Managing Secrets in Kubernetes

Managing your cloud native ecosystem securely

Andrew Block

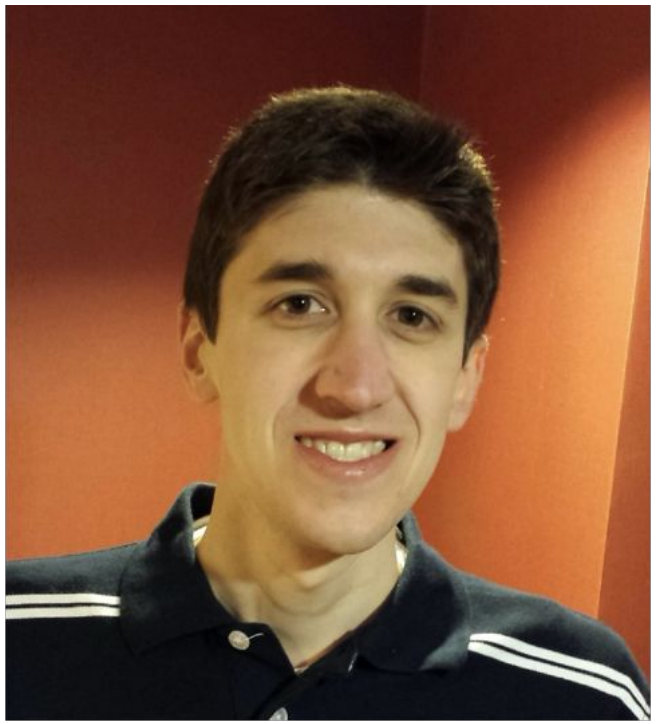
Distinguished Architect

Red Hat

$ git log --author="Andrew Block" --patch

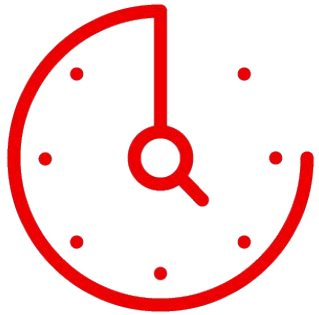
Author: Andrew Block <andrew.block@redhat.com>
Date: Thu January 26 16:00:00 2022 -0500
  Added speaker bio
diff --git a/speaker_bio.txt b/speaker_bio.txt
new file mode 100644
index 0000000..23c2ed6
--- /dev/null
+++ b/speaker_bio.txt
@@ -0,0 +1,7 @@

+ **Distinguished Architect at Red Hat**
+
+ **Specialize in Security, CI/CD and Automation**
+
+ **Author:**
+. **- Learn Helm**
+ **- Kubernetes Secrets Management**
+
+ **Helm Maintainer**
+
+ **Lead Helm integration on sigstore project**



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What we'll discuss today



- Application Configurations and Handling Sensitive Resources
- Cloud Based Configuration Management Patterns
- Kubernetes Secrets and Their Weaknesses
- Tools for Managing Secrets in Kubernetes

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Application Configurations

Applications typically make use of configurable properties to customize their execution

Application Metadata

- Attributes associated for identifying the application
  - Ex: Application owner, organization

Deployment Environment

- Details related to the operating environment
  - Ex: Region of public cloud provider

Externalized from Application

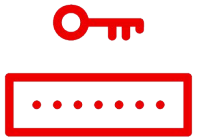
- Referenced from a location outside the application itself
  - A properties file on the file system
  - Stored within the hosting environment



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Sensitive Resources

The inclusive of sensitive assets is a common trait in many applications



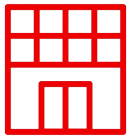
Credentials

Usernames, passwords, certificates and keys that are used for authentication



Certificates

PKI content



Proprietary Information

Certain application configurations may contain properties that are considered sensitive given their context

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Storing Configurations in Kubernetes

Kubernetes Provides Several Constructs for Storing Configurations Within the Platform



ConfigMap

- Storage of non-confidential data in key/value pairs

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: game-demo
data:
  # property-like keys
  player_initial_lives: "3"
  # file-like keys
  game.properties: |
    enemy.types=aliens,monsters
    player.maximum-lives=5
```



Secret

- Storage of obfuscated sensitive data

```
apiVersion: v1
kind: Secret
# Secret Data
metadata:
  name: employee-database-auth
  namespace: default
# The type of Secret
type: kubernetes.io/basic-auth
# Secret data
stringData:
  username: dGhlYWRtaW4= //theadmin
  password: YWRtaW5wYXNz //adminpass
```


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Fallacy of Kubernetes Secrets

Kubernetes Secrets Presents Security Limitations



- Secrets are Base64 Encoded
  - Encoding is not a security mechanism!



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Approaches for Managing Secrets in Kubernetes

Kubernetes Resource Management

There are two high level approaches for managing Kubernetes Resources

Imperative

- Executing commands to perform actions
  - kubectl commands with specific parameters

```
kubectl run nginx --image=nginx --port=80
```

Declarative

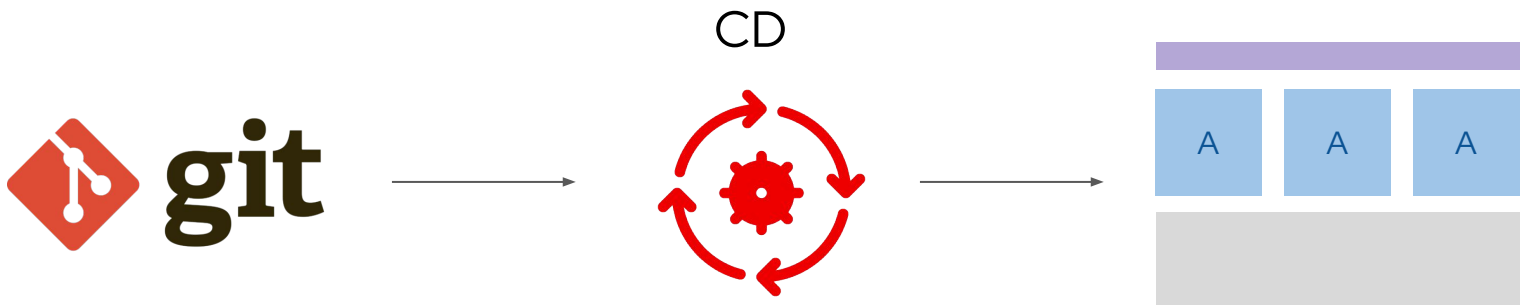
- Expressing desired state by defining intentions
  - Manifest specifying resources

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx
    name: nginx
    ports:
    - containerPort: 80
      protocol: TCP
```


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GitOps Workflow

A Declarative Approach Towards Infrastructure and Application Delivery



Red Hat

GitOps Tooling

Several Tools Are Available for Managing GitOps Workflows



Argo CD



Flux



Ansible

- Automating how resources are applied
- Enforcing Drift Control
- Not tied to Kubernetes and is a methodology that can be applied in other contexts

Any automation tool can implement GitOps principles

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Sensitive Kubernetes Resource Considerations



- How to declaratively manage sensitive values and GitOps?
- What tools are available to manage these concerns?
- Are there any external tools that can help?
- What automation opportunities are available?

Managing Secrets the Wrong Way

- **DO NOT** store sensitive resources in plain text
  - Committed to Git repositories
  - Within associated tooling
- Not understanding the capabilities and limitations of the tools being used
- Implementing “security theater”
  - Security by obscurity



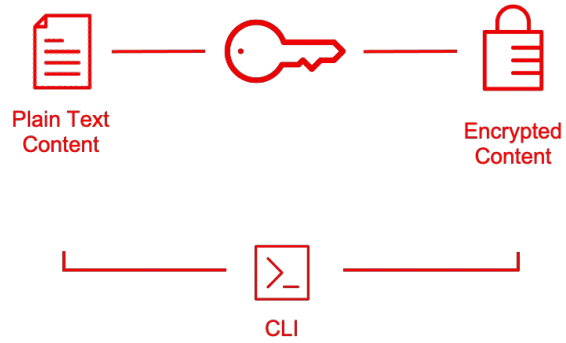
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Storing Secrets

Two primary approaches for storing sensitive assets within source code repositories

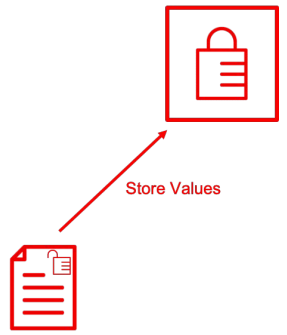
Encrypted Content

Sensitive values are encrypted and stored within repository



External Reference

Sensitive values are stored within another location. Reference is provided within repository content.



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Encrypted Content Tooling

Mozilla SOPS

- General purpose configuration file encryption tool
- CLI based
- Supports multiple encryption technologies
  - OpenPGP, AWS KMS, GCP KMS and Azure Key Vault
- Not tied to the Kubernetes ecosystem
- Integrated into several GitOps based tools



Mozilla SOPS in Action

Plain text configuration file



SOPS CLI



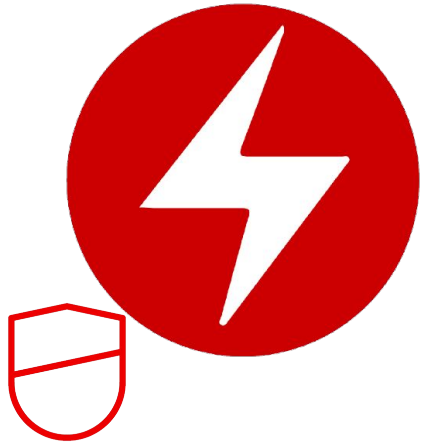

```
{
	"data":
"ENC[AES256_GCM,data:k1EB/e2szKkXq1Lk,iv:hfcmUcgpdjsTzJUzPHlTEkTX5jwQbu7XetaRzUdlJ7s=,t
ag:lSHo42RRdutPmlcvtcvz3Q==,type:str]",
	"sops": {
		"kms": null,
		"gcp_kms": null,
		"azure_kv": null,
		"hc_vault": null,
		"age": null,
		"lastmodified": "2023-01-24T14:55:35Z",
		"mac": "ENC[AES256_GCM,data:<data>,type:str]",
		"pgp": [
			{
				"created_at": "2023-01-24T14:55:26Z",
				"enc": "<PGP_MESSAGE>",
				"fp": "2CE5F1FB9E8C59B87BBD5F2B02DFE631AEF35EBC"
			}
		],
		"unencrypted_suffix": "_unencrypted",
		"version": "3.7.3"
	}
}%
```

Encrypted Configuration File

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Sealed Secrets

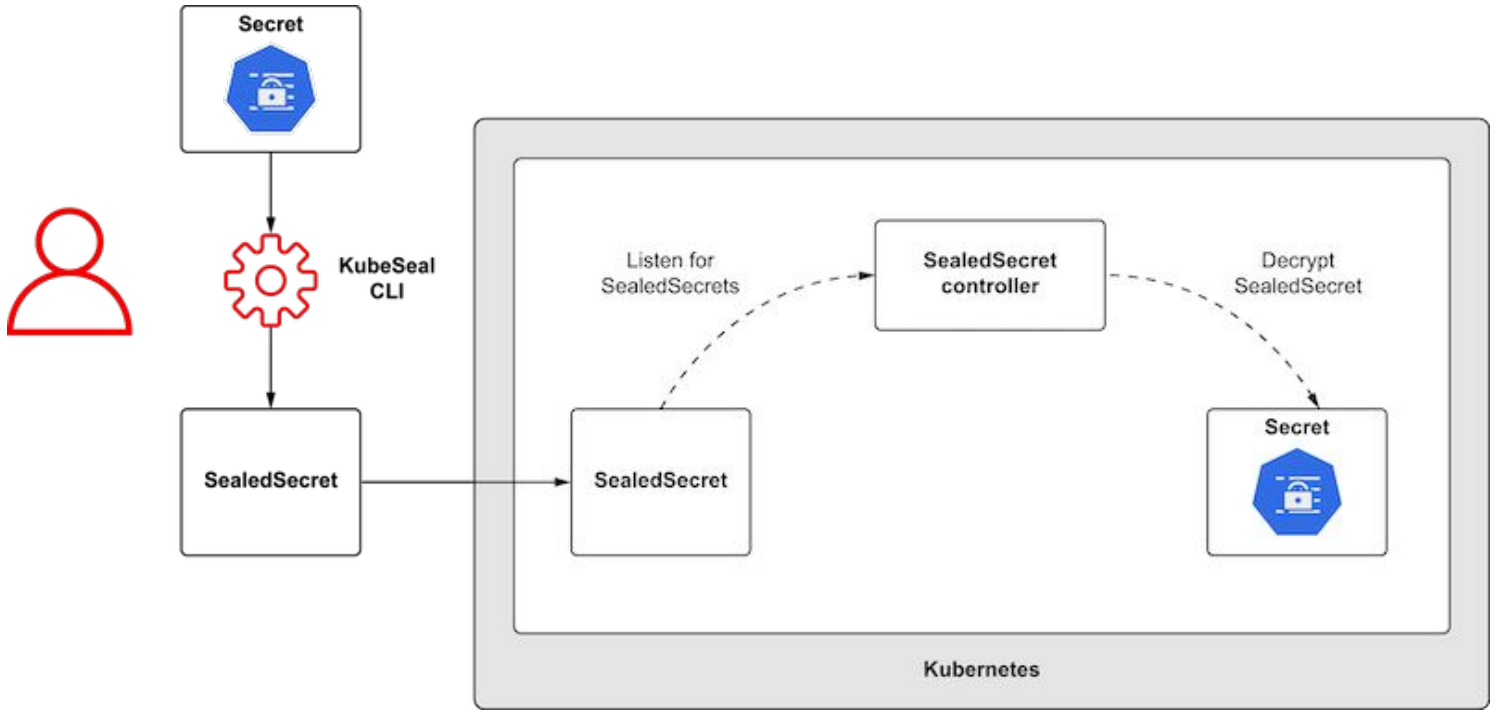
- Kubernetes based Operator responsible for translating encrypted `SealedSecret` Custom Resource manifest to a Kubernetes Secret
  - Performs “one way” encryption
  - In cluster public/private key used for encryption



- `kubeseal` CLI enables encrypting Kubernetes secret for safe storage

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Sealed Secrets in Action




```yaml
apiVersion: bitnami.com/v1alpha1
kind: SealedSecret
metadata:
  name: mysecret
  namespace: mynamespace
spec:
  encryptedData:
  foo: AgB3140JSWK+PiTySYZZA9orO43cGDEq...
```

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
spec:
  data:
    foo: bar # <- base64 encoded “bar”
```

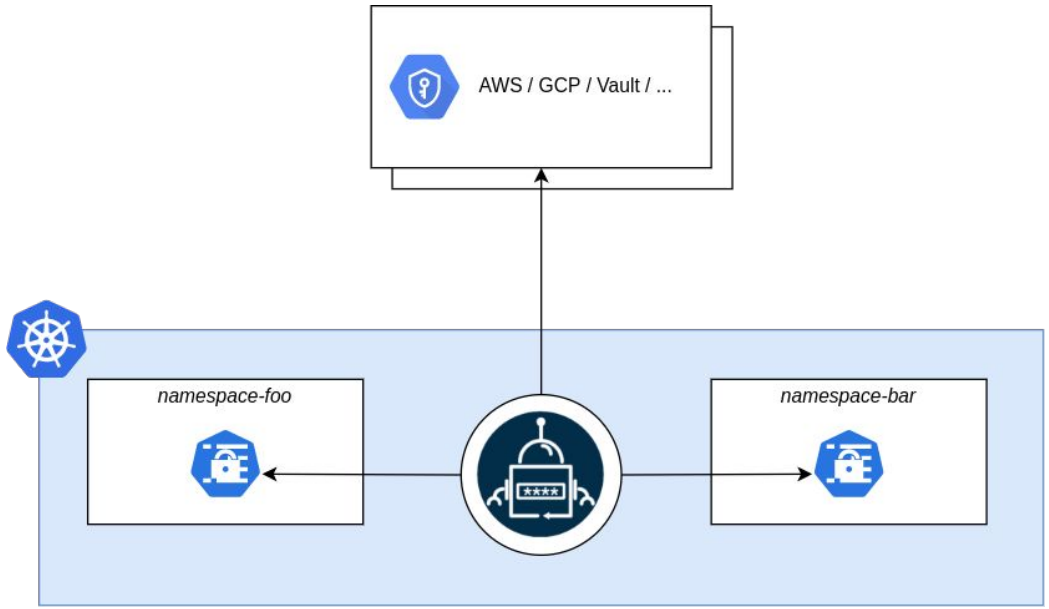

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External Reference Tooling

External Secrets

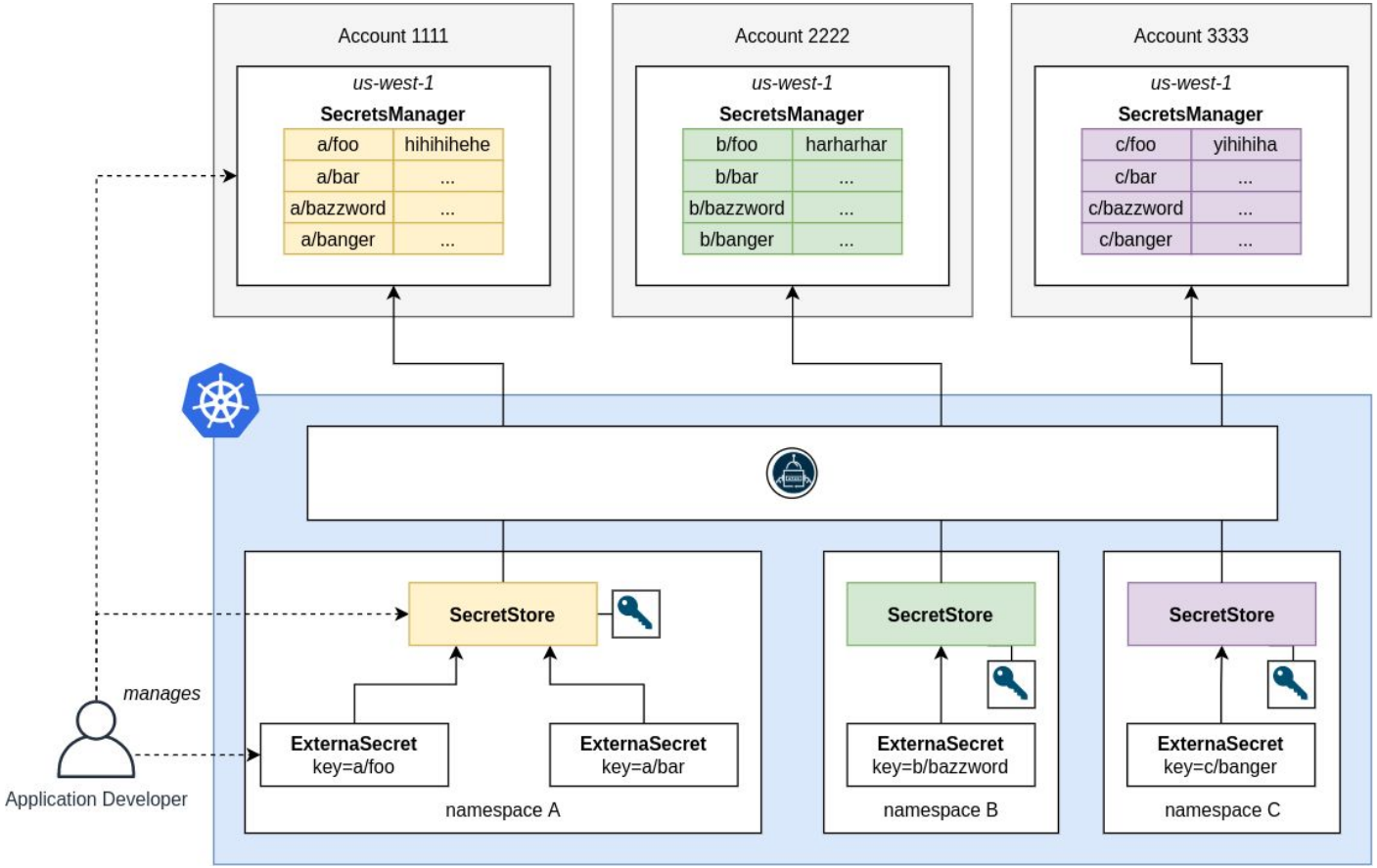
Kubernetes Operator that integrates external secrets management tool

- Synchronizes the state of the external secrets management tool
- Extensive list of pluggable providers
  - AWS Secrets Manager, HashiCorp Vault, Google Secrets Manager, Azure Key Vault, IBM Cloud Secrets Manager, and many more



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External Secrets in Action

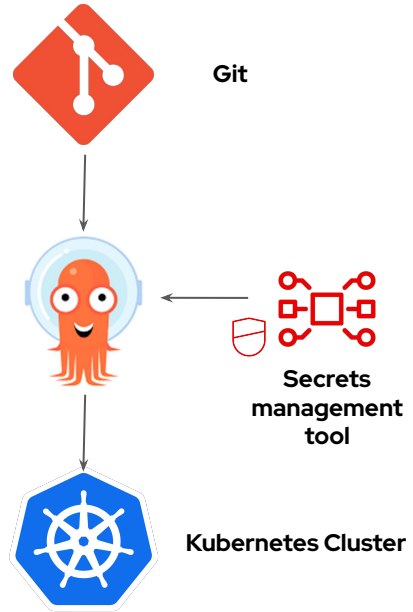


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GitOps Integration

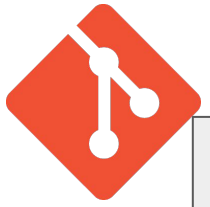
GitOps tooling includes support for managing sensitive resources

- Argo CD Vault Plugin enables injecting values stored in HashiCorp vault into Kubernetes manifests
- Manifests stored in Git contain placeholders that are dynamically replaced at runtime



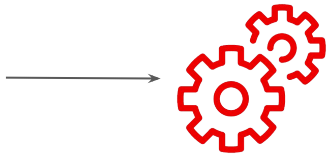
Argo CD Vault Plugin

Argo CD Vault Plugin in Action



```
kind: Secret
apiVersion: v1
metadata:
  name: example-secret
  annotations:
    avp.kubernetes.io/path:
"path/to/secret"
type: Opaque
data:
  password: <password-vault-key>
```

Manifest stored in Git



Argo CD Vault Plugin

```
kind: Secret
apiVersion: v1
metadata:
  name: example-secret
  annotations:
    avp.kubernetes.io/path: "path/to/secret"
type: Opaque
data:
# The Value from the key password-vault-key in vault
  password: cGFzc3dvcmQK
```

Secret Created in Kubernetes

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Why Create Secrets at All?

Avoid Base64 encoded values altogether!

Kubernetes Secrets Store CSI Driver

Kubernetes Secrets Store CSI Driver interacts with external secret stores while leveraging the native CSI capabilities provided by Kubernetes

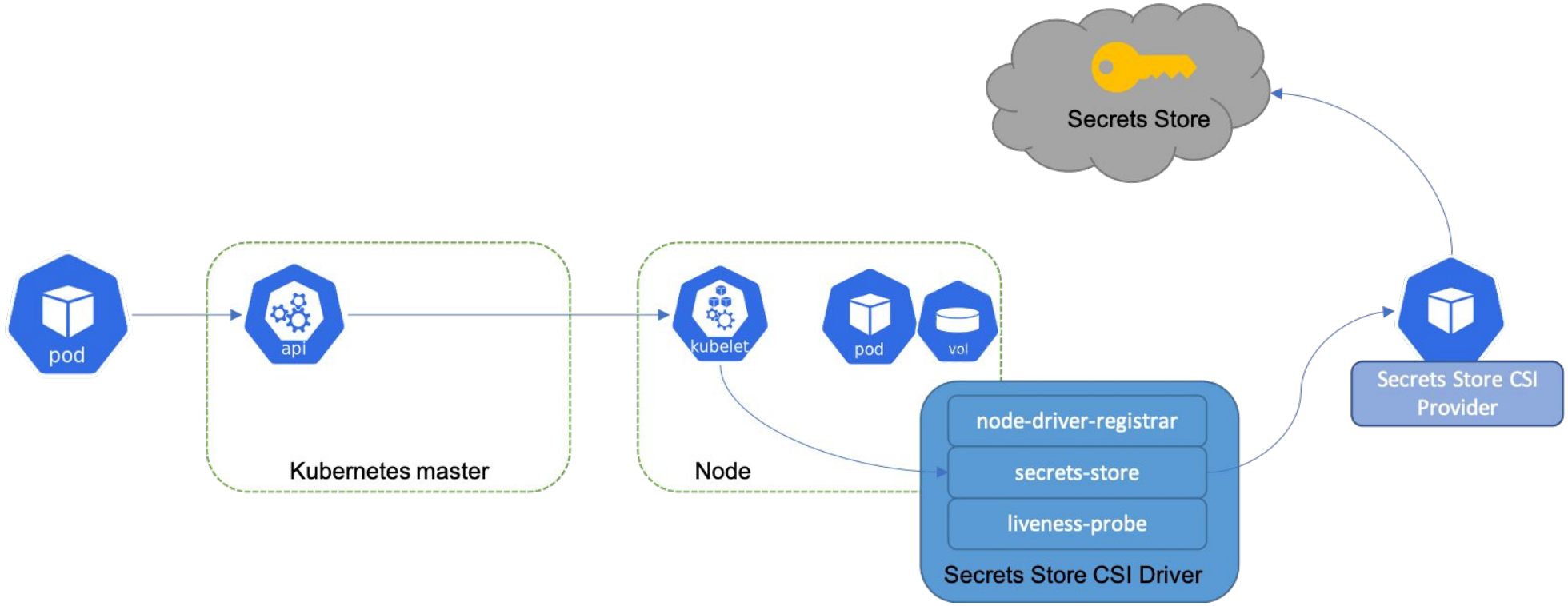


- Pluggable and supports multiple secrets management backends
  - AWS, Azure, GCP, Vault
- Extendable to enable user defined providers
- Applications performs standard volume mounting using `csi` volume type
- Avoids traditional Kubernetes Secret from being created



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Kubernetes Secrets Store CSI Driver in Action



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Additional Secrets Management Solutions

Secrets Management Provided Tooling

Direct integration is provided by certain Secrets Management solutions

HashiCorp Vault Agent Sidecar Injector

- Enabled the mutation of Pods to inject secrets stored in Vault into applications
- Leverages annotations on manifests to declare how values are accessed
- Supports templating to dynamically configure rendered resources

Hashicorp Vault CSI Driver

- Injects values stored into Vault into Kubernetes Pods
- Inherits the benefits provided by CSI capabilities



Application Framework Tooling

Certain application frameworks have support for managing access to sensitive resources

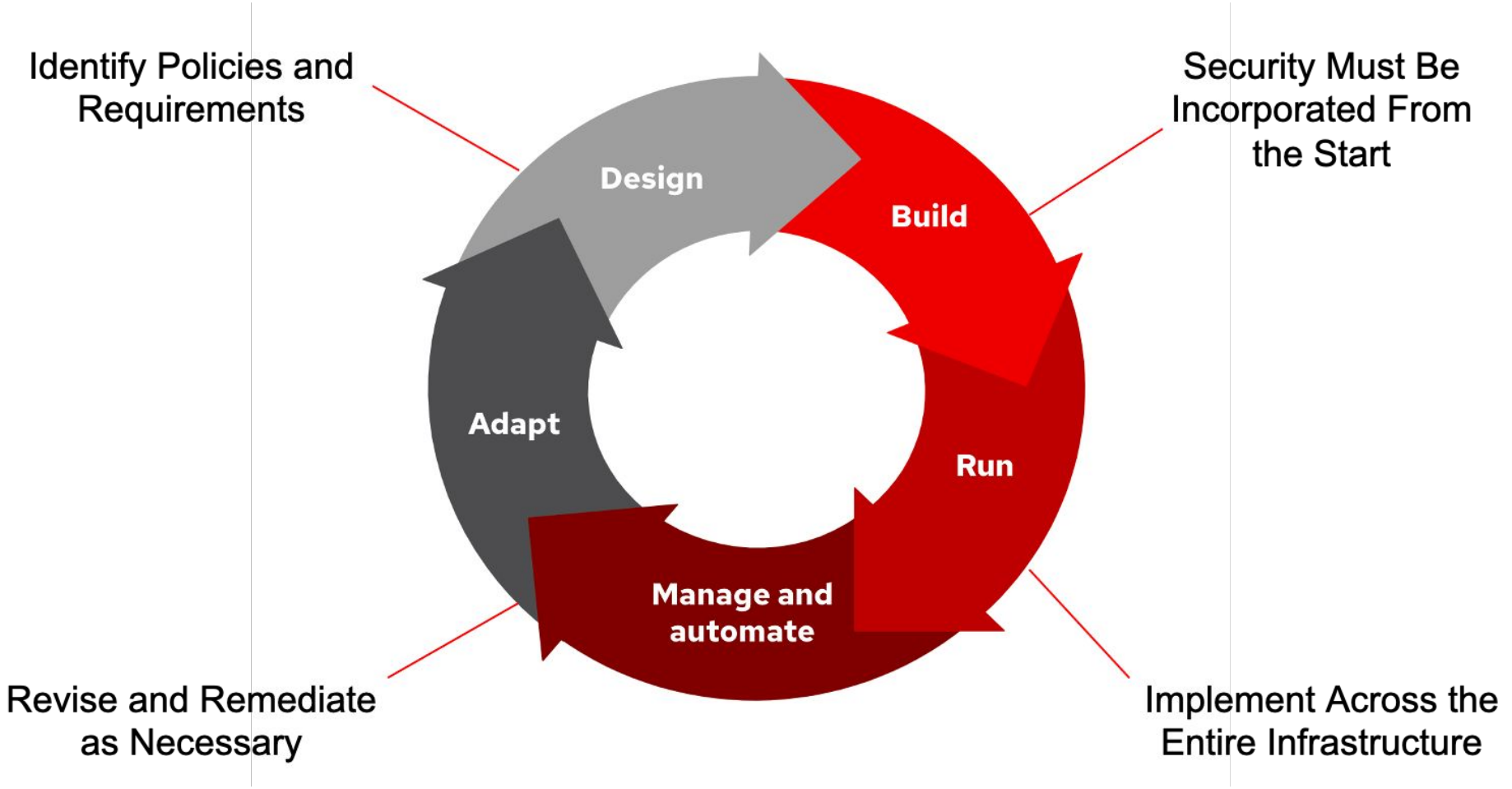




QUARKUS

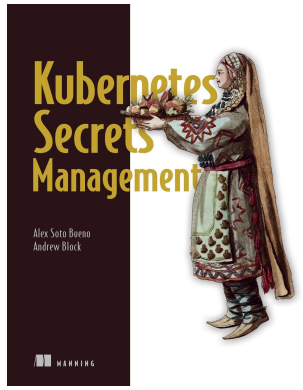
- Application configuration properties sourced from Kubernetes Secrets and ConfigMaps
- Datasource credentials can be obtained from external secrets management tools
- Robust integration with HashiCorp Vault to access sensitive data within applications

Security is Continuous



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Resources



Publications

- Comprehensive guide on managing Kubernetes Secrets in depth
  - https://manning.com/books/securing-kubernetes-secrets

GitOps Principles

- OpenGitOps - Open source standards and best practices for GitOps
  - https://opengitops.dev

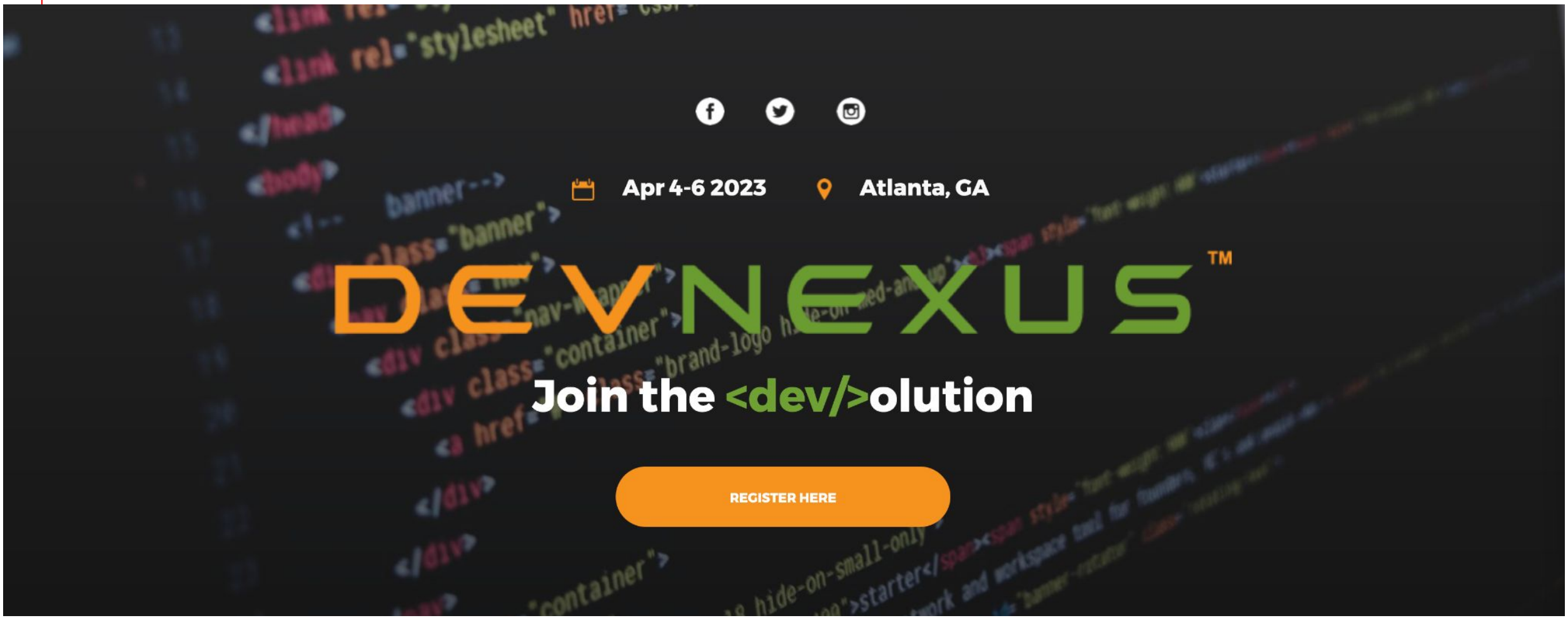
Cloud Native Security Whitepaper

CLOUD NATIVE COMPUTING FOUNDATION

- Includes guidance on how to best manage sensitive information
  - https://www.cncf.io/blog/2022/05/18/announcing-the-refreshed-cloud-native-security-whitepaper/

Interactive Demo

Questions?


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Adopting a Cloud Native Approach

Top Considerations



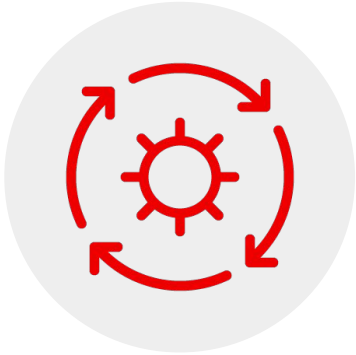
Speed

Increase developer productivity and ship quality applications faster



Security

Application and supply chain security from start to production



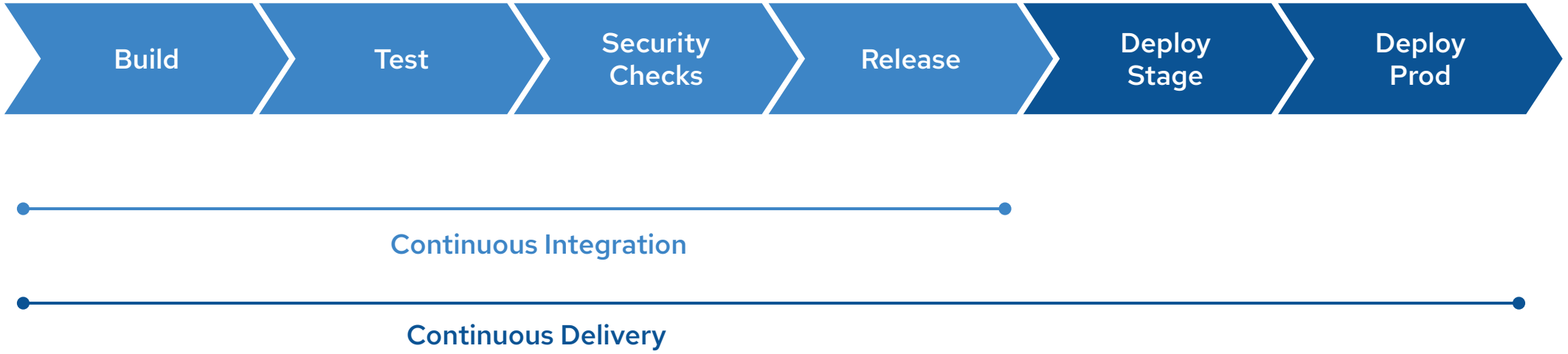
Scale

Automate and scale application delivery on hybrid cloud infrastructure

Innovate your new future and optimize what you have

Continuous Integration(CI) & Continuous Delivery (CD)

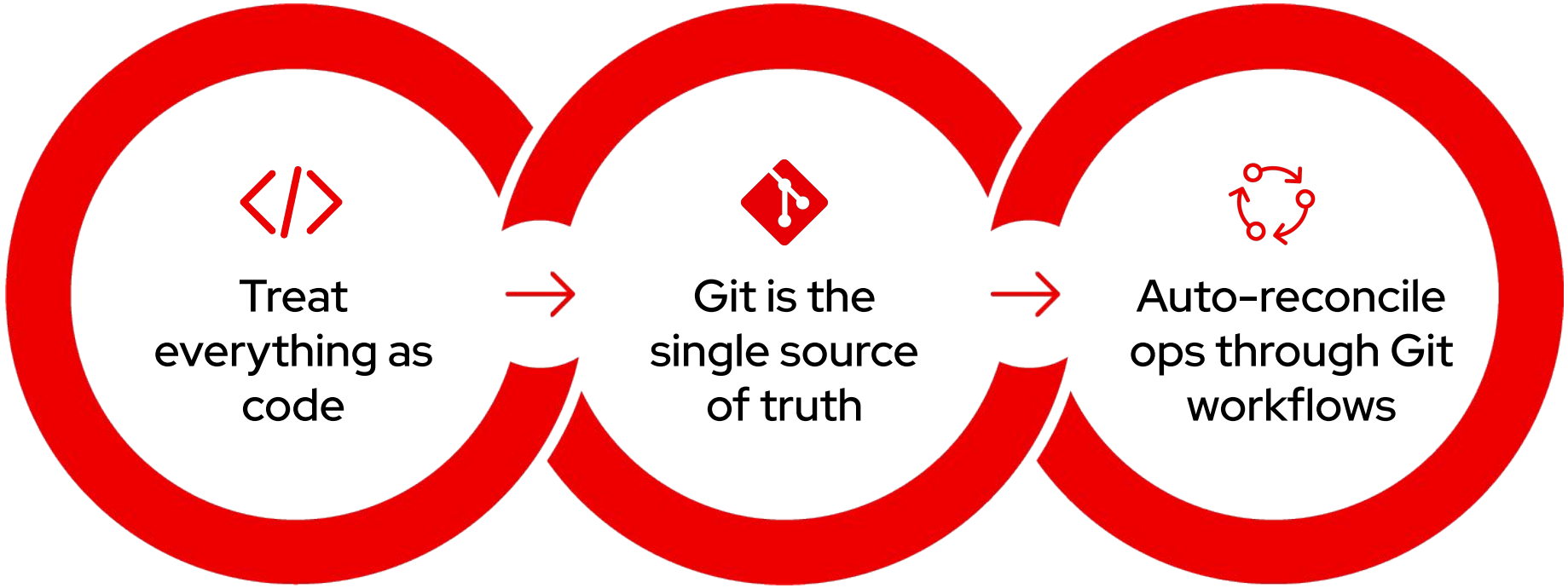
A key DevOps principle for automation, consistency and reliability



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What is GitOps?

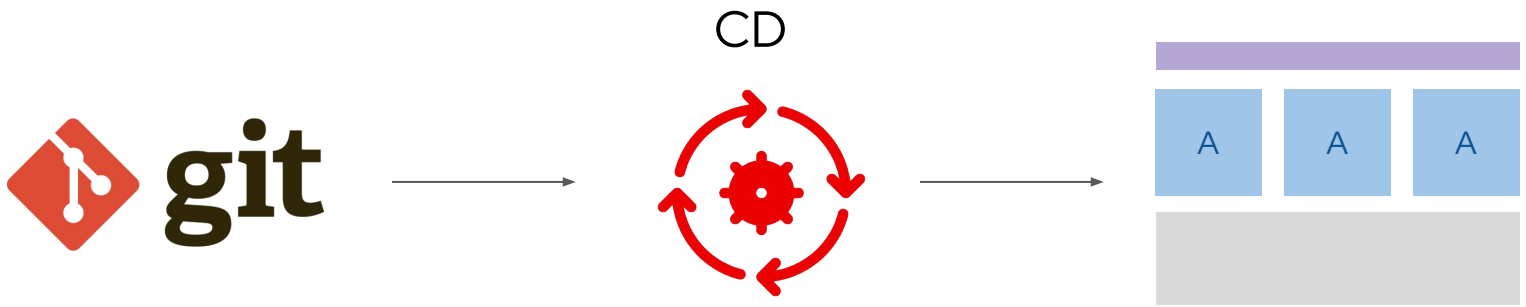
An developer-centric approach to Continuous Delivery and infrastructure operation



Red Hat

GitOps Workflow

a declarative approach to application delivery



What you want
(desired state)

What you have
(current state)

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Why GitOps?

Standard Workflow

Familiar tools and Git workflows from application development teams

Enhanced Security

Review changes beforehand, detect configuration drifts, and take action

Visibility and Audit

Capturing and tracing any change to clusters through Git history

Multi-cluster consistency

Reliably and consistently configure multiple Kubernetes clusters and deployment

The GitOps Evolution

Adopting GitOps Principles is a Departure from How Infrastructure and Applications are Traditionally Managed

Traditional Models

- Emphasizing access management against individuals instead of systems
- Actions performed manually
- Dedicated teams responsible for managing infrastructure and applications
- Change request and approvals

GitOps

- Actions automated
- Infrastructure codified
- Participation by both infrastructure and application teams
- Changes applied automatically
- Self healing

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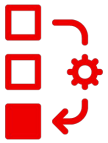
OpenShift GitOps

OpenShift GitOps



Multi-cluster config management

Declaratively manage cluster and application configurations across multi-cluster OpenShift and Kubernetes infrastructure with Argo CD



Automated Argo CD install and upgrade

Automated install, configurations and upgrade of Argo CD through OperatorHub



Opinionated GitOps bootstrapping

Bootstrap end-to-end GitOps workflows for application delivery using Argo CD and Tekton with GitOps Application Manager CLI



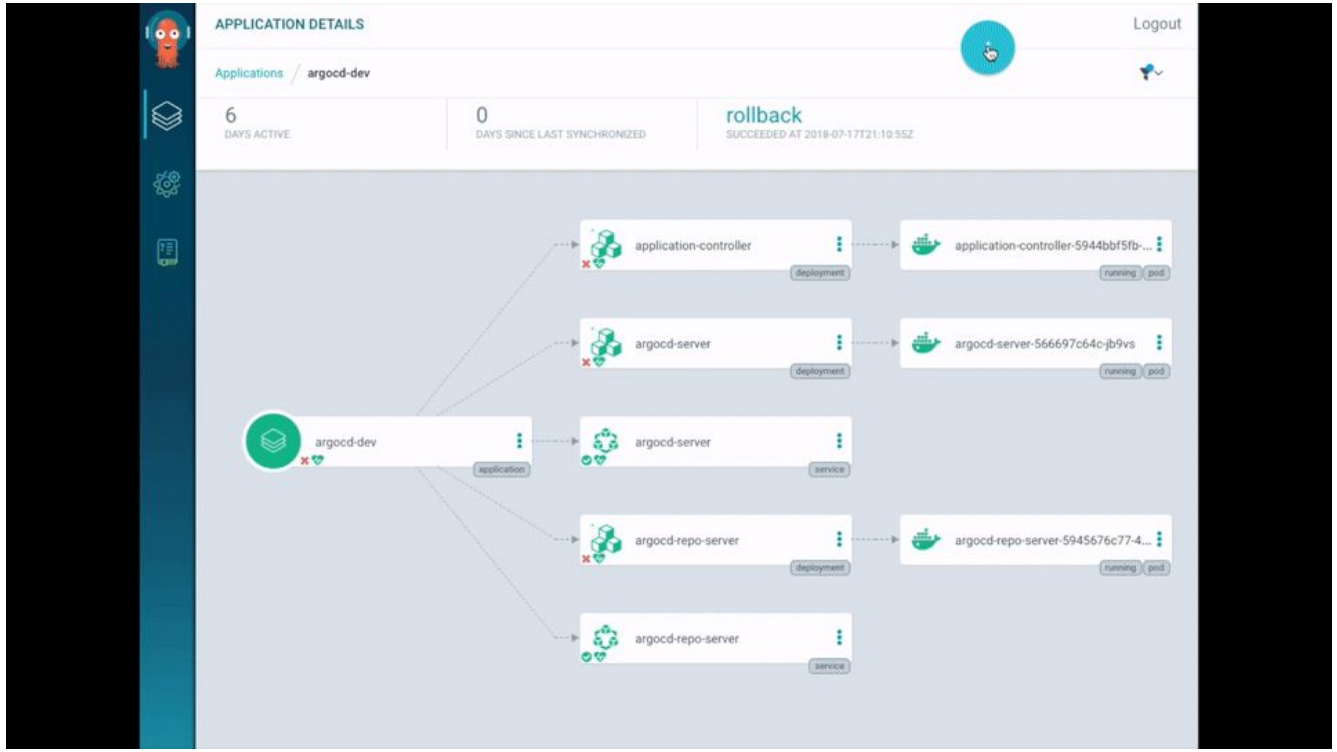
Deployments and environments insights

Visibility into application deployments across environments and the history of deployments in the OpenShift Console

Argo CD - What is It?

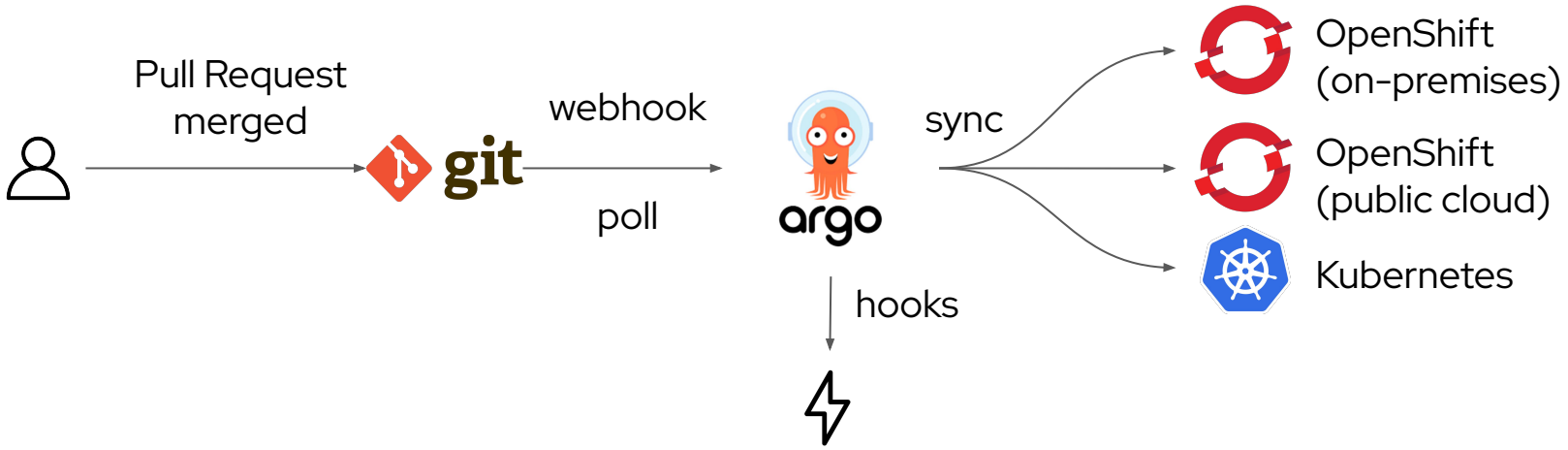
Argo CD is a declarative, GitOps continuous delivery tool for Kubernetes.

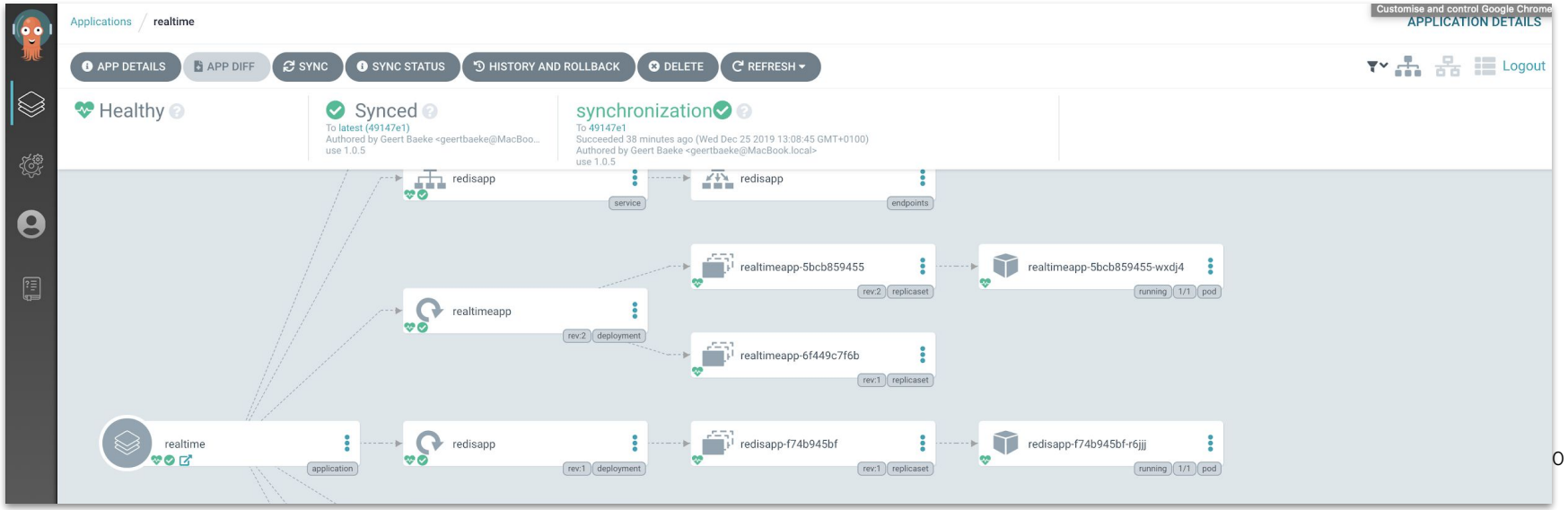
- Easily deploy applications in a declarative way
- Synchronizes cluster state with git repos
- Works with a variety of Kubernetes deployment tools including:
  - Helm
  - Kustomize
  - Ksonnet/Jsonnet
  - Directories of yaml
- It is **not** a CI tool!



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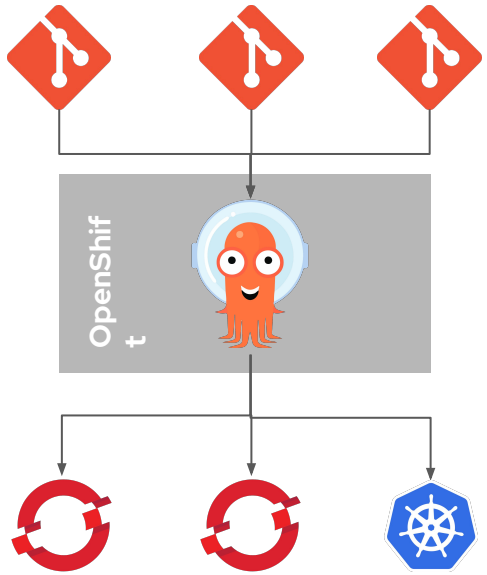
Git Workflow with Argo CD





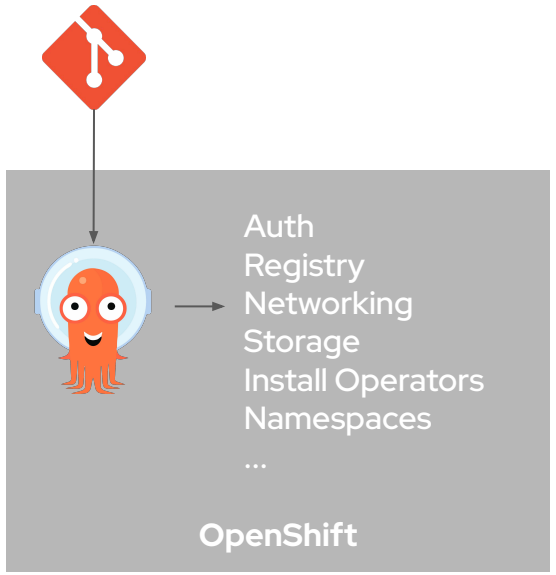
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Flexible Deployment Strategies



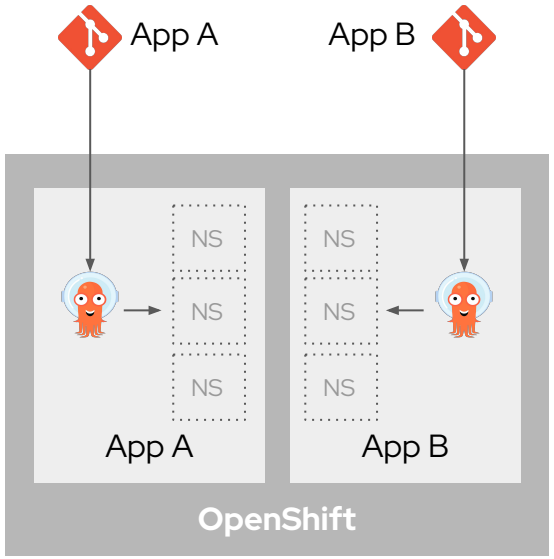
Central Hub (Push)

A central Argo CD pushes Git repository content to remote OpenShift and Kubernetes clusters



Cluster Scoped (Pull)

A cluster-scope Argo CD pulls cluster service configurations into the OpenShift cluster



Application Scoped (Pull)

An application scoped Argo CD pulls application deployment and configurations into app namespaces

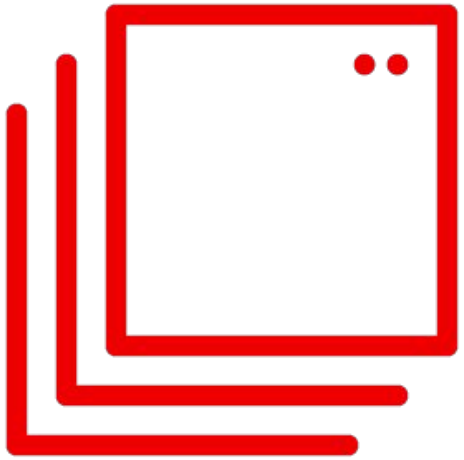
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What is an Argo CD Application?

- *Application* is a Custom Resource (CR) is a custom resource provided by Argo CD
- Application definition includes:
  - Name
  - Cluster
  - Git repository
  - Synchronization Policy
- Application is the unit of work
- Applications can be deployed from Argo CD GUI or CLI (argocd or kubectl or oc)

```yaml
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
 name: product-catalog-dev
 namespace: argocd
spec:
 destination:
  namespace: argocd
  server: https://kubernetes.default.svc
 project: product-catalog
 source:
  path: manifests/app/overlays/dev-quay
  repoURL: https://github.com/gnunn-gitops/product-catalog.git
  targetRevision: main
 syncPolicy:
  automated:
   prune: false
   selfHeal: false
```

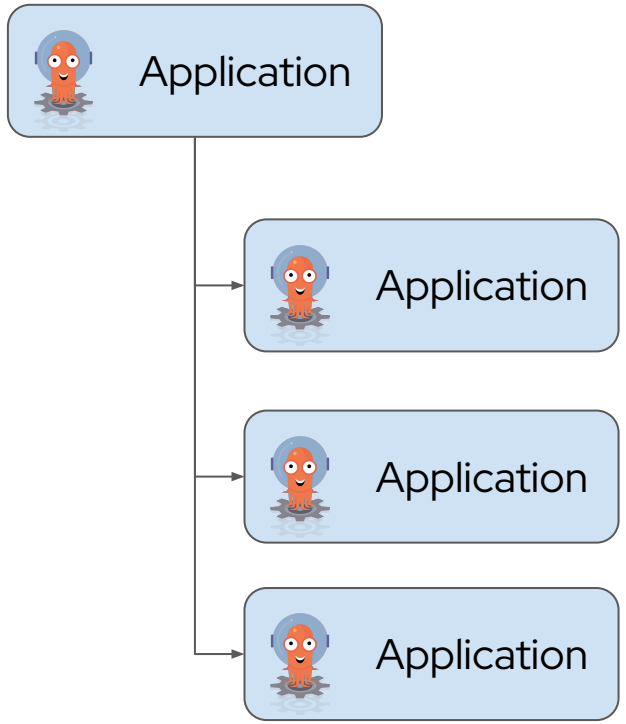
Application Scope of Deployment



- Argo CD Application can span multiple Kubernetes Namespaces
- In Argo CD, the Application is the “center of the world”
- Argo CD has multi tenancy capabilities with Projects
  - These differ from OpenShift Projects
  - Is not 1:1 with Namespaces/Projects
- Argo CD Application deployed to an Argo CD Project can be explicitly be deployed across multiple Namespaces/Projects

Argo CD “App of Apps”

- App of Apps is a common pattern where one Argo CD Application points to a repo that only contains other Argo CD Applications
- Very useful to be able to provision and manage a group of related applications or items together in a single shot
- Pattern has evolved over time, expected to be supplanted by new ApplicationSets feature



https://argoproj.github.io/argo-cd/user-guide/application-set

ApplicationSets

- Use a single manifest to target multiple clusters
- Deploy Application from a single or multiple git repos
- Manages lifecycle of the Application CR
- Can be thought of as sort of a “factory” for building Application CRs
  - You still end up with Application definitions, it’s just managed now from a central configuration.



Managing Secrets in GitOps

GitOps and Secrets

GitOps Commonly Involves the Use of Sensitive Assets



Source Code Repositories

Credentials to obtain access to the content driving GitOps



Application Configurations

Properties that are utilized by applications



Infrastructure Management

Configurations for managing the infrastructure



Access to Platform Resources

Assets to communicate to platform components

Red Hat

Managing Secrets the Wrong Way

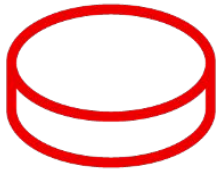
- **DO NOT** store sensitive resources in plain text
  - Committed to Git repositories
  - Within associated tooling
- Not understanding the capabilities and limitations of the tools being used
- Implementing “security theater”
  - Security by obscurity



Red Hat

Properly Handling Secrets in GitOps

GitOps Commonly Involves the Use of Sensitive Assets



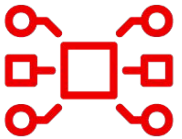
Storing Secrets

Methods for secure storage of sensitive assets



Accessing Secrets

Obtaining previously stored values



Consuming Secrets

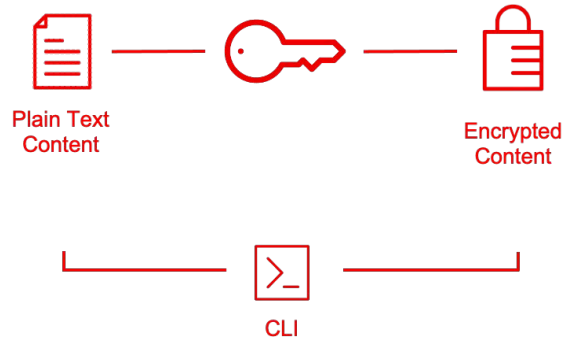
Mechanisms for which target components make use of sensitive assets

Storing Secrets

Two primary approaches for storing sensitive assets within source code repositories

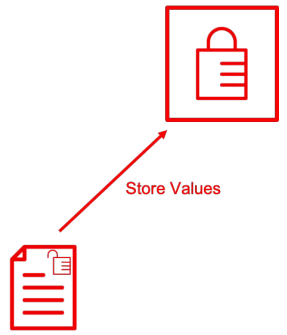
Encrypted Content

Sensitive values are encrypted and stored within repository



External Reference

Sensitive values are stored within another location. Reference is provided within repository content.



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Tools for Accessing Secrets

Various utilities are available retrieve previously stored sensitive assets



Command Line Interface

- Interactive methods when working on a local machine
- Standalone or integrated into existing tooling



CI/CD

- Popular solutions (Jenkins, GitHub, GitLab) support such integrations
- Accelerates DevSecOps processes



Plugins

- Extension of existing tooling
- Abstracts interactions supporting secrets management
- Lifecycle can integrated within tool or handled by plugin manager
  - helm, kubectl, etc

```
$ <CLI_TOOL> <PLUGIN> <COMMANDS>
```




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Kubernetes Native Secret Access

Popular tooling to support Secrets Management in Kubernetes

Sealed Secrets

- Controller containing private keys to encrypt/decrypt sensitive values

External Secrets

- Retrieve values stored within external Secrets Management utilities.

Vault Agent Sidecar Injector

- Feature rich tool for HashiCorp Vault
- Injects sidecars to applications
- Manages lifecycle of secrets within cluster

```
apiVersion: external-secrets.io/v1alpha1
kind: ExternalSecret
metadata:
  name: aws-creds
  namespace: gitops
spec:
  refreshInterval: "60s"
  secretStoreRef:
    name: vault
    kind: ClusterSecretStore
  target:
    name: aws-creds
  data:
  - secretKey: aws_secret_access_key
    remoteRef:
      key: kv/data/mycluster
      property: aws_secret_access_key
  - secretKey: aws_access_key_id
    remoteRef:
      key: kv/data/mycluster
      property: aws_access_key_id
```

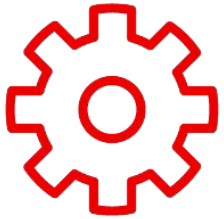
AWS credentials stored in Vault and integrated into Kubernetes using External Secrets project



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Consuming Secrets

Common methods of consuming values from within applications



Environment Variables

Values are exposed to applications through Operating System environment variables



File System

Values are included within files mounted into the containers for access by applications

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Kubernetes Secrets

Kubernetes Secrets are a common storage facility utilized after obtaining values from secrets stores



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Kubernetes Secrets

Kubernetes Secrets Store CSI Driver interacts with external secret stores while leveraging the native CSI capabilities provided by Kubernetes



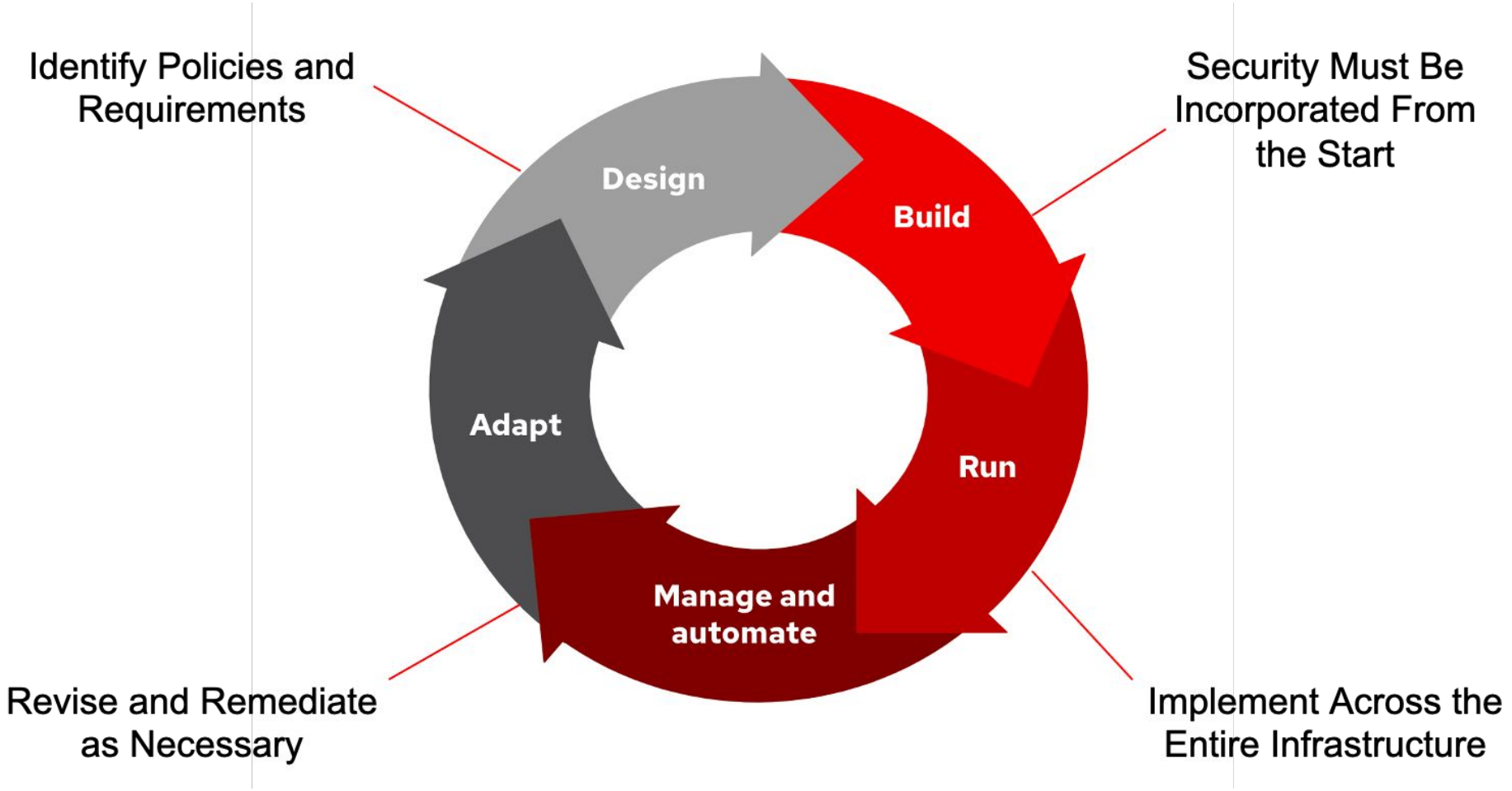
Why Create Kubernetes Secrets at All?

- Pluggable and supports multiple secrets management backends
  - AWS, Azure, GCP, Vault
- Extendable to enable user defined providers
- Applications performs standard volume mounting using `csi` volume type
- Avoids storing sensitive assets as Kubernetes Secrets



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Security is Continuous





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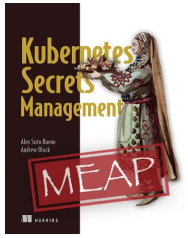
Resources

GitOps Principles

- OpenGitOps - Open source standards and best practices for GitOps
  - https://opengitops.dev

OpenShift GitOps

- Hands on training and self paced exercises
  - https://learn.openshift.com



Publications

- Kubernetes Secrets Management
  - Comprehensive look at secrets management in Kubernetes
  - Publisher Site

Presentations

- GitOpsCon
  - Sharing knowledge around GitOps concepts and practices
  - Recordings

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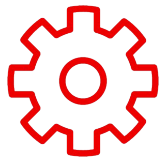
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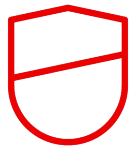
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https://www.redhat.com/en/about/brand/standards

Icon repository deck
https://docs.google.com/presentation/d/1SRhy8-bYBgaA3Jsi1t_Fxz-Yo9ORgdRy5Kec9hg_wSM/edit?usp=sharing

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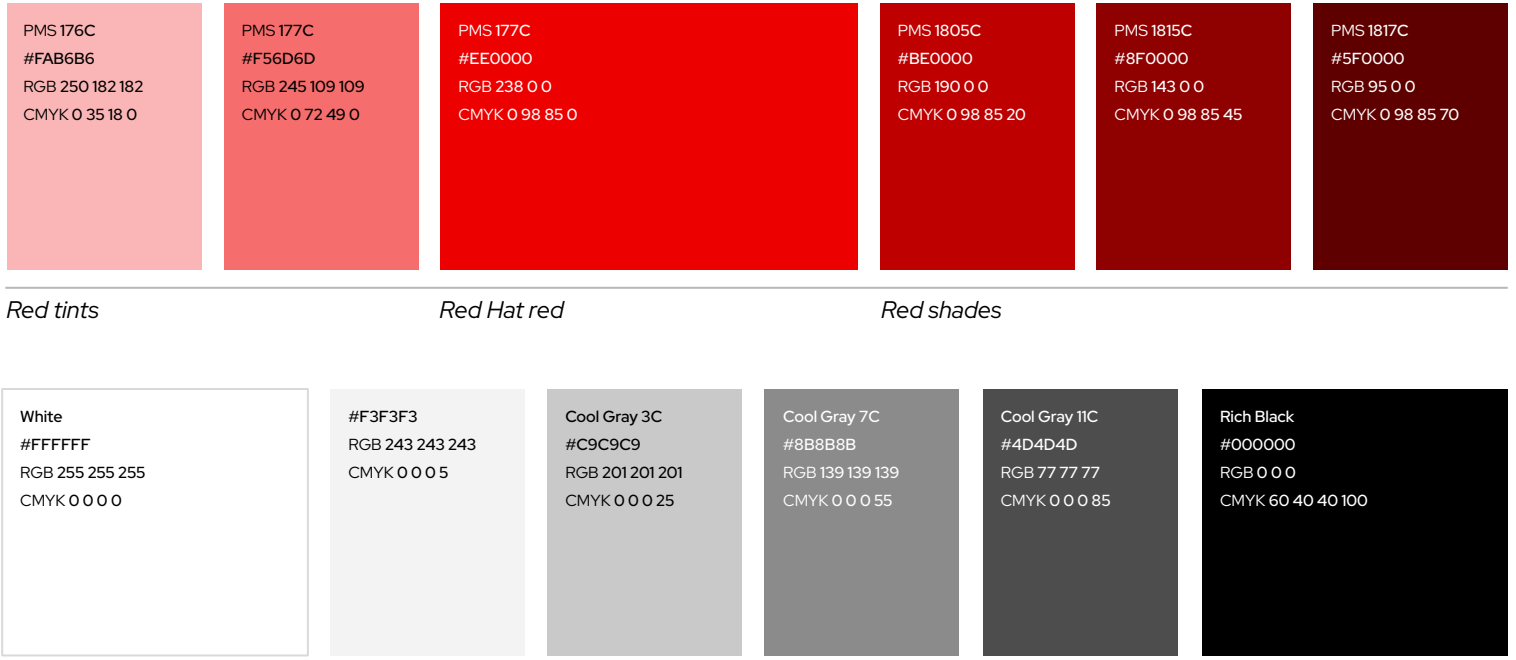
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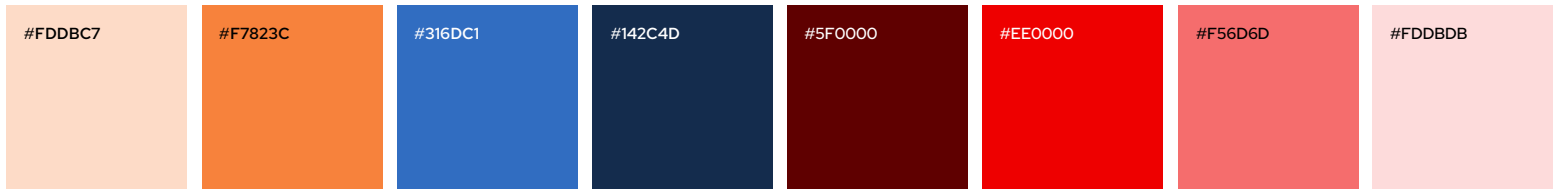
Presentation palette 1



Presentation palette 2



Presentation palette 3



Presentation palette 4

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Closing slide templates

Divider slide templates



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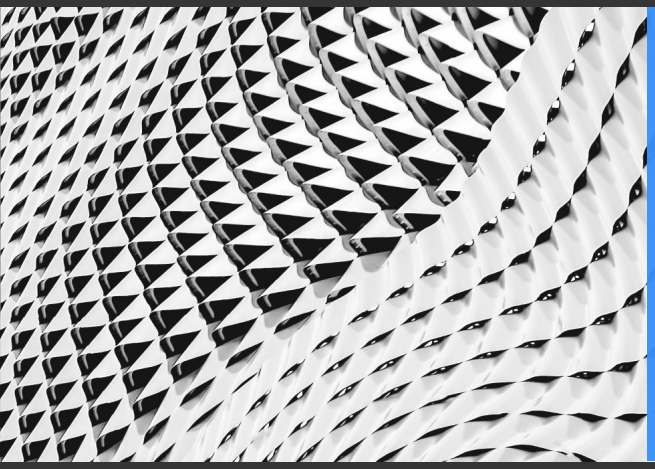
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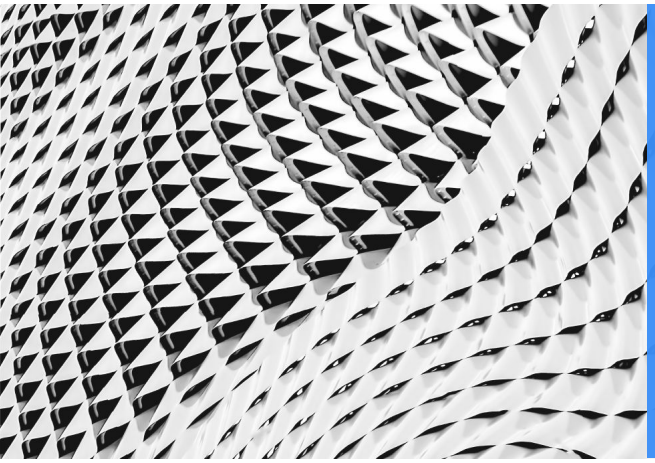
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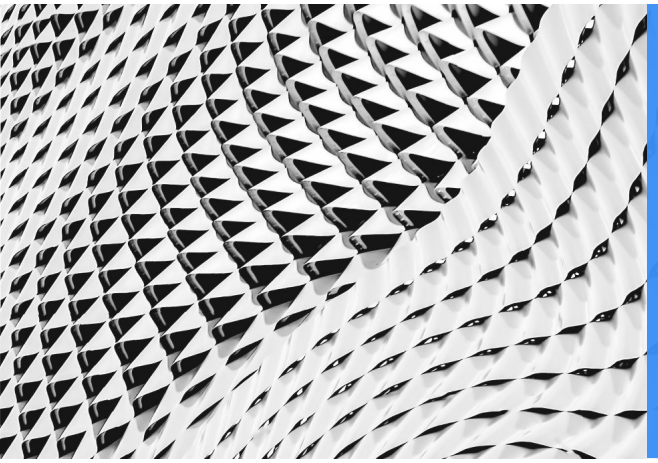


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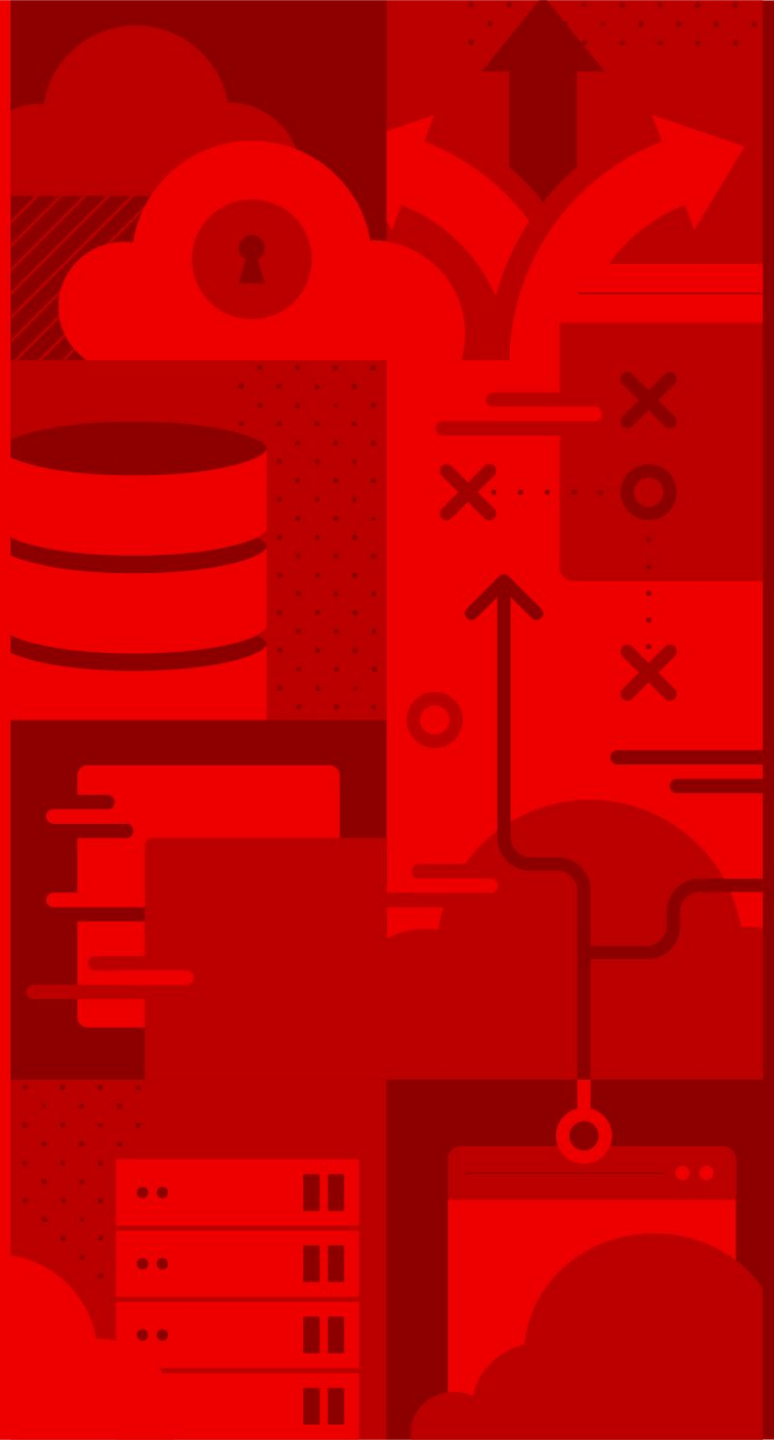
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Agenda slide templates

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Topic

Topic

Topic

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What we'll discuss today

- Topic
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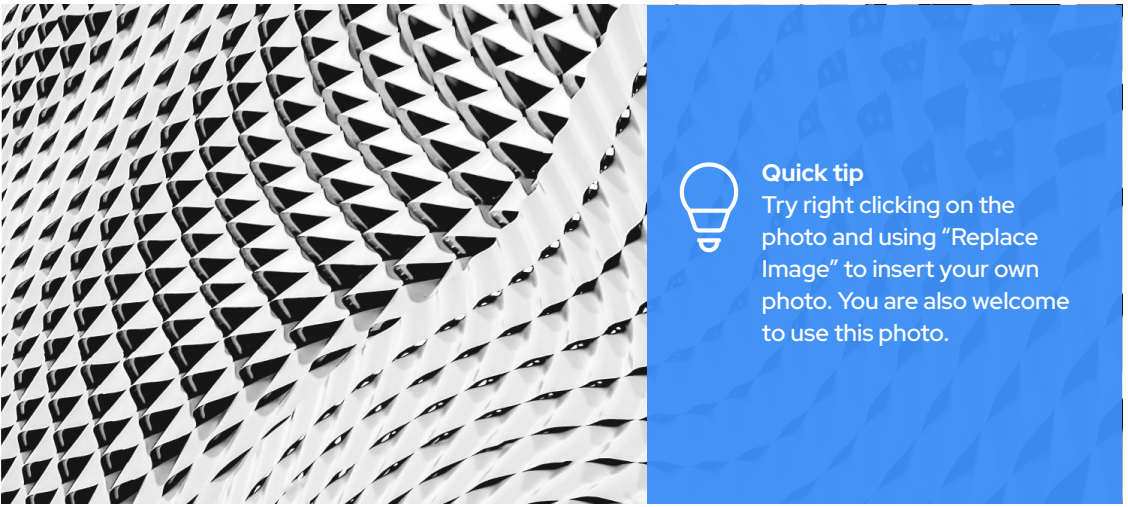
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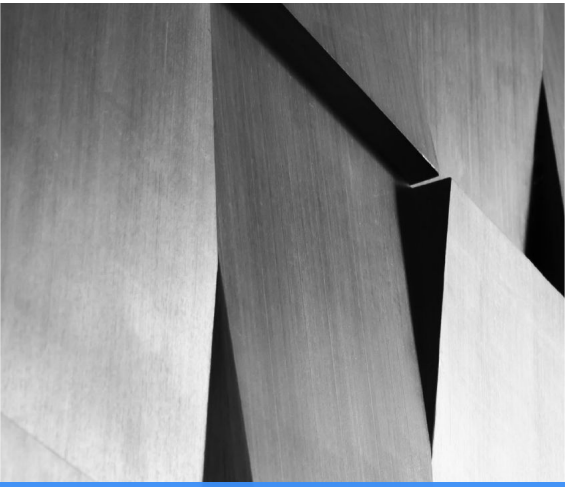
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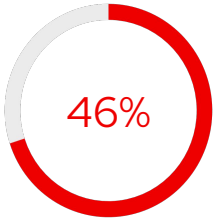


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Ciclo de vida de plataformas Automatizado

Gestión de Infraestructura

- Infraestructura actualizada
- Gobierno de la infraestructura

Automatización

- Patching & Upgrades Automatizados
- Configuración gestionada en repositorios
- Creación de infraestructura consistente
- Creación oportuna de infraestructura

Upgrade Satellite

- Infraestructura actualizada
- Gobierno de la infraestructura
- Patching & Upgrades Automatizados

Done



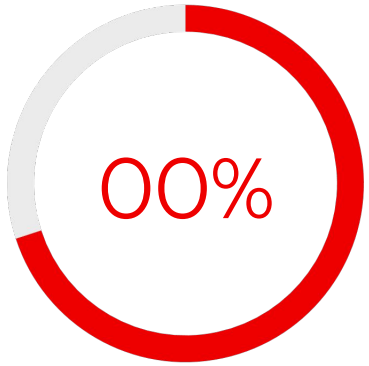
Máquinas virtuales Ansible Tower	Actualización de Satellite	Diseño de solución de Satellite definido	Nueva instalación Satellite Etapa 2	Configuración de ciclo de vida S.O
Mapeo de hipervisores y asociación de suscripción	Nueva instalación Satellite	Uso de Suscripciones y Repositorios		

To Do



Nueva instalación de Ansible Tower	Roles, perfiles, inventarios y organizaciones	Casos de uso y migraciones	Templates y workflows Ansible	Automation Platform
Registrar maquinas en Satellite	Habilitación e instalación de insights	Parchado de servidores	Pruebas DRP Satellite	

Reducción de Impacto en cliente por Outages



Estabilización Operación

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Patching & Upgrades

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Break & Fix Womac

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Done

Máquinas virtuales Ansible Tower	Actualización de Satellite	Diseño de solución de Satellite definido	Nueva instalación Satellite Etapa 2	Configuracion de ciclo de vida S.O
Mapeo de hipervisores y asociación de suscripción	Nueva instalación Satellite	Uso de Suscripciones y Repositorios		

To Do

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Try right clicking on the icon and using "Replace Image" to insert another icon from the Red Hat icon repository.

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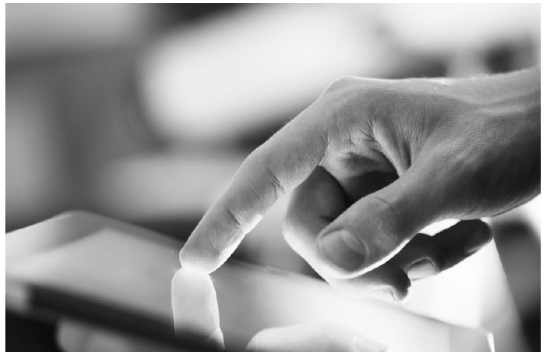
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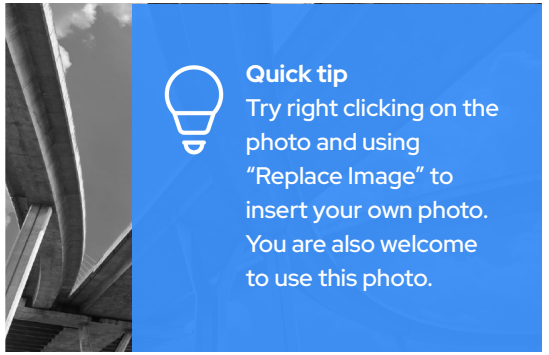
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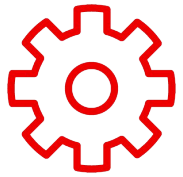
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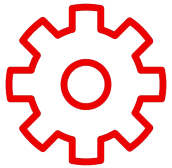


Quick tip
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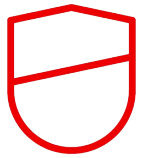
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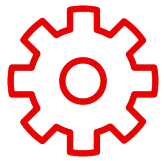


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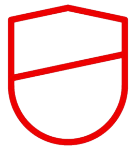
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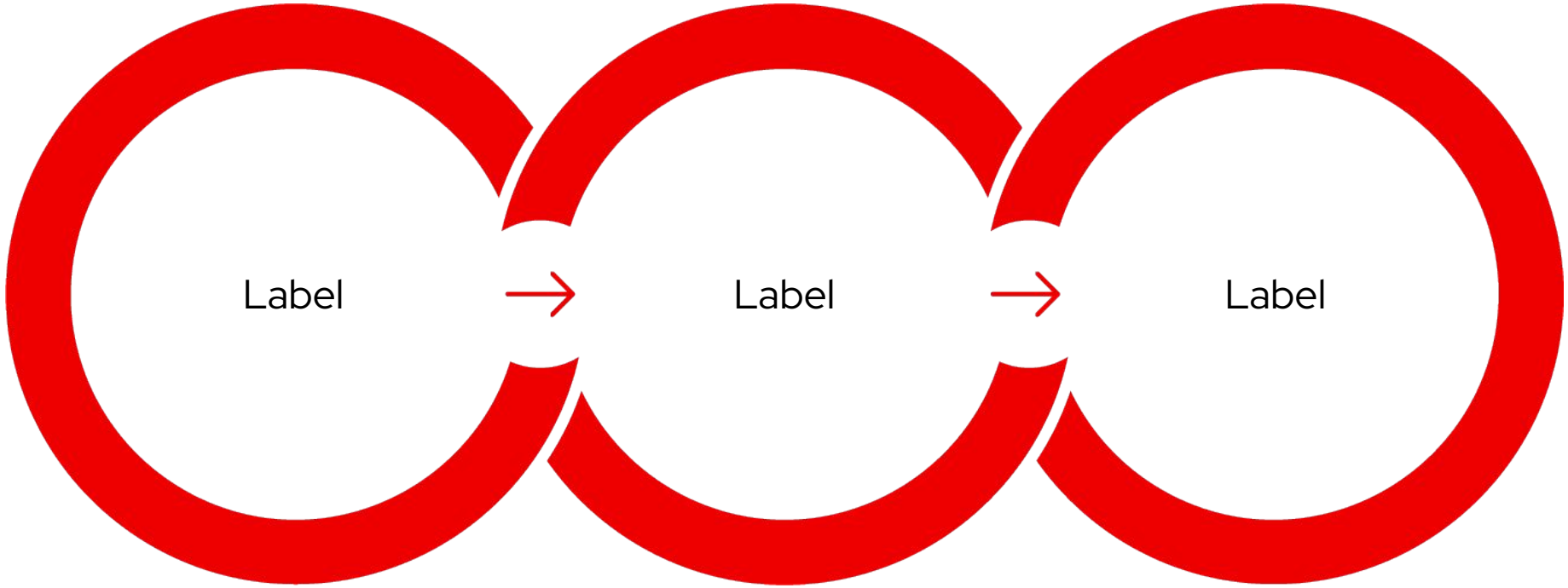


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Quick tip
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John Doe
CTO, Acme Unlimited

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This section includes:

Data slide templates

Table slide templates

Timeline templates

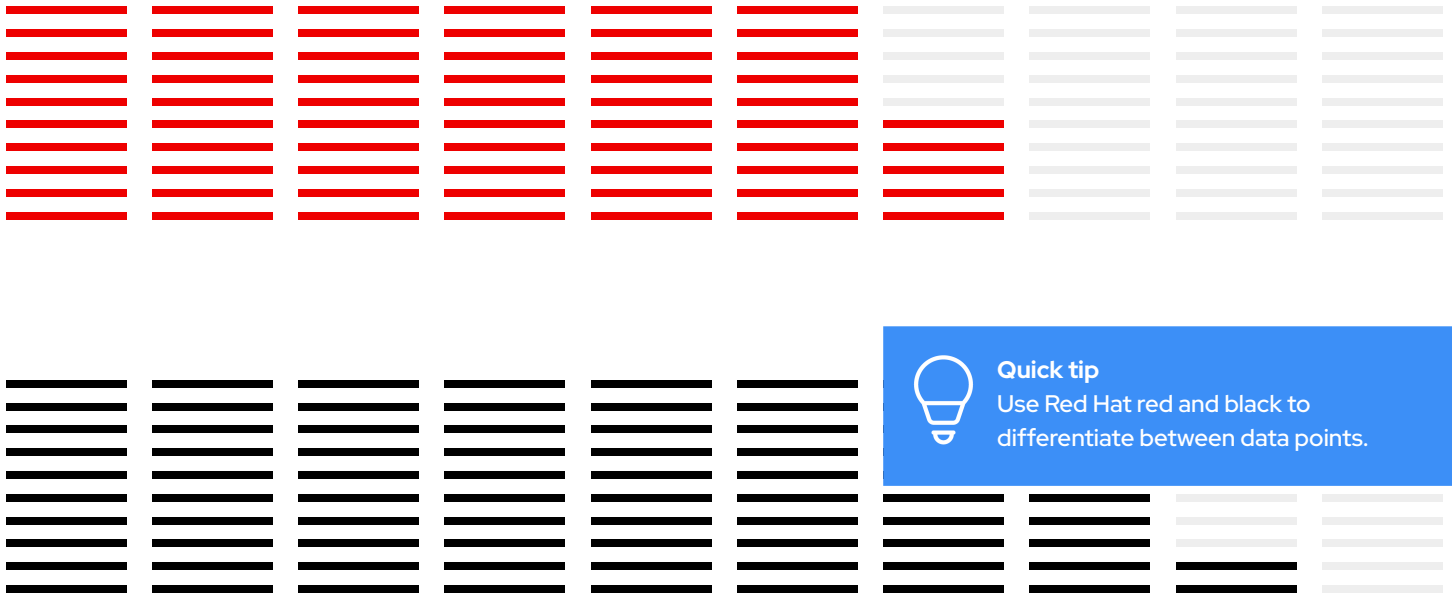


Template slide
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Red Hat

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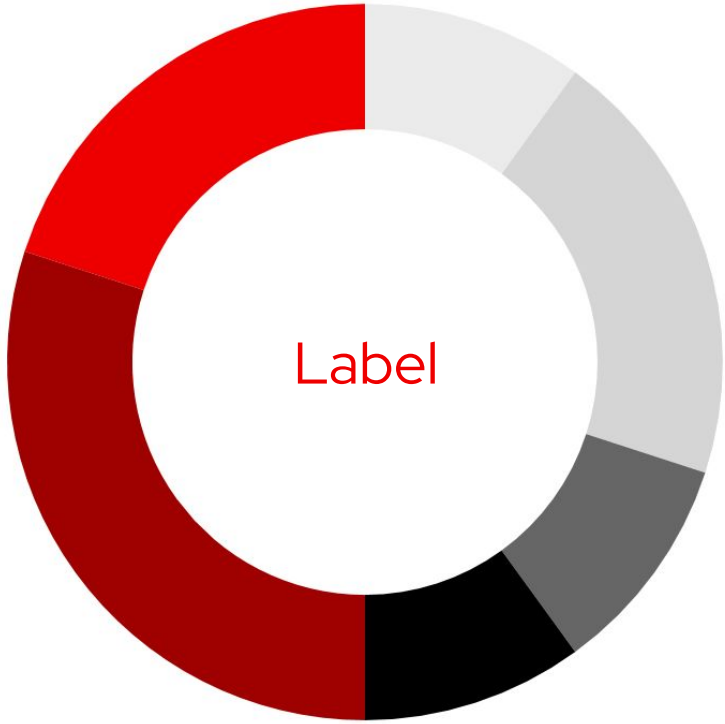
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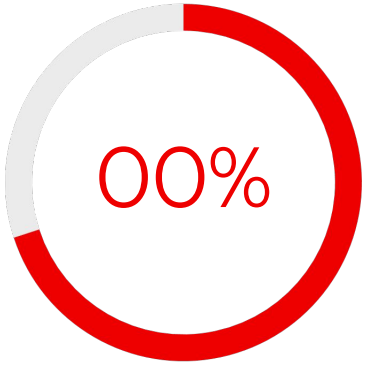
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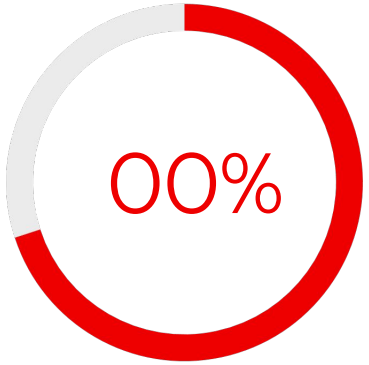
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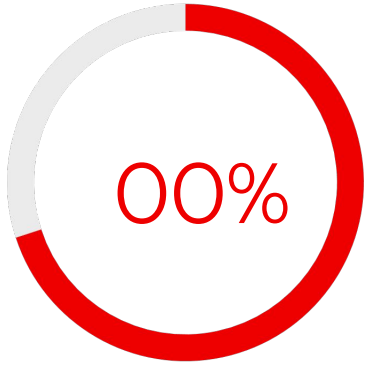
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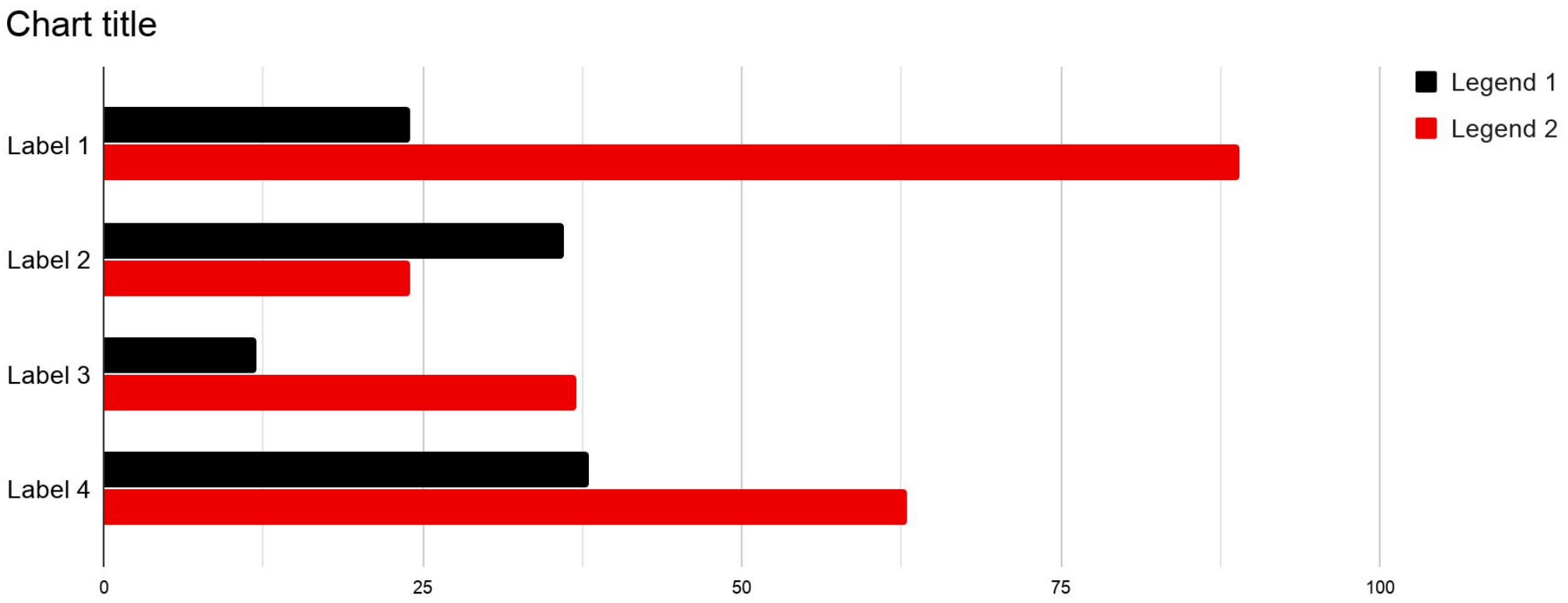
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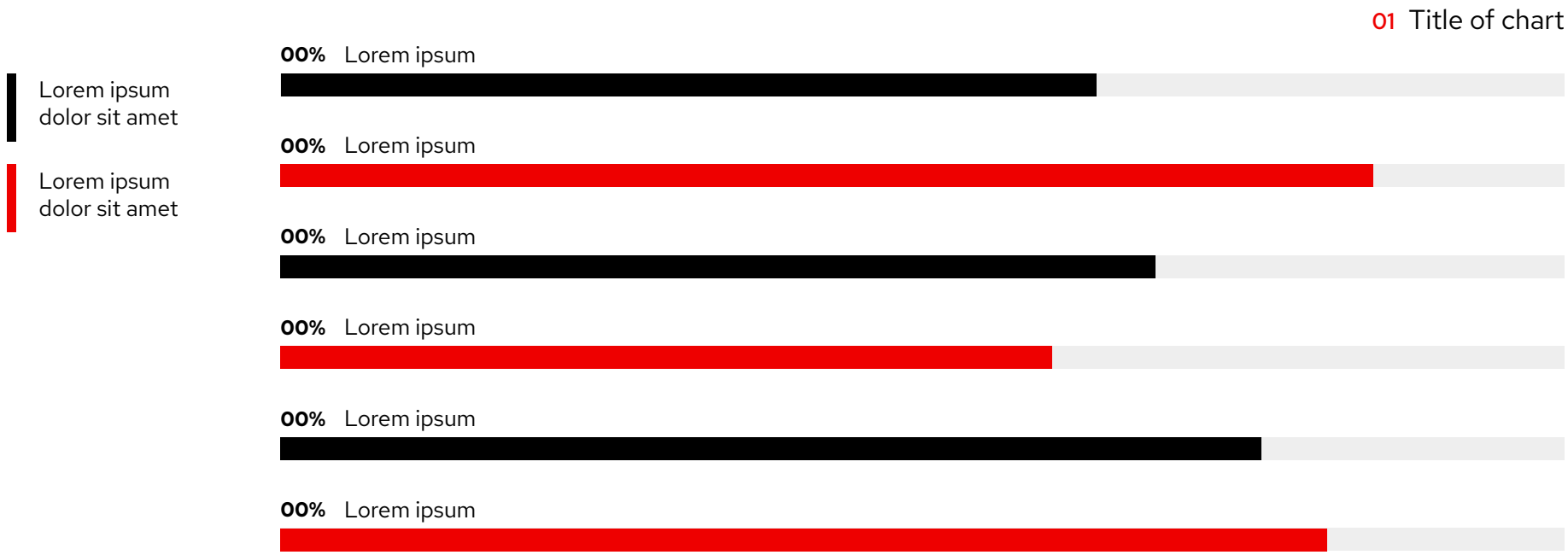
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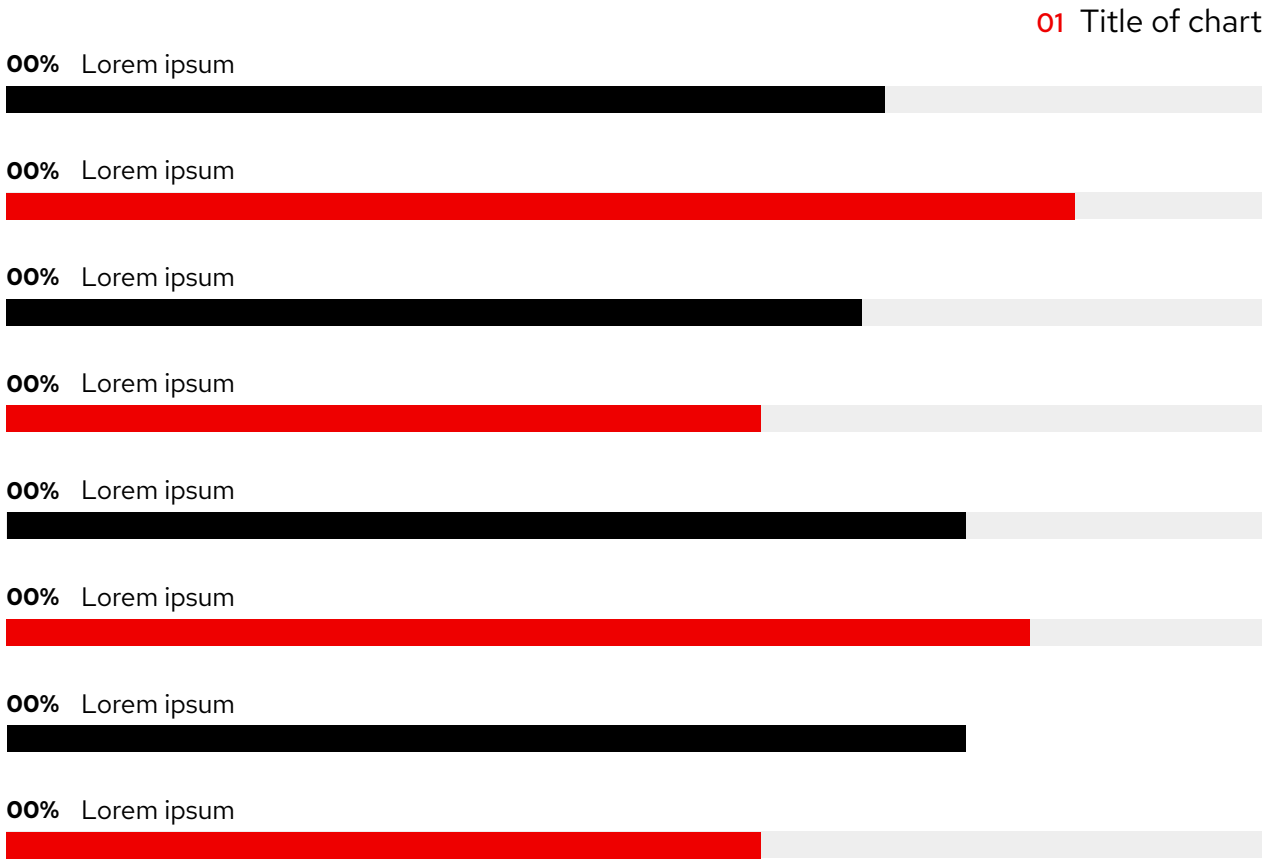
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Quick tip
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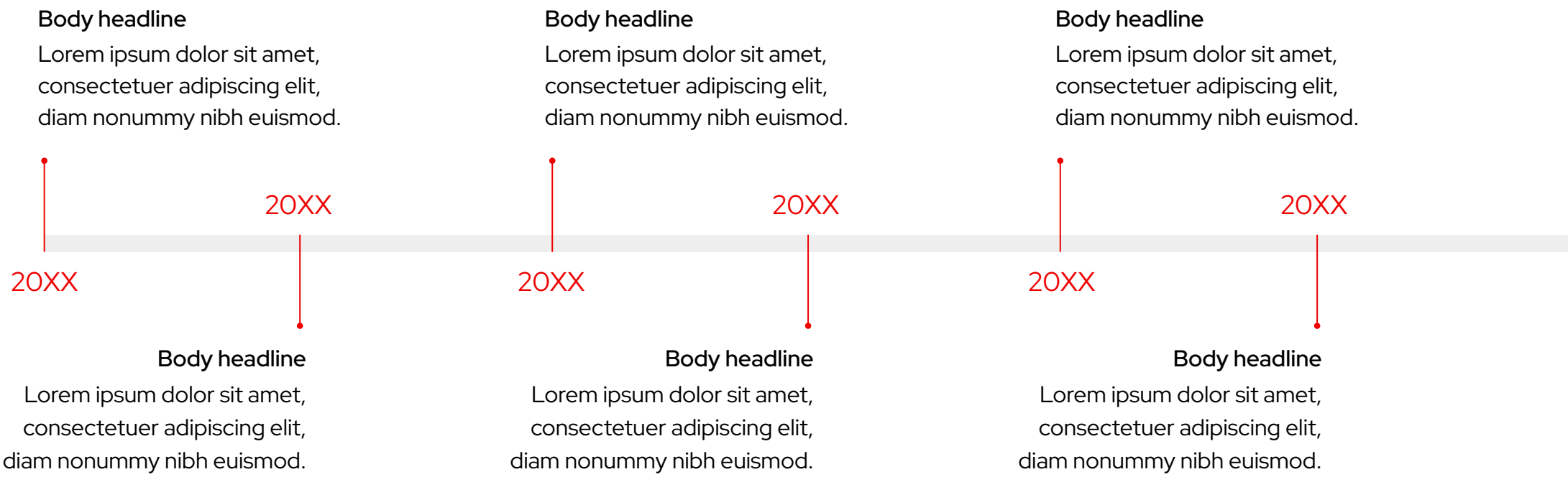
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Red Hat Enterprise Linux

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Presenter’s Name
Title

Presenter’s Name
Title

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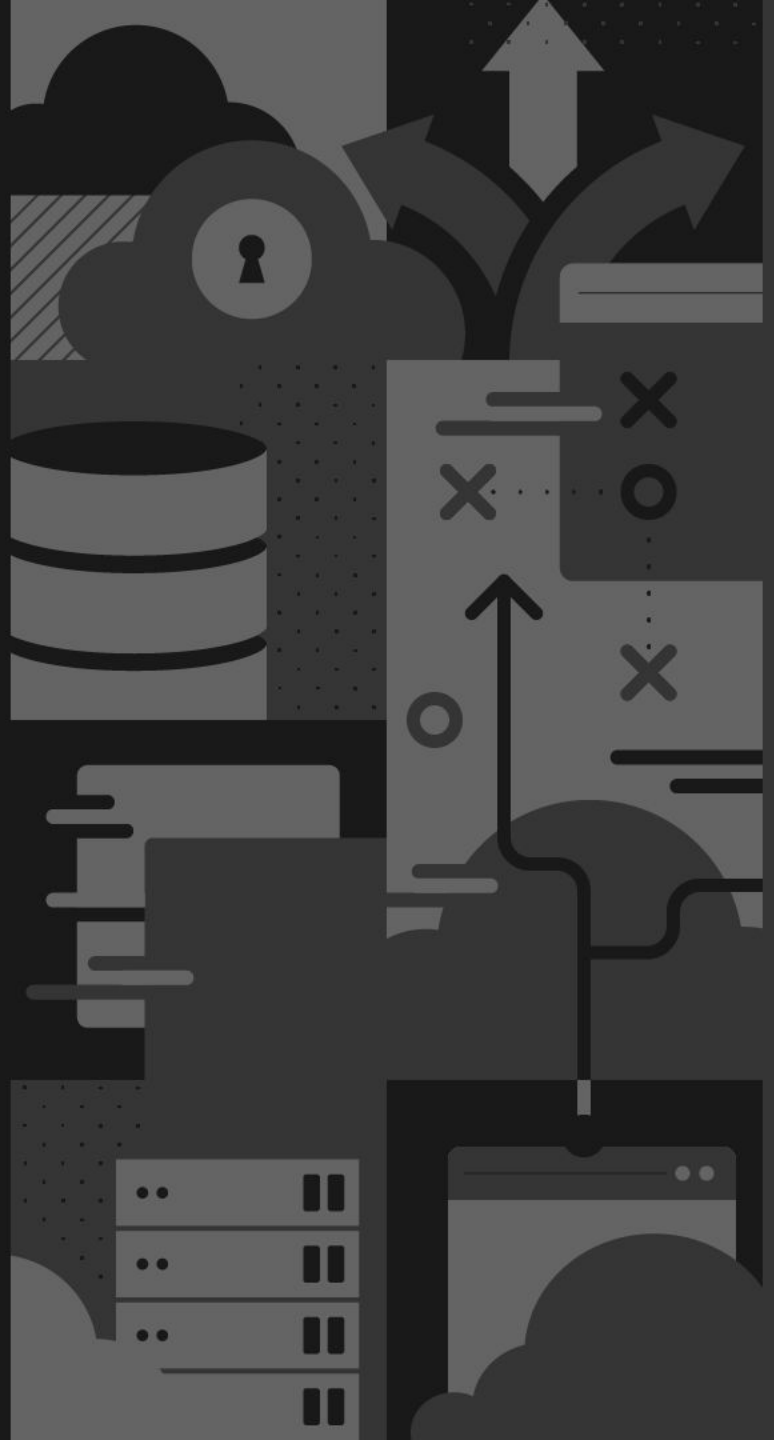

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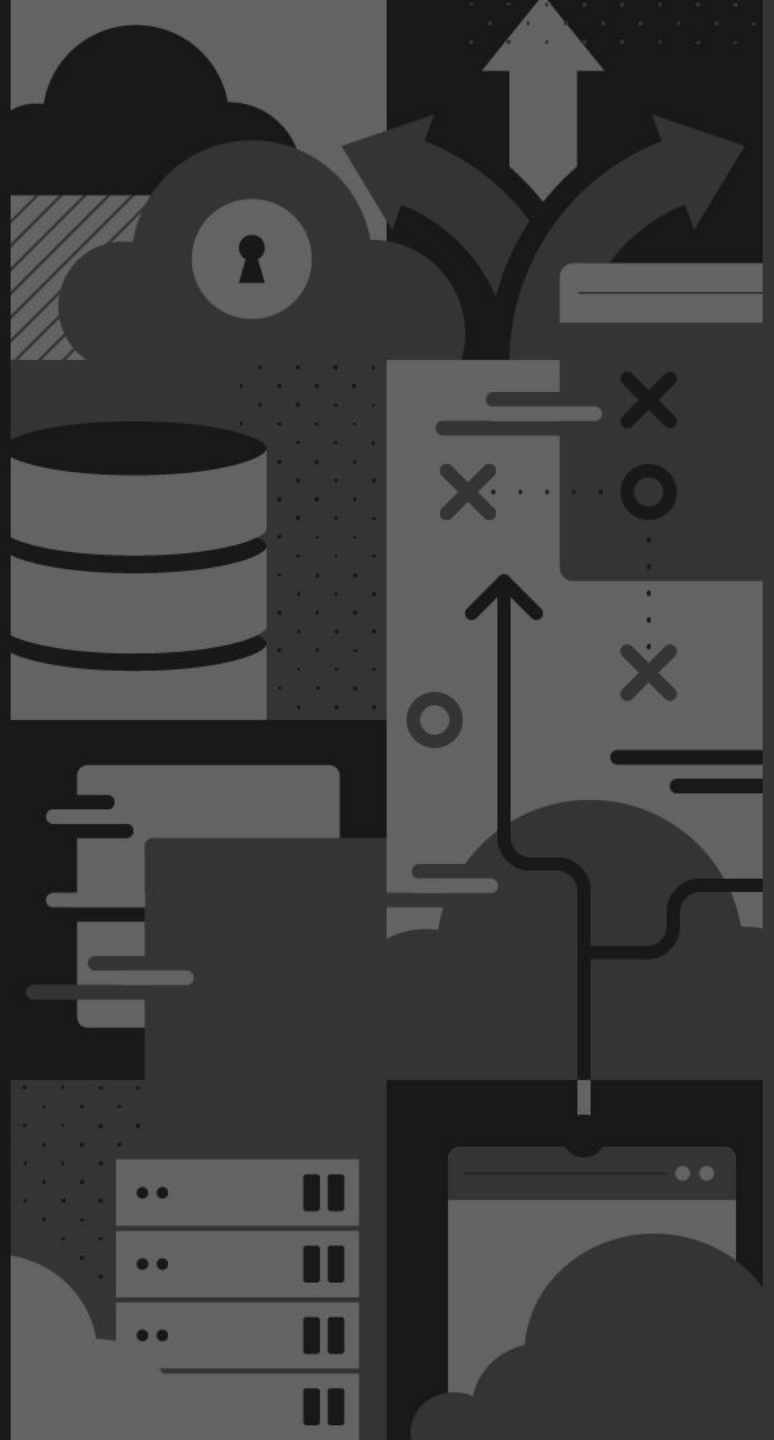
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Presenter's Name
Title



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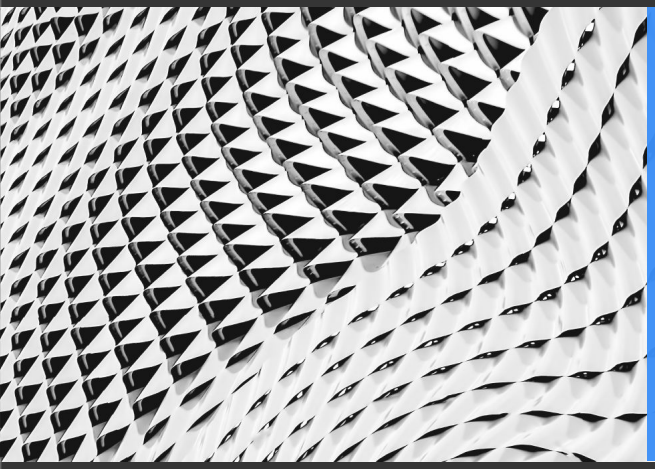
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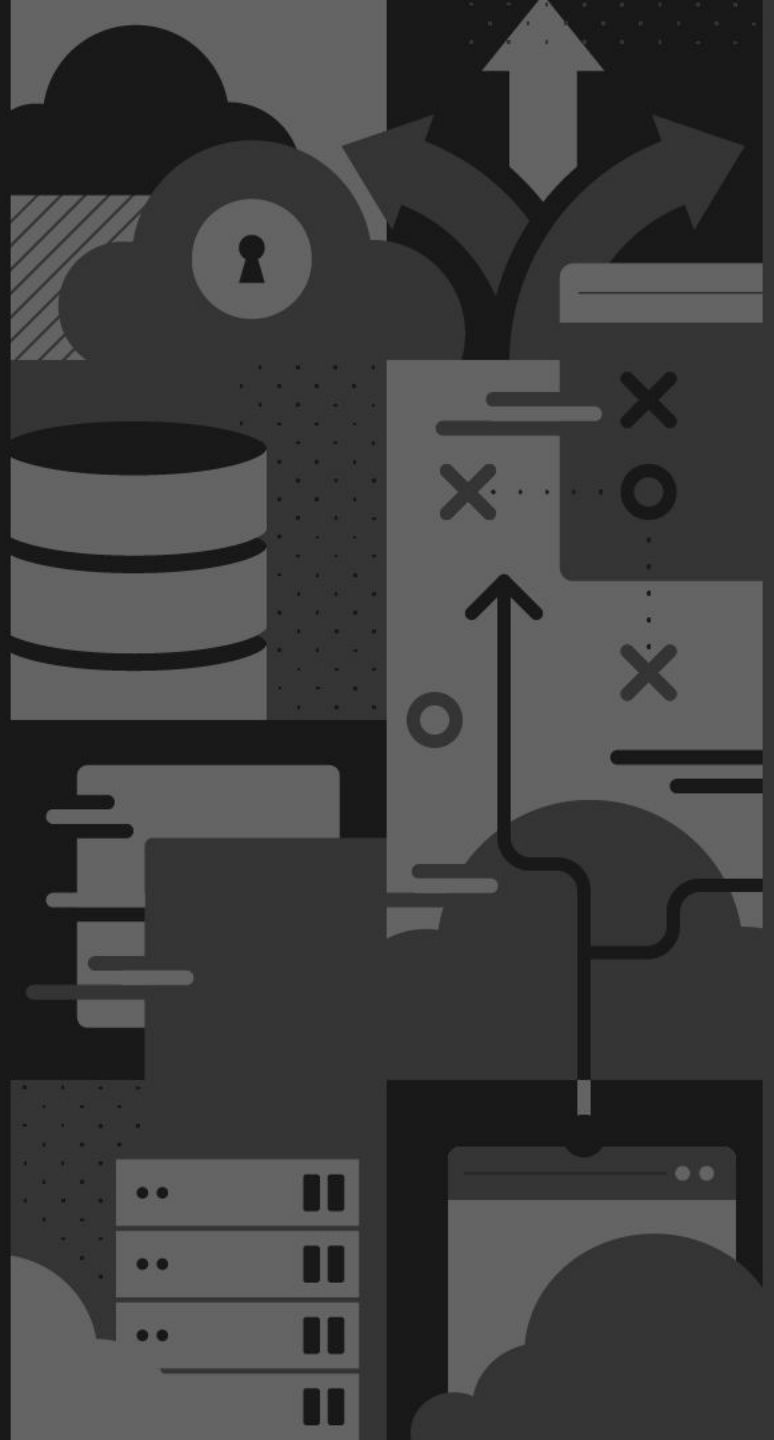


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If no subheading is needed, delete the subheading text, and the content can extend into the lighter shaded area.

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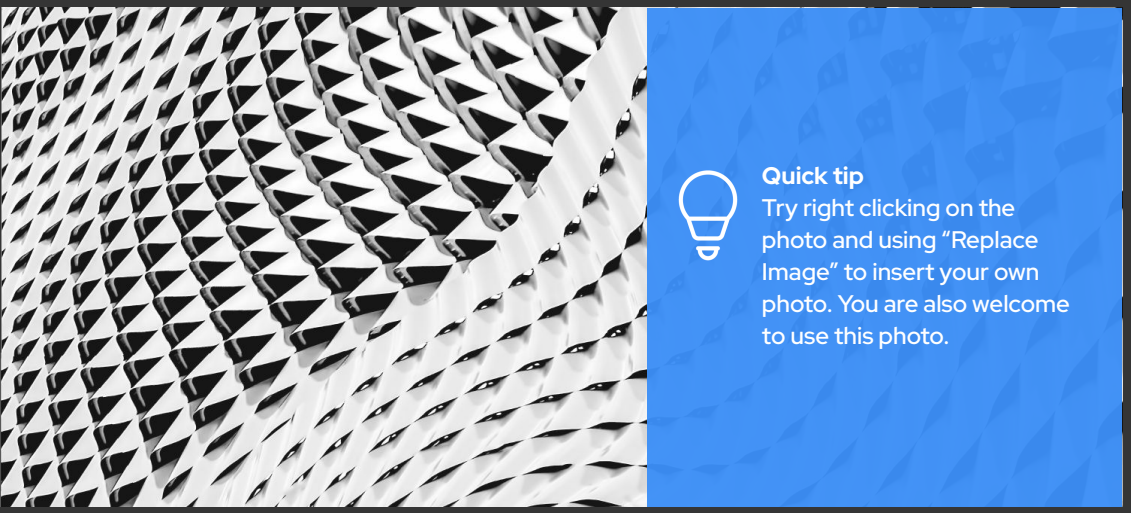
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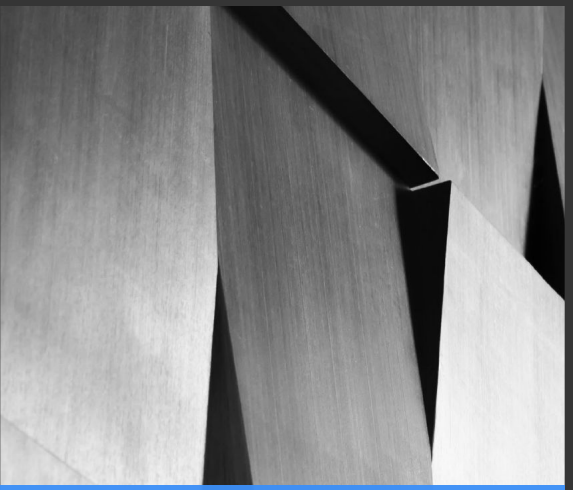


Quick tip
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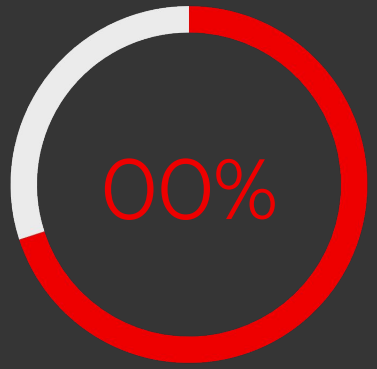
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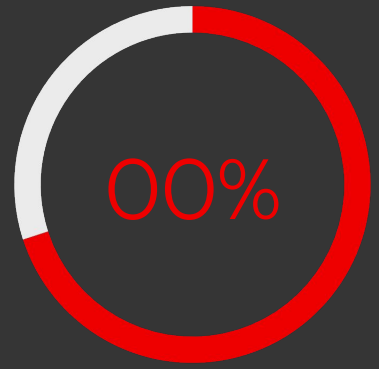
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Quick tip
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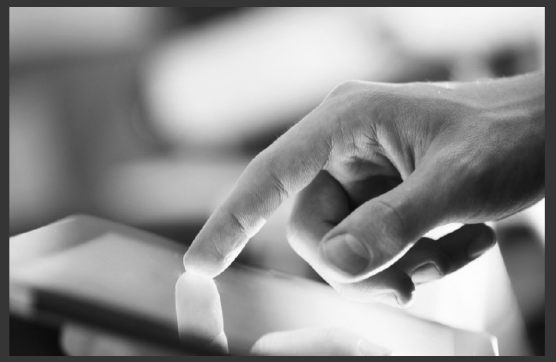
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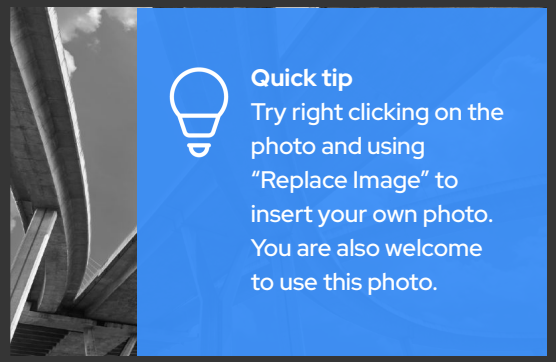
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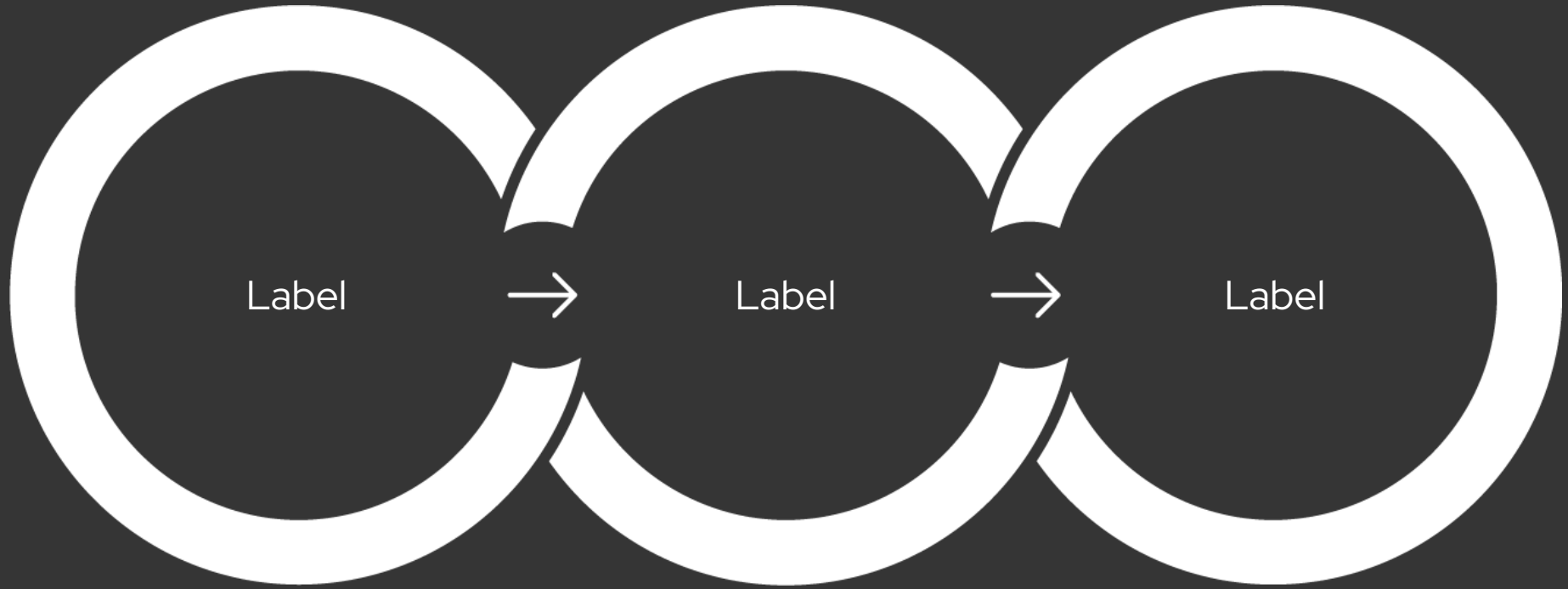
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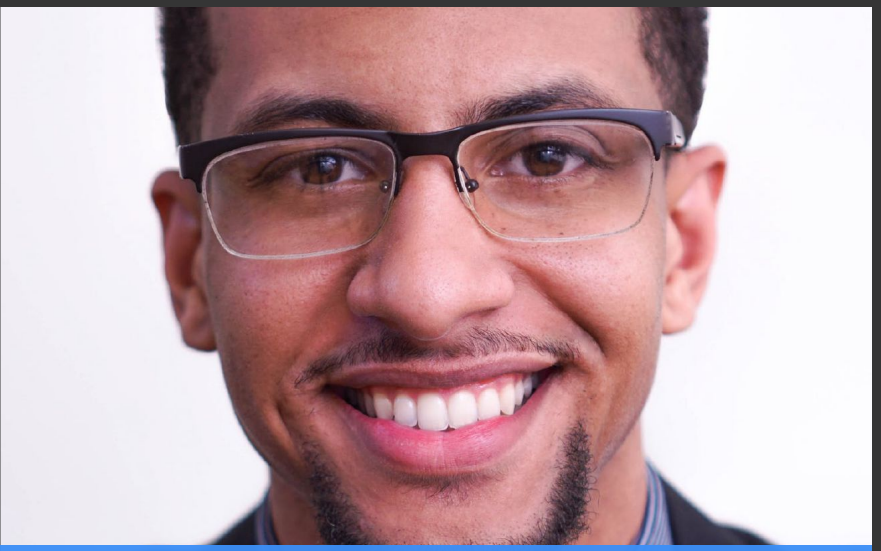
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Quick tip
Using a photo with the large quote is optional. Try right clicking on the photo and using “Replace Image” to insert your own photo.

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John Doe
CTO, Acme Unlimited

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John Doe
CTO, Acme Unlimited



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John Doe
CTO, Acme Unlimited



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John Doe
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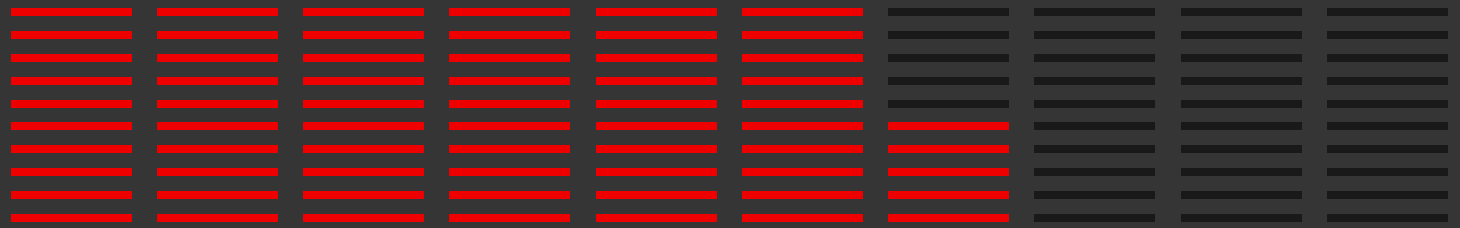
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CTO, Acme Unlimited

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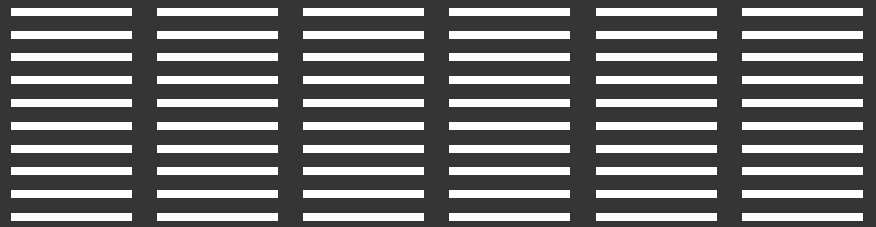
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Quick tip
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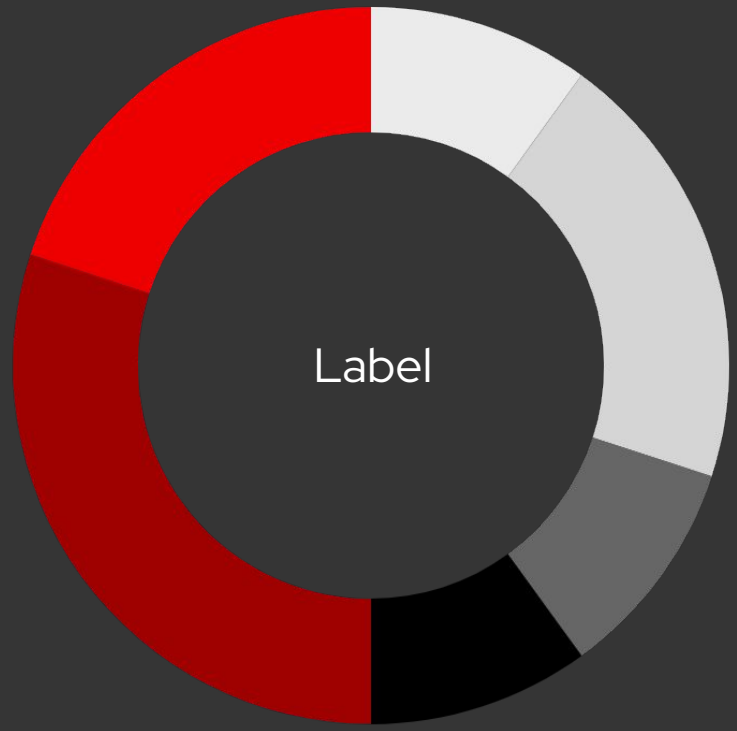
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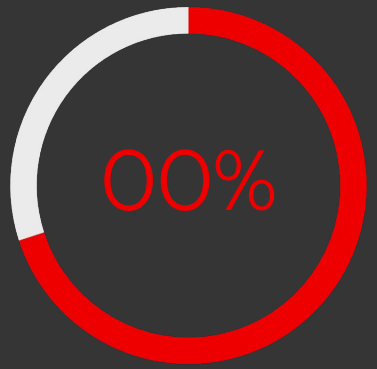
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Quick tip
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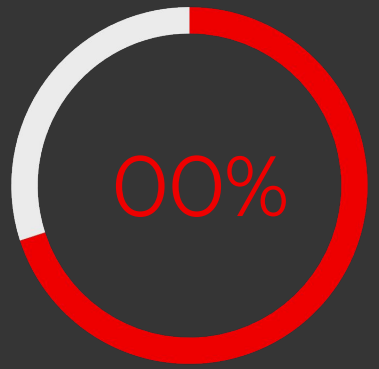
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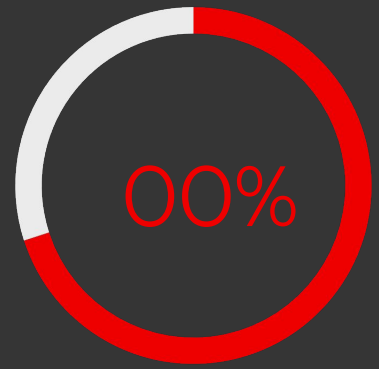
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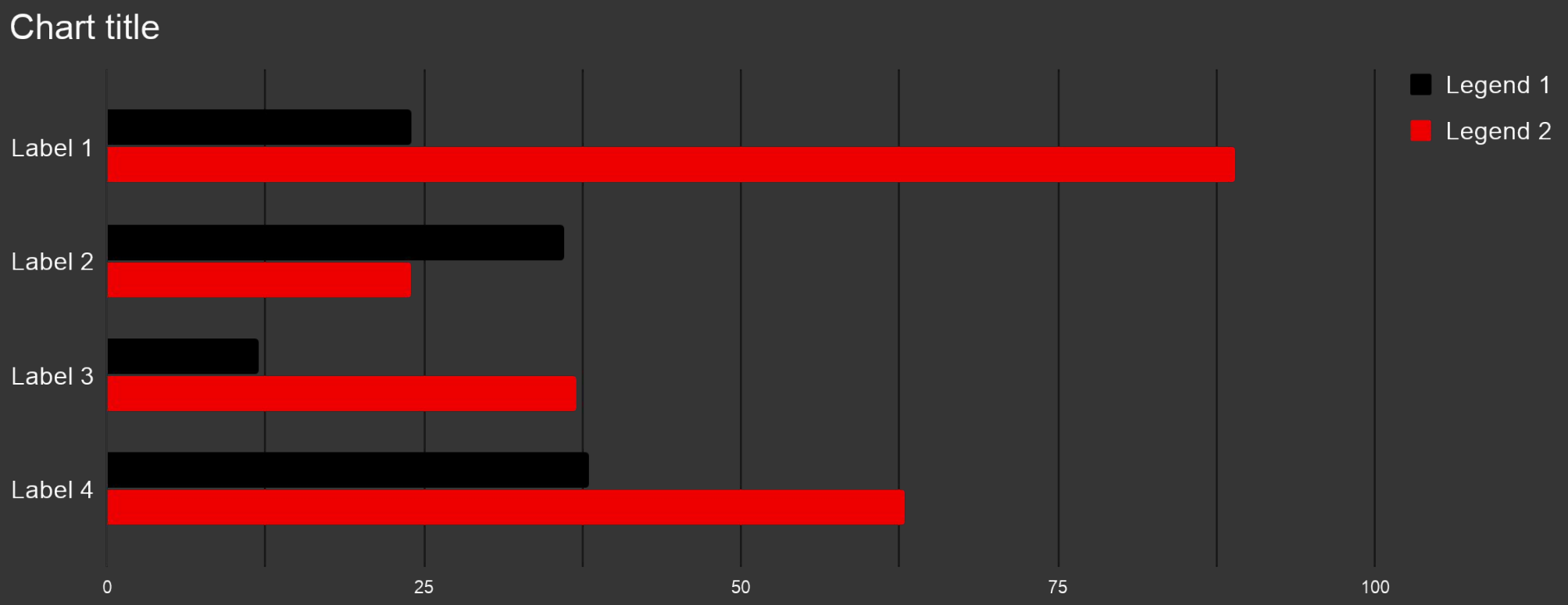
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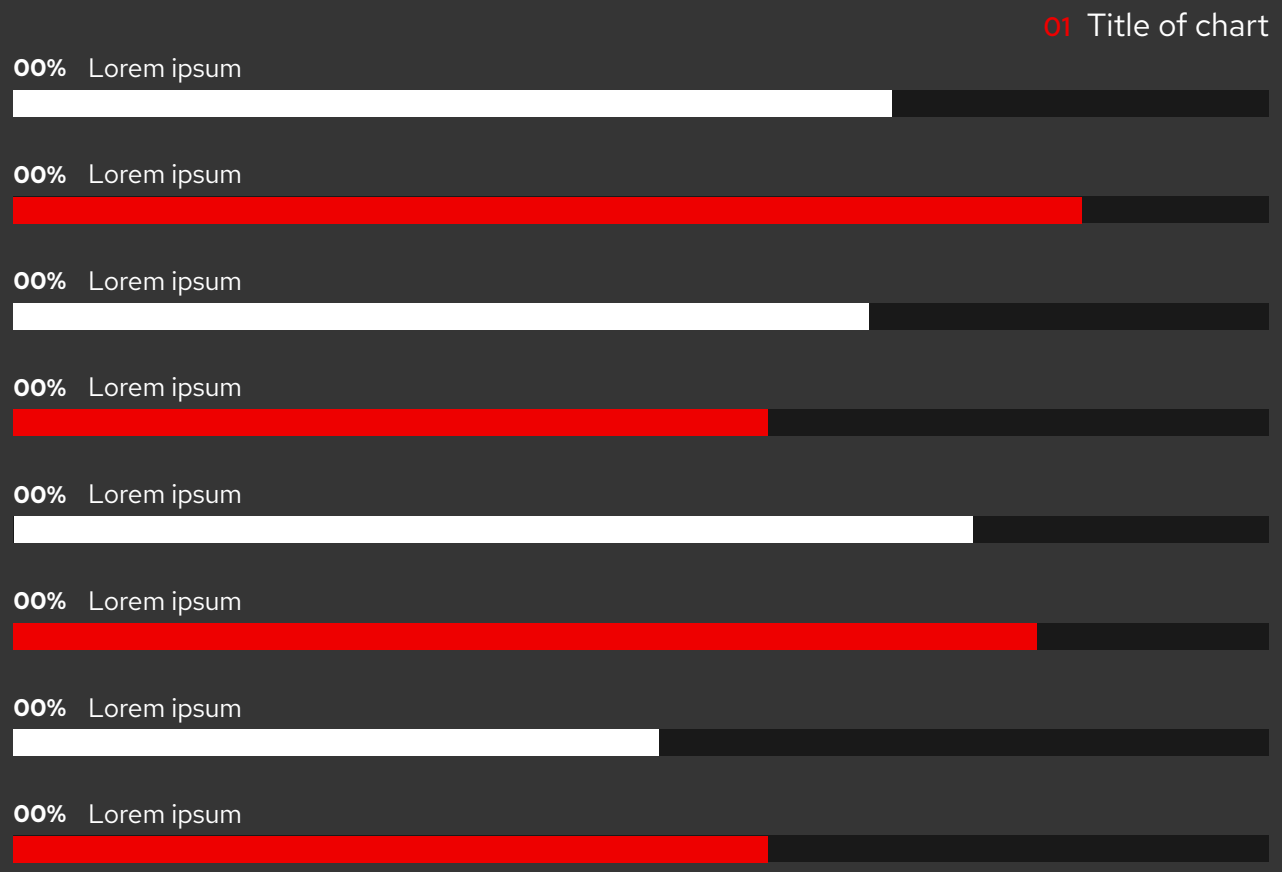


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Quick tip
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01 Title of table

	Column header two lines maximum	Column header two lines maximum	Column header two lines maximum
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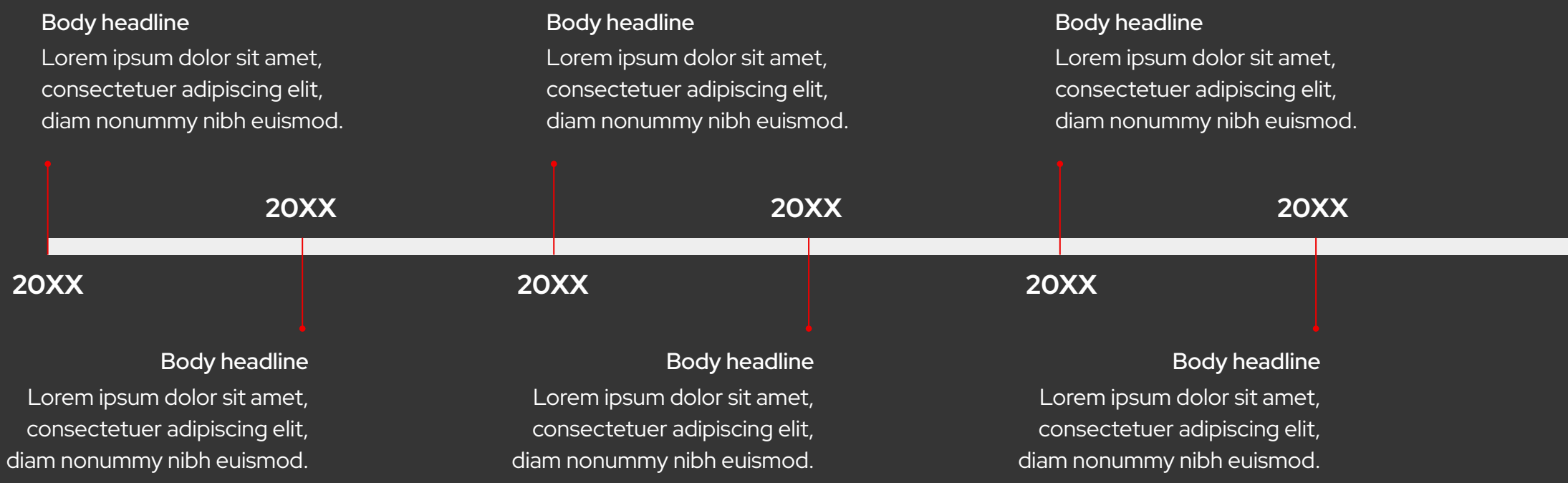
01 Title of table

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Quick tip
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