can be enforced by platform teams.

Fairwinds Insights is software tooling that can help ensure cluster security. Insights continuously scans your containers and Kubernetes to pinpoint and prioritize risks, provide remediation guidance and status tracking. When developers use Kubernetes, code can be scanned to ensure it meets the security requirements of the organization. Checking for Kubernetes security best practices, Fairwinds Insights provides DevSecOps with consistency by enforcing Kubernetes security best practices across the entire software development life cycle.

CHECKING FOR KUBERNETES SECURITY BEST PRACTICES, FAIRWINDS INSIGHTS PROVIDES DEVSECOPS WITH CONSISTENCY BY ENFORCING KUBERNETES SECURITY BEST PRACTICES ACROSS THE ENTIRE SOFTWARE DEVELOPMENT LIFE CYCLE.

- **Container Vulnerability Scanning** - Integrate container runtime monitoring. Track known vulnerabilities, prioritize findings and give developers remediation guidance. Integrate with ticketing workflows.
- **Kubernetes Runtime Security -** Proactively protect containers and pods against active threats once running in production. Detect and prevent malicious activity occurring in your containers.
- **Infrastructure-as-Code Scanning in CI/CD** - Integrate Insights into CI/CD systems or GitHub directly and scan your Kubernetes manifests, such aslike YAML and Helm Charts, against K8s guardrails at every pull request.
- **Image Upgrade Recommendations** - Accelerate remediation by recommending newer versions of third-party images with fewer vulnerabilities.
- **Secure Configuration / Pod Security** - Continuously scan clusters to identify image, container, cluster and Kubernetes misconfigurations. Integrate into CI/CD to prevent configuration mistakes in production.
- **Least Privilege Access Controls** - Ensure role-based access controls (RBAC) are implemented properly to enforce least privilege access.
- **NSA Hardening Checks** - Comply with guidelines laid out in the NSA Kubernetes Hardening technical report. Gain strong defense-in-depth to ward off attacks and minimize the blast radius.
- **Vulnerability Explorer** - Use Fairwinds Insights to identify the riskiest container images across your Kubernetes clusters, including recommended upgrade and remediation options.
- **Enable Secure GitOps** - Auto-Scan GitOps-enabled workloads to discover and scan K8s manifests without requiring individual CI pipeline integration. Devs get immediate feedback on IaC changes.

No code is 100% bug-free, and all applications have flaws. Since your applications need to serve traffic to the outside world, it's a matter of if, not when, someone manages to find a hole. Building an IDP that enforces security standards and includes continuous scanning of cluster configurations can severely limit the blast radius of an attack. It can make the difference between a minor security incident and a crippling breach.



Kubernetes is a dynamic system that automatically adapts to your workload's resource utilization.

KUBERNETES BEST PRACTICES FOR COST OPTIMIZATION

Set Just Right CPU and Memory

One reason container technology has surpassed the capabilities of traditional virtual machines is its inherent efficiency with regard to infrastructure utilization. Whereas in a traditional virtual machine environment one application is typically run per host, in a containerized environment you can run multiple applications per host, each within its own container. Packing multiple applications per host reduces your overall number of compute instances and thus your infrastructure costs.

Kubernetes is a dynamic system that automatically adapts to your workload's resource utilization. Kubernetes has two levels of scaling. Each individual Kubernetes deployment can be scaled automatically using a Horizontal Pod Autoscaler (HPA), while the cluster at large is scaled using Cluster Autoscaler. HPAs monitor the resource utilization of individual pods within a deployment and they add or remove pods as necessary to keep resource utilization within specified targets per pod. Cluster Autoscaler, meanwhile, handles scaling of the cluster itself. It watches the resource utilization of the cluster at large and adds or removes nodes to the cluster automatically.

A key feature of Kubernetes that enables both of these scaling actions is the capability to set specific resource requests and limits on your workloads. By setting sensible limits and requests on how much CPU and memory each pod uses, you can maximize the utilization of your infrastructure while ensuring smooth application performance.

To maximize the efficient utilization of your Kubernetes cluster, it is critical to set resource limits and requests correctly. Setting your limits too low on an application will cause problems. For example, if your memory limits are too low, Kubernetes is bound to kill your application for violating its limits. Meanwhile, if you set your limits too high, you're inherently wasting resources by overallocating, which means you will end up with a higher bill.

While Kubernetes best practices dictate that you should always set resource limits and requests on your workloads, it is not always easy to know what values to use for each application. As a result, some teams never set requests or limits at all, while others set them too high during initial testing and then never course correct. The key to ensuring scaling actions work properly is dialing in your resource limits and requests on each pod so workloads run efficiently.

Setting resource limits and requests is key to operating applications on Kubernetes clusters as efficiently and reliably as possible.

SET KUBERNETES RESOURCES "JUST RIGHT"

Fairwinds created the open source project, Goldilocks, to help teams allocate resources to their Kubernetes deployments and get those resource calibrations just right. Goldilocks is a Kubernetes controller that collects data about running pods and provides recommendations on how to set resource requests and limits. It can help organizations understand resource use, resource costs and best practices around efficiency of usage.

Goldilocks employs the Kubernetes Vertical Pod Autoscaler (VPA). It takes into account the historical memory and CPU usage of your workloads, along with the current resource usage of your pods, in order to recommend how to set your resource requests and limits. (While the VPA can actually set limits for you, it is often best to use the VPA engine only to provide recommendations.) Essentially, the tool creates a VPA for each deployment in a namespace and then queries that deployment for information.

Teams that are managing multiple clusters may want visibility across their entire environment to undertake cost attribution and resource tuning at scale.

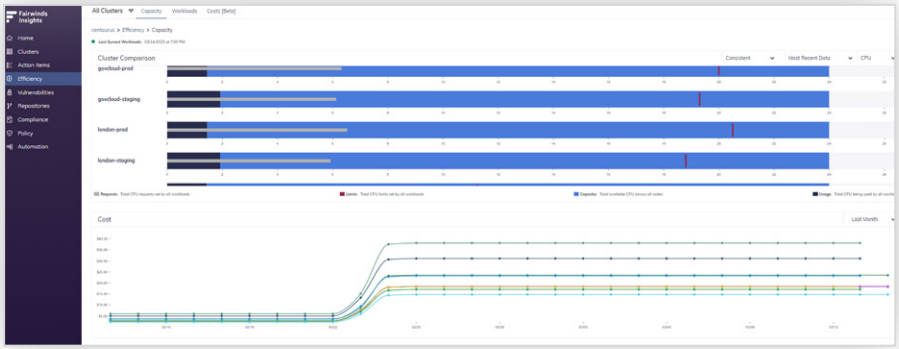
FAIRWINDS INSIGHTS OFFERS RECOMMENDATIONS TO INCREASE EFFICIENCY OF KUBERNETES COMPUTE RESOURCES:

- **Gain visibility** - Dig into application resources and historical usage to discover unknowns. Adjust settings to increase efficiency of Kubernetes.
- **Monitor Kubernetes cost** - Evaluate individual applications and find opportunities to reduce costs without impacting application performance.
- **Optimize resources** - Insights monitors CPU and memory usage to provide recommendations on resource limits and requests. Maximize the efficiency of CPU and memory utilization for your Kubernetes workloads.
- **Allocate cost by namespace or label** - Allocate and group cost estimates by namespace or labeling, making it easier for reports to align to business context.

How to Enable Resource Recommendations

Goldilocks is one of the tools Fairwinds Insights deploys to provide workload efficiency and performance optimizations. With Fairwinds Insights, Goldilocks can be deployed across multiple clusters so information is available to teams in a single pane of glass. Fairwinds Insights adds data and recommendations to Goldilocks, including potential cost savings.

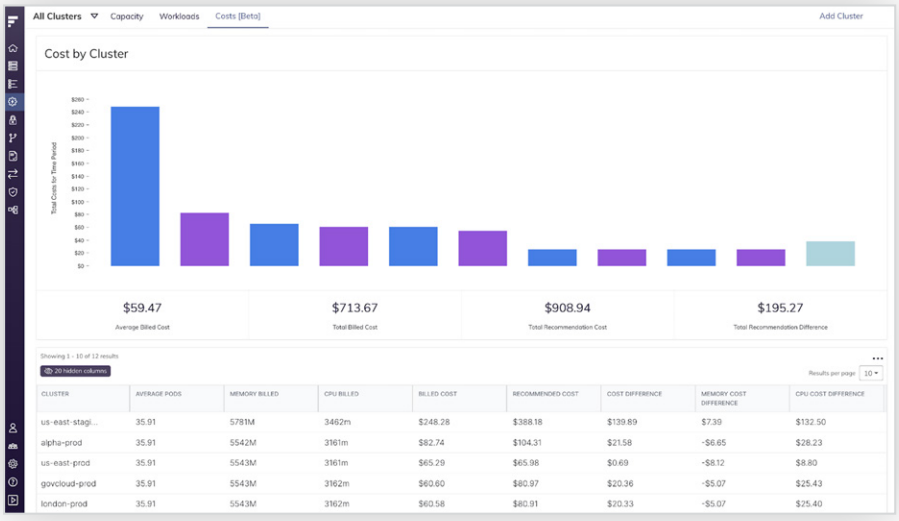
The dashboard includes a list of clusters with average total cost and cost recommendations.



Many organizations set their CPU and memory requests and limits too high, and when they apply these recommendations they are able to put more pods on fewer Kubernetes worker nodes. When Cluster Autoscaler is enabled, any extra nodes are removed when they are unused, which saves time and money.

Workload Cost Allocation

Fairwinds Insights includes Workload Cost Allocation. It allows platform teams to view the historical cost of a group of workloads and allocate spend to specific teams so companies can showback cost to stakeholders and identify areas for savings. Platform teams can use actual cloud spend and workload usage to understand historical costs incurred across multiple clusters, aggregations, and custom time periods.



Understanding Your Workloads

Another benefit of Fairwinds Insights and Goldilocks is that the information provided can help you understand if your workloads are CPU-intensive, memory-intensive, or balanced between the two. This data can help you evaluate whether or not you've selected the most efficient workload for your Kubernetes worker nodes.

To view these recommendations, you would have to use kubectl to query every VPA object, which could quickly become tedious for medium-to-large deployments. That's where the dashboard comes in. Once your VPAs are in place, recommendations will appear in the Goldilocks dashboard.

THE DASHBOARD PRESENTS TWO TYPES OF RECOMMENDATIONS DEPENDING ON THE QUALITY OF SERVICE (QOS) CLASS YOU DESIRE FOR YOUR DEPLOYMENTS:

1. **Guaranteed,** which means the application will be scheduled on a node where resources will be assured. In this class, you set your resource requests and limits to exactly the same values, which guarantees that the resources requested by the container will be available to it when it gets scheduled. This QoS class generally lends itself well to the most stable Kubernetes clusters.
2. **Burstable,** which means the application will be guaranteed a minimum level of resources but will receive more if and when available. Essentially, your resource requests are lower than your limits. The scheduler will use the request to place the pod on a node, but then the pod can use more resources up to the limit before it's killed or throttled.

The dashboard provides recommendations for both the Guaranteed and Burstable QoS classes. In the Guaranteed class, consider setting your requests and limits to the VPA "target" field. In general, using this value along with the HPA allows applications to scale.

Note: a third QoS class, BestEffort, means that no requests or limits are set and that the application will be allocated resources only when all other requests are met. Use of BestEffort is not recommended.

Specializing Instance Groups for Your Cluster

If you are interested in fine-tuning the instances that your workloads run on, you can use different instance group types and node labels to steer workloads onto specific instance types.

Different business systems often have different-sized resource needs, along with specialized hardware requirements (such as GPUs). The concept of node labels in Kubernetes allows you to put labels onto all of your various nodes. Pods, meanwhile, can be configured to use specific "nodeSelectors" set to match specific node labels, which decide which nodes a pod can be scheduled onto. By utilizing instance groups of different instance types with appropriate labeling, you can mix and match the underlying hardware available from your cloud provider of choice with your workloads in Kubernetes.

If you have different-sized workloads with different requirements, it can make sense strategically and economically to place those workloads on different instance types and use labels to steer your workloads onto those different instance types.

Spot instances (from AWS) and preemptible instances (from Google Cloud) tie into this idea. Most organizations are familiar with paying for instances on demand or on reserved terms over fixed durations. However, if you have workloads that can be interrupted, you may want to consider using spot instances on AWS or preemptible instances on Google Cloud. These instance types allow you to make use of the cloud provider's leftover capacity at a significant discount—all at the risk of your instance being terminated when the demand for regular on-demand instances rises.

If the risk of random instance termination is something that some of your business workloads can tolerate, you can use the same concept of node labeling to specifically schedule those workloads onto these types of instance groups and gain substantial savings.

FINAL THOUGHTS ON KUBERNETES BEST PRACTICES FOR COST OPTIMIZATION

Setting up and managing clusters and then telling software developers to deploy their apps to those clusters is a complex process. It's not uncommon for developers to deploy apps but not know how to set the right resource limits or requests. Using software like Fairwinds Insights, platform teams can help optimize the platform by removing guesswork for developers. It opens the door for you to increase the efficiency of your clusters and reduce your cloud spend.

RELIABILITY BEST PRACTICES

Avoid incorrect configuration

Reliability becomes harder and harder to achieve as the business scales. Achieving Kubernetes reliability is complex due to the skill it takes to optimize the capabilities Kubernetes offers.

Reliability becomes harder and harder to achieve as the business scales. Consider adopting a more direct, more streamlined approach to cloud native applications and infrastructure. Containers abstract and isolate cloud native applications and their dependencies from what's running on the underlying operating system. You can scale these lighter weight containers instead of scaling application server virtual machines. Cloud native methodologies provide an opportunity to adjust how application components communicate and scale.

For instance, components of your application use:

- APIs to communicate instead of sharing a common filesystem.
- Service discovery to route traffic to services as they scale.
- Containers to abstract application dependencies from the underlying operating system.

The more cloud native characteristics an application has, the easier it is to put that application in a container and manage it in Kubernetes. Another way you can ensure the reliability of your clusters is by shifting to the use of infrastructure as code (IaC).

THE BENEFITS OF INFRASTRUCTURE AS CODE

Simply put, IaC is the process of managing your IT infrastructure using configuration files. Some of the most important IaC advantages include:

- Reduced human error and future proofing
- Repeatability and consistency
- Disaster recovery
- Improved auditability

Reduced Human Error and Future Proofing

IaC and automation reduce human error by creating predictable results. You can produce new environments to test infrastructure upgrades to validate changes without impacting production. If you want to apply changes to infrastructure across multiple environments, using code reduces errors because focus and attention to detail are less impacted by repetitive manual work.

IaC also helps to reduce single points of failure against talent loss or tech progress by documenting the infrastructure. In other words, the code and comments increase awareness about the design and configuration of infrastructure. They help with training as well, reducing the need for subject matter experts to get developers up to speed.

Repeatability and Consistency

The repeatability of IaC helps you create consistent infrastructure in other regions much more rapidly. This feature frees up time to move on to the next set of problems, such as how to route traffic to applications throughout the region and how to test failover without impacts on production.

Disaster Recovery

How long does it take to rebuild a container image in an emergency (for example, deploy new code to address an application outage or degradation)? If you're using manual processes or complex chains of tooling, then that disaster recovery (DR) process will take longer. The reliability of an application is impacted by the ability to pivot and the speed to redeploy. Be sure you know what that process looks like and how to put in place the right practice, tooling and underlying processes to make a Kubernetes deployment as straightforward as possible.

Improved Auditability

IaC also helps track changes to an audit infrastructure. Because your infrastructure is represented in code, commits to your Git repository reflect who, when and why changes were made. You'll be able to look at the code and know how environments were built, what's happening and why.

KUBERNETES RELIABILITY BEST PRACTICES

BELOW, WE HIGHLIGHT THE FOLLOWING KEY KUBERNETES BEST PRACTICES RELATED TO RELIABILITY:

- Simplicity vs. complexity
- High-availability (HA) architecture/fault tolerance
- Resource limits and autoscaling
- Liveness and readiness probes

Simplicity vs. Complexity

Unfortunately you can introduce too much complexity into your Kubernetes environments. Avoid complexity by keeping it simple. Here are three ways to do that:

1. **Service delivery vs. traffic routing** - Manually maintained DNS entries can be used to point to an application, and DNS hostnames can be hardcoded into application components so they can communicate. However, rather than using traffic routing, use service delivery, which is a more streamlined, dynamic solution. Service delivery enables a user or another application to find instances, pods or containers. Service delivery is required because your application is scaling in and out, and changes are happening at a fast rate.
2. **Application configuration** - Shift to files or environment variables in your container. Those are populated by Kubernetes ConfigMaps or Secrets. You can run an application in multiple environments, but the configuration will differ because you have different ConfigMaps or Secrets in Kubernetes for each environment.
3. **Configuration management tools** - Containers are ephemeral. If you need to change something about how an application runs, CI/CD best practices dictate that you should build and then deploy a new container image through your CI pipeline instead of attempting to modify an existing container.

HA Architecture/Fault Tolerance

Kubernetes helps improve reliability by making it possible to schedule containers across multiple nodes and multiple availability zones (AZs) in the cloud. Anti-affinity allows you to constrain which nodes in your pod are eligible to be scheduled based on labels on pods that are already running on the node rather than based on labels on nodes. With node selection, the node must have each of the indicated key-value pairs as labels for the pod to be eligible to run on a node. When you create a Kubernetes deployment, use anti-affinity or node selection to help spread your applications across the Kubernetes cluster for high availability.

Kubernetes HA means having no single point of failure in a Kubernetes component. An example of a component might be a Kubernetes API server or the etcd database where state is stored in Kubernetes. How do you help ensure these components are HA? Let's say you are using Kubernetes on premises and you have three master servers with a load balancer that runs on a single machine. While you have multiple masters, your one load balancer is a single point of failure for the Kubernetes API. You need to avoid this.

If a redundant component in your Kubernetes cluster is lost, the cluster keeps operating because K8S best practice is to deploy a number of redundant instances based on the component (for example, etcd requires an odd number, so 3+, API server requires 2+, kube-scheduler requires 2+). If you lose a second component, then what happens? If you have three masters and you lose one, the two remaining masters could get overloaded, contributing to the degradation or potential loss of another master. It's key to plan the resiliency of your cluster according to the risk your business can tolerate for the applications running on that cluster.

tl:dr plan your fault tolerance stra1egy and employ HA redundancy based on your orkload.

Resource Limits and Autoscaling

Resource requests and limits for CPU and memory are at the heart of what allows the Kubernetes scheduler to do its job well. If a single pod is allowed to consume all of the node CPU and memory, then other pods will be starved for resources. Setting limits on what a pod can consume increases reliability by keeping pods from consuming all of the available resources on a node (this is referred to as the "noisy neighbor problem").

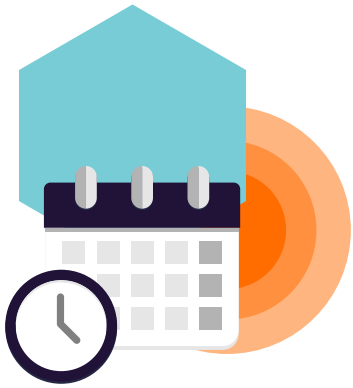
Autoscaling, in turn, can increase cluster reliability by allowing the cluster to respond to changes in load. Horizontal Pod Autoscaler (HPA) and cluster autoscaling work together to provide a stable cluster by scaling your application pods and cluster nodes.

Reliability first requires good resource requests and limits, and the Cluster Autoscaler will have a hard time doing its job if your resource requests are not set correctly. The Cluster Autoscaler relies on the scheduler to know that a pod won't fit on the current nodes, and it also relies on the resource request to determine whether adding a new node will allow the pod to run.

tl:dr set limits on what a pod can consume to increase reliability. This avoids the noisy neighbor problem.

Liveness and Readiness Probes

Another important facet of cluster reliability involves the concept of "self-healing." The idea here is to automatically detect issues in the cluster and automatically fix those issues. This concept is built into Kubernetes in the form of liveness and readiness probes.



Kubernetes helps **improve reliability** by making it possible to schedule containers across multiple nodes and multiple availability zones (AZs) in the cloud.

A liveness probe indicates whether or not the container is running, and it is fundamental to the proper functioning of a Kubernetes cluster. If this probe is moved into a failing state, then Kubernetes will automatically send a signal to kill the pod to which the container belongs. In addition, if each container in the pod does not have a liveness probe, then a faulty or non-functioning pod will continue to run indefinitely, using up valuable resources and possibly causing application errors.

A readiness probe, on the other hand, is used to indicate when a container is ready to serve traffic. If the pod is behind a Kubernetes service, the pod will not be added to the list of available endpoints in that service until all of the containers in that pod are marked as ready. This procedure allows you to keep unhealthy pods from serving any traffic or accepting any requests, thus preventing your application from exposing errors.

Both probes check that the Kubernetes cluster performs on your containers at set intervals. Each probe has two states, pass and fail, along with a threshold for how many times the probe has to fail or succeed before the state is changed. When configured correctly on all of your containers, these two probe types provide the cluster with the ability to "self-heal." Problems that arise in containers will be automatically detected, and pods will be killed or taken out of service automatically.

tl:dr configure liveness probes and readiness probes to provide your cluster with the ability to self-heal.

FINAL THOUGHTS ON BUILDING RELIABLE KUBERNETES CLUSTERS

Reliability in a Kubernetes environment is synonymous with stability, streamlined development and operations, and a better user experience. In a Kubernetes environment, reliability becomes much easier to achieve with the right configuration. Many factors need to be considered when building a stable and reliable Kubernetes cluster, including the possible need for application changes and changes to cluster configuration. Steps include setting resource requests and limits, autoscaling pods using a metric that represents application load, and using liveness and readiness probes.

Reliability becomes much easier to achieve with the right configurations. Platform engineers with multiple teams working across multiple clusters can use Insights to gain visibility into your Kubernetes configurations. With Insights, you can use guardrails to ensure the reliability best practices outlined above are followed, enforce these standards and avoid outages based on your fault tolerance. After all, your customers demand availability.

POLICY ENFORCEMENT BEST PRACTICES

Avoid Consistency Multi-User, Cluster, Tenant Kubernetes Environments

In most cases, organizations pilot Kubernetes with a single application. Once successful, these organizations commit to Kubernetes across multiple apps, development and ops teams. Often a self-service model, DevOps and infrastructure leaders will have many users across many different clusters building and deploying.

Managing cluster configuration becomes unwieldy fast as workloads are inconsistently or manually deployed and modified. Without guardrails, there are likely to be discrepancies in configurations across containers and clusters, which can be challenging to identify, correct and keep consistent. This misconfiguration happens when users copy and paste YAML configurations from online examples like StackOverflow or other dev teams, workloads are over-provisioned to "just get things to work" or if there are no existing processes to verify configurations.

Manually identifying these misconfigurations is highly error-prone and can quickly overwhelm platform teams with code review.

WHEN MANAGING MULTI-CLUSTER ENVIRONMENTS WITH A TEAM OF ENGINEERS, CREATING CONSISTENCY REQUIRES YOU TO ESTABLISH KUBERNETES GUARDRAILS TO ENFORCE DEVELOPMENT BEST PRACTICES.

1. **Standard policies** - enable best practices across all organizations, teams and clusters. Examples include disallowing resources in the default namespace, requiring resource limits to be set or preventing workloads from running as root.
2. **Organization-specific policies** - enforce best practices that are specific to your organization. Examples include requiring particular labels on each workload, enforcing a list of allowed image registries or policies that help with compliance and auditing requirements.
3. **Environment-specific policies** - enforce or relax policies for particular clusters or namespaces. Examples include stricter security enforcement in prod clusters or looser enforcement in namespaces that run low-level infrastructure.

When Does Policy Enforcement Make Sense

- **Shared Cluster:** You're a Platform Engineering/ Operations team building or running a Shared Kubernetes Cluster that serves multiple app teams.
- **Multi-Cluster:** You're a Platform Engineering/Operations team running multiple clusters, with plans to expand your footprint in the cloud, on-prem or both.
- **Service Ownership:** Development teams own all things application and operations and want to help engineers avoid mistakes that distract from building their app.

Simply putting a best practices document in place for your engineering team doesn't work — it will be likely forgotten or ignored. By creating your golden path or IDP that includes Kubernetes guardrails and policy enforcement, common misconfigurations will be prevented from being deployed into the cluster, enables. IT compliance and governance and allows teams to ship with confidence knowing that guardrails are in place.

KUBERNETES POLICY ENFORCEMENT OPTIONS

There are three options you can take when approaching Kubernetes policy enforcement.

Develop Internal Tools

Of course engineers like to develop their own tools for a problem, however, here leaders need to decide whether their team can spend the time, money and resources developing and maintaining home-grown tooling, rather than working on problems that are specific to their business.

Deploy Open Source

There are a number of different open source tools that can help with security, reliability and efficiency configuration. There are open source auditing tools for container scanning and network sniffing, as well as Fairwinds' own contributions that audit Kubernetes clusters uch as Polaris, Goldilocks, Nova and Pluto.

Polaris comes with 20 built-in checks around security, efficiency and reliability. Some example checks Polaris looks out for include:

- Whether a readiness or liveness probe is configured for a pod
- When an image tag is either not specified or set to latest
- When the `hostNetwork` or `hostPort` attribute is configured
- When memory and CPU requests and limits are not configured
- When `securityContext.privileged` is true or when `securityContext.readOnlyRootFilesystem` is not true (amongst a number of other security configuration checks)

If you select the open source route, your team will spend time deploying and managing each tool. You'll need to ask whether your team has the bandwidth for this and if it will enable you to focus on the apps or services that make you money.

Managing cluster configuration becomes unwieldy fast as workloads are inconsistently or manually deployed and modified.

Kubernetes Governance Software

Here you have the software expense, but your team can immediately take action by fixing inconsistencies and enforcing policy throughout your entire CI/CD pipeline.

To address the challenges around policy-enforcement in Kubernetes, Fairwinds Insights can help platform teams automatically enforce policies so that clusters are secure, scale properly to avoid downtime and have controls in place to manage costs.

- A single solution that includes CI, Admission Controller, and In-Cluster integrations across your organization.
- Write once, use everywhere — policies can be configured once and deployed into as part of CI/CD, Admission controller, and In-Cluster checks.
- Single platform for managing results across multiple clusters, pushing notifications, creating tickets, and so on.

FINAL THOUGHTS ON KUBERNETES POLICY ENFORCEMENT BEST PRACTICES

Your golden path or IDP requires Kuberntes governance, especially when running multi-tenant or multi-cluster environments with many teams and users.

USING A TOOL LIKE FAIRWINDS INSIGHTS TO ENFORCE YOUR POLICY-AS-CODE OFFERS THESE BENEFITS:

- **Enforce consistency** - Automate deployment guardrails and security best practices at the CI/CD stage or as an admission controller.
- **Prevent mistakes** - Automate issue detection during application development to prevent mistakes from entering production in the first place.
- **Improve security** - Gain continuous visibility into your Kubernetes security posture by auditing workloads for misconfigurations and weaknesses.
- **Reduce cost** - Increase the efficiency of Kubernetes resource usage to save you money in the cloud or capacity in the data center.
- **Save time** - Eliminate the guesswork and increase speed-to-market with built-in collaboration tools, notifications, workflows and integrations into the tools that teams use everyday.

CONCLUSION

Platform teams looking to simplify Kubernetes for development teams by creating a golden path or internal developer platform need to ensure best practices are followed. By using software built for platform engineers, teams can enforce development practices throughout the full application lifecycle. Platform engineering teams can save up to 50% of their time by not having to manually review code or serve as the "Kubernetes helpdesk." The right platform relieves developers from some of the pressure of configuring Kubernetes, keeps security and compliance teams happy and ensures cost effective cloud usage.

HELPFUL RESOURCES:

- Polaris helps engineers align their Kubernetes deployment manifests with best practices, detecting issues related to security, networking and container images.
- Goldilocks saves engineering time by recommending resource requests and limits (essentially, data-informed CPU and memory settings) for Kubernetes deployments. Both of these tools work nicely at the handoff from development to production, providing developers with a critical feedback loop before they release.
- Fairwinds Insights is software for DevSecOps managing multiple clusters and teams that want the benefit of visibility across their Kubernetes environment. Insights continuously scans your environment for misconfigurations against security and compliance, policy and cost optimization.

Benefits of Fairwinds

Fairwinds provides software built in response to years of Kubernetes managed services. Our in-house Kubernetes experts have seen every kind of cluster implemented in every possible way. We know what to look for, and this depth and breadth of hard-won experience allows us to anticipate and address the range of challenges that can occur. We have seen everything that can go wrong, and we know how to make things go right.

Fairwinds Insights was purpose-built to address problems we saw with Kubernetes. Insights is for platform teams that need to enable developers on Kubernetes. Fairwinds Insights is software that uniquely solves this problem by implementing policies across the development lifecycle to standardize Kubernetes. It saves time, resources and frustration by enabling developers to create secure, cloud efficient and reliable applications.

Fairwinds

WHY FAIRWINDS

Fairwinds builds software for Kubernetes platform engineers to standardize and enable development best practices. With Fairwinds, platform teams decrease friction, increase dev velocity and improve the dev experience to accelerate time to market and revenue generation. Customers ship cloud native applications faster, more cost-effectively and with less risk.

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