

Reference Implementation

- K3s



Reference Implementation - K3s

Draft

Publication Date: 2021-06-02

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Preface

The purpose of this document is to provide an overview and procedure of implementing [SUSE](https://www.suse.com) [®](https://www.suse.com) offerings for [K3s](https://rancher.com/products/k3s/), an official CNCF sandbox project that delivers a lightweight yet powerful certified Kubernetes distribution designed for production workloads across resource-restrained, remote locations or on Edge IoT devices.

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1 Introduction

On the digital transformation journey to a full cloud native landscape, utilization of microservices becomes the main approach with the dominant technology for such container orchestration being Kubernetes¹ With its large community of developers and abundant features and capabilities, Kubernetes has become the defacto standard and is included across most container-as-a-service platforms. With all of these technologies in place, both developer and operation teams can effectively deploy, manage and deliver functionality to their end users in a resilient and agile manner.

1.1 Motivation

As developers and organizations continue their journey from simple, containerized microservices towards having these workloads orchestrated and deployed where ever they need, being able to install, monitor and use such Kubernetes infrastructures is a core need. Such deployments, being Cloud Native Computing Foundation (CNCF²) conformant³ and certified⁴ are essential for both development and production workloads.

For simplified scenarios, like edge, remote or IoT, this is where K3s leads the industry, being simple and secure.

1.2 Scope

The scope of this document is to provide a general *reference implementation* of K3s. This can be done in a variety of scenarios to create an edge-oriented, lightweight Kubernetes cluster deployment.

¹ <https://kubernetes.io/> 

² <https://www.cncf.io/> 

³ <https://www.cncf.io/certification/software-conformance> 

⁴ <https://www.cncf.io/certification/cka/> 

1.3 Audience

This document is intended for IT decision makers, architects, system administrators and technicians who are implementing a flexible, software-defined Kubernetes platform. One should still be familiar with the traditional IT infrastructure pillars — networking, computing and storage — along with the local use cases for sizing, scaling and limitations within each pillars' environments.

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2 Business aspect

Agility is the name of the game in modern application development. This is driving developers toward more cloud native methodologies that focus on microservices architectures and streamlined workflows. Container technologies, like Kubernetes, embody this agile approach and help enable cloud native transformation.

By unifying IT operations with Kubernetes, organizations realize key benefits like increased reliability, improved security and greater efficiencies with standardized automation. Therefore, Kubernetes infrastructure platforms are adopted by enterprises to deliver:

Cluster Operations

Improved Production and DevOps efficiencies with simplified cluster usage and robust operations

Security Policy & User Management

Consistent security policy enforcement plus advanced user management on any Kubernetes infrastructure

Access to Shared Tools & Services

A high level of reliability with easy, consistent access to a broad set of tools and services

2.1 Business problem

Kubernetes is the leading solution to address edge computing use cases in industry verticals such as manufacturing, transportation, power generation, healthcare, retail and banking. Typical edge systems that leverage Kubernetes to run complex workloads include energy meters, aircraft engines, gas & oil rigs, cruise ships, high-speed trains, retail scanners, wind turbine base stations, internet-connected cars, ATMs and much more.

For such target edge systems, which are often unattended, resource constrained and remote, orchestrating containerized workloads on Kubernetes deployments may seem overbearingly complex.

2.2 Business value

After two years of research and development in June 2020, K3s was donated to the CNCF. The donation is a testament of the commitment to the open source community and their mission to run Kubernetes everywhere.

Perfect for Edge

K3s is a highly available, certified Kubernetes distribution specifically designed for production workloads in unattended, resource-constrained, remote locations or inside IoT appliances.

Simplified & Secure

K3s is packaged as a tiny, single binary that reduces the dependencies and steps needed to install, run and auto-update a production Kubernetes cluster. For workloads, automated Manifest and Helm Chart management deployments can be utilized. Also, multiple architectures, like x86_64, ARM64, and ARMv7, are supported with binaries and images available.

Given its extensive Kubernetes capabilities, K3s can also be a suitable choice for:

- embedded platforms,
- continuous integration and continuous deployment platforms,
- branch locations or individual developer deployments, and
- even core or cloud production instances



Tip

When K3s is imported and combined with SUSE Rancher, organizations are equipped with an easy, complete and reliable management solution for Kubernetes at the edge.

3 Architectural overview

This section outlines the core elements of the K3s solution, along with the suggested target platforms and components.

3.1 Solution architecture

The figure below illustrates the high-level architecture of K3s:

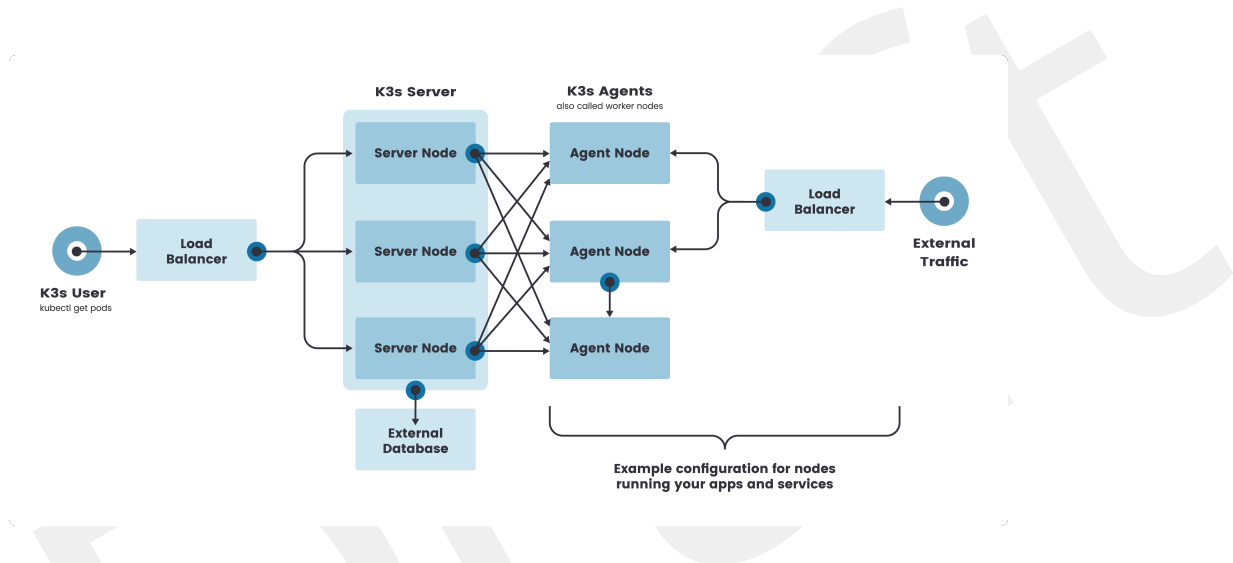


FIGURE 3.1: **FIXME - ARCHITECTURE OVERVIEW - K3S**

Container Runtime

Containerd & runc Kine as a datastore shim that allows etcd to be replaced with other databases

Networking

Flannel for CNI Kube-router for network policy

Services

CoreDNS Metrics Server Traefik for ingress Klipper-lb as an embedded service loadbalancer provider Local-path-provisioner for provisioning volumes using local storage

Workloads

Helm-controller to allow for CRD-driven deployment of helm manifests

Host utilities

iptables/nftables, ebtables, ethtool, & socat

Once setup, users can potentially interact with K3s FixMe - through the web-based user interface (UI), the command-line interface (CLI), and programatically through the application programming interface (API). Depending upon the assigned roles, group membership and privileges, a user could:

- kubectl
 - directly on the K3s host or
 - remotely, leveraging the KUBECONFIG file of the {pn_K3s} cluster's deployment (FixMe)
- manual or automatic, Manifest or Helm Chart based, workload deployments

4 Component model

This section describes the various components being used to create a K3s solution deployment.

4.1 Component overview

By utilizing:

- Software
 - Kubernetes Platform - K3s
 - Linux Operating System - SUSE Linux Enterprise Micro
- Compute Platform

one can create the necessary infrastructure and services. Further details for these components are described in the following sections.

4.2 Software - K3s

K3s is packaged as a single binary, which is about 50 megabytes in size. Bundled in that single binary is everything needed to run Kubernetes anywhere, including low-powered IoT and Edge-based devices. The binary includes:

- the container runtime
- any important host utilities like
 - iptables, socat and du.

The only OS dependencies are the Linux kernel itself and a proper dev, proc and sysfs mounts (this is done automatically on all modern Linux distributions). K3s bundles the Kubernetes components:

- kube-apiserver,
- kube-controller-manager,
- kube-scheduler,

- kubelet and
- kube-proxy

into combined processes that are presented as a simple server and agent model, as represented in the following figure:

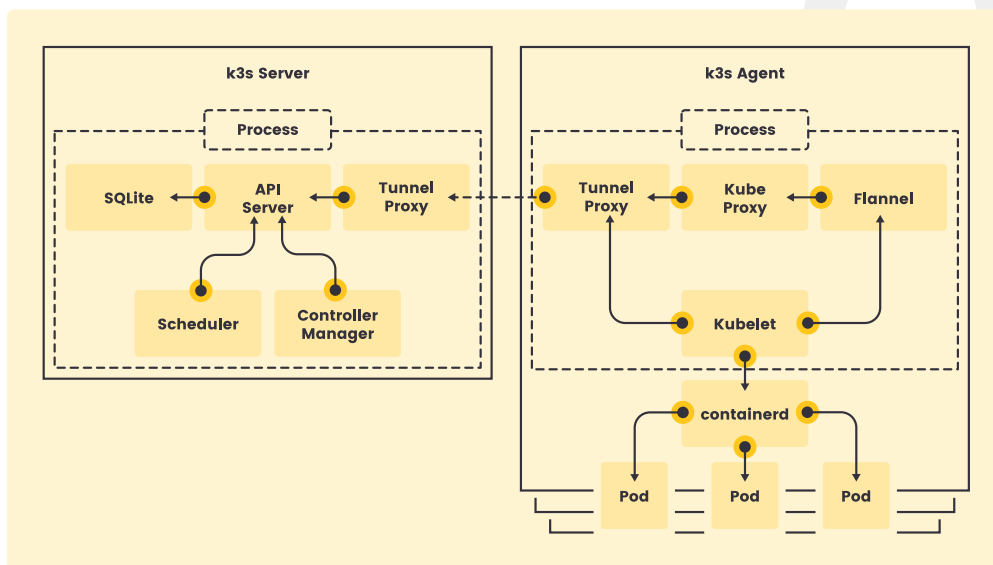


FIGURE 4.1: OVERVIEW OF K3S

K3s can run as a complete cluster on a single node or can be expanded into a multi-node cluster. Besides the core Kubernetes components, these are also included:

- containerd,
- Flannel,
- CoreDNS,

- ingress controller and
- a simple host port-based service load balancer.

All of these components are optional and can be swapped out for your implementation of choice. With these included components, you get a fully functional and CNCF-conformant cluster so you can start running apps right away. K3s is now a CNCF Sandbox project, being the first Kubernetes distribution ever to be adopted into sandbox.

Learn more information about K3s at <https://k3s.io> 

As K3s can be deployed on a single or multiple nodes, the next sections describe the suggested component layering approach.

4.3 Software - SUSE Linux Enterprise Micro

SUSE Linux Enterprise Micro combines the assurance of enterprise-grade security and compliance with the immutability and portability of a modern, lightweight operating system. The top 4 features are:

Immutable OS

Immutable design ensures the OS is not altered during runtime and runs reliably every single time. Security signed and verified transactional updates are easy to rollback if things go wrong.

Security and Compliance

Fully open source and built using open standards, SUSE Linux Enterprise Micro leverages SUSE Linux Enterprise common code base, to provide FIPS 140-2, DISA SRG/STIG, integration with CIS and Common Criteria certified configurations. Includes fully supported security framework (SELinux) with policies.

Architectural Flexibility

Both Arm and x86-64 architectures are supported so you can deploy edge applications with confidence across multiple architectures.

Kubernetes-Ready

You can easily combine SUSE Linux Enterprise Micro with the latest cloud-native technologies including SUSE Rancher, Rancher Kubernetes Engine, Longhorn persistent block storage, and K3s, the world's most popular Kubernetes distribution for use in low resource, distributed edge locations.

As a result, you get an ultra-reliable infrastructure platform that is also simple to use and comes out-of-the-box with best-in-class compliance. Furthermore, SUSE's flexible subscription model ensures enterprise assurance for any edge, embedded or IoT deployment without vendor lock-in. A free, evaluation copy can be [downloaded \(https://www.suse.com/download/sle-micro/\)](https://www.suse.com/download/sle-micro/)  or if the organization already has subscriptions, both install media and updates can be obtained from [SUSE Customer Center \(https://scc.suse.com/login\)](https://scc.suse.com/login) .


4.4 Compute Platform

Leveraging the enterprise grade functionality of the operating system mentioned in the previous section, many compute platforms can be the foundation of the deployment:

- Virtual machines on supported hypervisors or hosted on cloud service providers
- Physical, baremetal or single-board computers, either on-premise or hosted by cloud service providers



Tip

Any [SUSE YES \(https://www.suse.com/yesssearch/\)](https://www.suse.com/yesssearch/)  certified platform can be used for the nodes of this deployment, as long as the certification refers to the major version of the underlying SUSE operating system required by its release.

5 Deployment

This section describes the process steps for the deployment of the K3s solution. It describes the process steps to deploy each of the component layers starting as a base functional *proof-of-concept*, having considerations on migration towards *production*, providing *scaling* guidance that is needed to create the solution.

5.1 Deployment overview

The deployment stack is represented in the following figure:

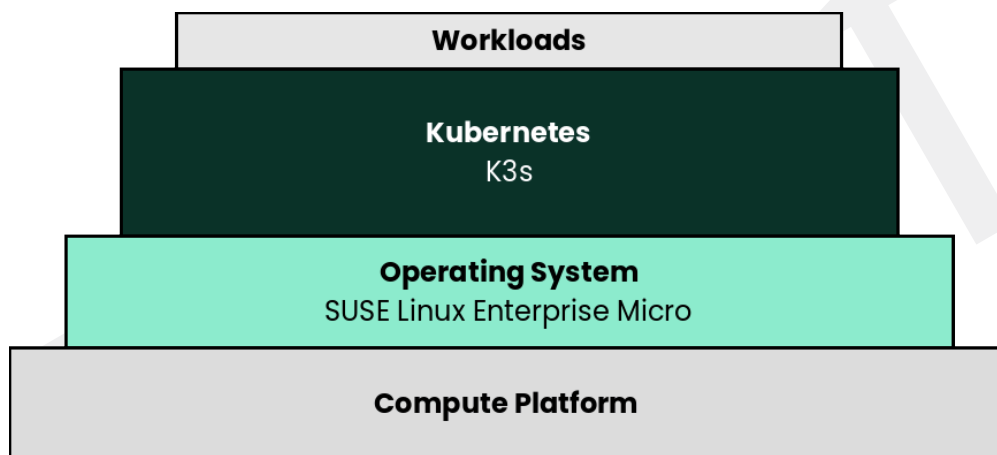


FIGURE 5.1: K3S DEPLOYMENT STACK

and details are covered for each layer in the following sections.



Note

The following section's content is ordered and described from the bottom layer up to the top.

5.2 Compute Platform

Preparation(s)

For each node used in the deployment:

- Validate the necessary CPU, memory, disk capacity, and network interconnect quantity and type are present for each node and its intended role. Refer to the recommended CPU/Memory/Disk/Networking requirements as noted in the [SUSE Rancher Hardware Requirements \(https://rancher.com/docs/rancher/v2.x/en/installation/requirements/#hardware-requirements\)](https://rancher.com/docs/rancher/v2.x/en/installation/requirements/#hardware-requirements).
- Further suggestions
 - Disk : Use a pair of local, direct attached, mirrored disk drives is present on each node (SSDs are preferred); these will become the target for the operating system installation.
 - Network : Prepare an IP addressing scheme and optionally create both a public and private network, along with the respective subnets and desired VLAN designations for the target environment.
 - Baseboard Management Controller : If present, consider using a distinct management network for controlled access.
 - Boot Settings : BIOS/uEFI reset to defaults for a known baseline, consistent state or perhaps with desired, localized values.
 - Firmware : Use consistent and up-to-date versions for BIOS/uEFI/device firmware to reduce potential troubleshooting issues later

5.3 SUSE Linux Enterprise Micro

Utilize an enterprise-grade Linux operating system , like SUSE Linux Enterprise Micro, as the base software layer.

Preparation(s)

To meet the solution stack prerequisites and requirements, SUSE operating system offerings, like [SUSE Linux Enterprise Micro \(https://www.suse.com/products/micro/\)](https://www.suse.com/products/micro/) can be utilized.

1. Ensure these services are in place and configured for this node to use:

- Domain Name Service (DNS) - an external network-accessible service to map IP Addresses to hostnames
- Network Time Protocol (NTP) - an external network-accessible service to obtain and synchronize system times to aid in timestamp consistency
- Software Update Service - access to a network-based repository for software update packages. This can be accessed directly from each node via registration to
 - the general, internet-based [SUSE Customer Center](https://scc.suse.com/login) (<https://scc.suse.com/login>) (SCC) or
 - an organization's [SUSE Manager](https://www.suse.com/products/suse-manager/) (<https://www.suse.com/products/suse-manager/>) infrastructure or
 - a local server running an instance of [Repository Mirroring Tool](https://documentation.suse.com/sles/15-SP2/single-html/SLES-rmt/#book-rmt) (<https://documentation.suse.com/sles/15-SP2/single-html/SLES-rmt/#book-rmt>) (RMT)



Note

During the node's installation, it can be pointed to the respective update service. This can also be accomplished post-installation with the command-line tool named [SUSEConnect](https://www.suse.com/support/kb/doc/?id=000018564) (<https://www.suse.com/support/kb/doc/?id=000018564>).

Deployment Process

On the compute platform node, install the noted SUSE operating system, by following these steps:

1. Download the [SUSE Linux Enterprise Micro](https://www.suse.com/download/sle-micro/) (<https://www.suse.com/download/sle-micro/>) product (either for the ISO or Virtual Machine image)
2. The installation process is described and can be performed with default values by following steps from the SUSE Linux Enterprise Micro product documentation, see [Installation Quick Start](https://documentation.suse.com/sle-micro/5.0/single-html/SLE-Micro-installation/#article-installation) (<https://documentation.suse.com/sle-micro/5.0/single-html/SLE-Micro-installation/#article-installation>)



Tip

Adjust both the password and the local network addressing setup to comply with local environment guidelines and requirements.

Deployment Consideration(s)

To further optimize deployment factors, leverage the following practices:

- *Automation*
 - To reduce user intervention, unattended deployments of SUSE Linux Enterprise Micro can be automated
 - for ISO-based installations, by referring to the [AutoYaST Guide](https://documentation.suse.com/sle-micro/5.0/single-html/SLE-Micro-autoyast/#book-autoyast) (<https://documentation.suse.com/sle-micro/5.0/single-html/SLE-Micro-autoyast/#book-autoyast>) ↗
 - for raw-image based installation, by configuring the Ignition and Combustion tooling as described in the [Installation Quick Start](https://documentation.suse.com/sle-micro/5.0/single-html/SLE-Micro-installation/#article-installation) (<https://documentation.suse.com/sle-micro/5.0/single-html/SLE-Micro-installation/#article-installation>) ↗

5.4 K3s

Utilize an enterprise-grade Linux operating system , like SUSE Linux Enterprise Micro, as the base software layer.

Preparation(s)

To meet the solution stack prerequisites and requirements, SUSE operating system offerings, like [SUSE Linux Enterprise Micro](https://www.suse.com/products/micro/) (<https://www.suse.com/products/micro/>) ↗ can be utilized.

1. Ensure these services are in place and configured for this node to use:

- Domain Name Service (DNS) - an external network-accessible service to map IP Addresses to hostnames
- Network Time Protocol (NTP) - an external network-accessible service to obtain and synchronize system times to aid in timestamp consistency
- Software Update Service - access to a network-based repository for software update packages. This can be accessed directly from each node via registration to
 - the general, internet-based [SUSE Customer Center \(https://scc.suse.com/login\)](https://scc.suse.com/login) (SCC) or
 - an organization's [SUSE Manager \(https://www.suse.com/products/suse-manager/\)](https://www.suse.com/products/suse-manager/) infrastructure or
 - a local server running an instance of [Repository Mirroring Tool \(https://documentation.suse.com/sles/15-SP2/single-html/SLES-rmt/#book-rmt\)](https://documentation.suse.com/sles/15-SP2/single-html/SLES-rmt/#book-rmt) (RMT)



Note

During the node's installation, it can be pointed to the respective update service. This can also be accomplished post-installation with the command-line tool named [SUSEConnect \(https://www.suse.com/support/kb/doc/?id=000018564\)](https://www.suse.com/support/kb/doc/?id=000018564).

2. Identify the appropriate, desired version of the K3s binary (e.g. vX.YY.ZZ + k3s1), by reviewing the "Releases" on the [Download \(https://github.com/k3s-io/k3s/\)](https://github.com/k3s-io/k3s/) web page.

Deployment Process

The primary steps for deploying this K3s Kubernetes instance layer are:

1. Set the following variable with the noted version of K3s, as found during the preparation steps.

```
K3s_VERSION=""
```

2. Install the version of K3s with embedded Etcd enabled:

```
curl -sfL https://get.k3s.io | INSTALL_K3S_VERSION=${K3s_VERSION}  
INSTALL_K3S_EXEC='server --cluster-init --write-kubeconfig-mode=644' sh -s -
```



Tip

To address *Availability* and possible *scaling* to a multiple node cluster, Etcd is enabled instead of using the default SQLite datastore.

- Monitor the progress of the installation: `watch -c "kubectl get deployments -A"`
 - The deployment is complete when elements of all the deployments (coredns, local-path-provisioner, metrics-server, and traefik) show at least "1" as "AVAILABLE"
 - Then use Ctrl+c to exit the watch loop after all deployment pods are running

Deployment Consideration(s)

To further optimize deployment factors, leverage the following practices:

- *Availability*
 - While a single K3s node works perfectly fine, a full high-availability K3s cluster is recommended for production workloads. The Etcd key/value store (aka database) requires an odd number of nodes be allocated to the K3s plane (aka master nodes). In this case, two additional control-plane nodes should be added; for a total of three.
 1. Deploy the same operating system on the new compute platform nodes, then log into the new nodes as root or as a user with sudo privileges.
 2. Execute the following sets of commands on each of the remaining control-plane nodes:

```
FIRST_SERVER_IP="" # Private IP preferred, if available
```

```
NODE_TOKEN=""          # From the /var/lib/rancher/k3s/server/node-  
token file on the first server  
K3s_VERSION=""         # Match the first of the first server
```

```
curl -sfL https://get.k3s.io | INSTALL_K3S_VERSION=${K3s_VERSION}  
K3S_URL=https://${FIRST_SERVER_IP}:6443 K3S_TOKEN=${NODE_TOKEN}  
K3S_KUBECONFIG_MODE="644" INSTALL_K3S_EXEC='server' sh -
```





Note

This can be changed to the normal Kubernetes default by adding a taint to each server node. See the official Kubernetes documentation for more information on how to do that.

3. (Optional) In cases where agent nodes are desired, execute the following sets of commands on each of the agent nodes to add it to the K3s cluster:

```
FIRST_SERVER_IP=""     # Private IP preferred, if available  
NODE_TOKEN=""          # From the /var/lib/rancher/k3s/server/node-  
token file on the first server  
K3s_VERSION=""         # Match the first of the first server
```

```
curl -sfL https://get.k3s.io | INSTALL_K3S_VERSION=${K3s_VERSION}  
K3S_URL=https://${FIRST_SERVER_IP}:6443 K3S_TOKEN=${NODE_TOKEN}  
K3S_KUBECONFIG_MODE="644" sh -
```

After this successful deployment of the K3s solution, review the [product documentation \(https://rancher.com/docs/k3s/latest/en/\)](https://rancher.com/docs/k3s/latest/en/)  for details on how to directly utilize this Kubernetes cluster. Furthermore, by reviewing the SUSE Rancher [product documentation \(https://rancher.com/docs/rancher/v2.x/en/\)](https://rancher.com/docs/rancher/v2.x/en/)  this solution can also be:

- imported (refer to sub-section "Importing Existing Clusters"), then
- managed (refer to sub-section "Cluster Administration") and
- accessed (refer to sub-section "Cluster Access") to address orchestration of workloads, maintaining security and many more functions are readily available.

6 Summary

Using components and offerings from SUSE and the Rancher portfolio streamlines the ability to quickly and effectively engage in a digital transformation, taking advantage of cloud native resources and disciplines. Using such technology approaches lets you deploy and leverage transformations of infrastructure into a durable, reliable enterprise-grade environment.

Simplify

Simplify and optimize your existing IT environments

- Using K3s enables you to quickly and simply deploy a Kubernetes cluster in a wide array of locations, across edge, branch, core and cloud.

Modernize

Bring applications and data into modern computing

- With K3s, the digital transformation to containerized applications can progress since both developers and production can leverage these deployments for the actual workloads.

Accelerate

Accelerate business transformation through the power of open source software

- Given the open source nature of K3s and the minimal underlying software components, you can expand into a very distributed ecosystem, bringing computing to where the data exists or arrives, to answer the necessary business needs.

7 References

WHITE PAPERS

- A Buyer's Guide to Enterprise Kubernetes Management Platforms - <https://info.rancher.com/enterprise-kubernetes-management-buyers-guide>
- How to Build an Enterprise Kubernetes Strategy - <https://info.rancher.com/how-to-build-enterprise-kubernetes-strategy>

BOOKS

- Kubernetes Management - <https://info.rancher.com/kubernetes-management-for-dummies-rancher-and-suse-0-0>

TRAINING

- SUSE - <https://training.suse.com/>
- Rancher - <https://rancher.com/training/>

WEBSITES

- SUSE - <https://www.suse.com>
- SUSE Customer Center (SCC) - <https://scc.suse.com/login>
- Products
 - SUSE Rancher - <https://rancher.com/products/rancher/> (documentation (<https://rancher.com/docs/rancher/v2.x/en/>))
 - Rancher Kubernetes Engine (RKE) - <https://rancher.com/products/rke/> (documentation (<https://rancher.com/docs/rke/latest/en/>))
 - K3s - <https://rancher.com/products/k3s/> (documentation (<https://rancher.com/docs/k3s/latest/en/>))
 - SUSE Linux Enterprise Micro (SLEMicro) - <https://www.suse.com/products/micro/> (documentation (<https://documentation.suse.com/sle-micro/5.0/>))
 - SUSE Linux Enterprise Server (SLES) - <https://www.suse.com/products/server/> (documentation (<https://documentation.suse.com/sles/15-SP2/>))

- SUSE Manager - <https://www.suse.com/products/suse-manager/> (documentation (<https://documentation.suse.com/suma/4.1/>))
- SUSE Repository Mirroring Tool (RMT) - <https://www.suse.com/products/server/> (documentation (<https://documentation.suse.com/sles/15-SP2/single-html/SLES-rmt/#book-rmt>))
- Projects
 - Rancher Kubernetes Engine Government (RKE2) - <https://github.com/rancher/rke2> (documentation (<https://docs.rke2.io/>))

Glossary

- Document Scope

Reference Implementation

A guide with the basic steps to deploy the highlighted components of the SUSE portfolio, including generalized pointers to other layers and elements. This is considered an introductory approach and a basis for other tested variations.

Reference Architectures ¹

A guide with the general steps to deploy and validate the structured solution components from both the SUSE and partner portfolios. This provides a shareable template of consistency for consumers to leverage for similar production ready solutions, including design considerations, implementation suggestions and best practices.

Best Practice

Information that can overlap both the SUSE and partner space. It can either be provided as a standalone guide that provides reliable technical information not covered in other product documentation, based on real-life installation and implementation experiences from subject matter experts or complementary, embedded sections within any of the above documentation types describing considerations and possible steps forward.

- Factor(s)

Automation ²

Infrastructure automation enables speed through faster execution when configuring the infrastructure and aims at providing visibility to help other teams across the enterprise work quickly and more efficiently. Automation removes the risk associated with human error, like manual misconfiguration; removing this can decrease downtime and increase reliability. These outcomes and attributes help the enterprise move towards implementing a culture of DevOps, the combined working of development and operations.

¹ link: Reference Architecture (https://en.wikipedia.org/wiki/Reference_architecture) 

² link: Infrastructure-as-Code (https://en.wikipedia.org/wiki/Infrastructure_as_code) 

Availability³

The probability that an item operates satisfactorily, without failures or downtimes, under stated conditions as a function of its reliability, redundancy and maintainability attributes. Some major objectives to achieve a desired service level objectives are:

- Preventing or reducing the likelihood and frequency of failures via design decisions within the allowed cost of ownership
- Correcting or coping with possible component failures via resiliency, automated failover and disaster-recovery processes
- Estimating and analyzing current conditions to prevent unexpected failures via predictive maintenance

Integrity⁴

Integrity is the maintenance of, and the insurance of the accuracy and consistency of a specific element over its entire lifecycle. Both physical and logical aspects must be managed to ensure stability, performance, re-usability and maintainability.

Security⁵

Security is about ensuring freedom from or resilience against potential harm, including protection from destructive or hostile forces. To minimize risks, one must manage governance to avoid tampering, maintain access controls to prevent unauthorized usage and integrate layers of defense, reporting and recovery tactics.

- Deployment Flavor(s)

Proof-of-Concept⁶

A partial or nearly complete prototype constructed to demonstrate functionality and feasibility for verifying specific aspects or concepts under consideration. This is often a starting point when evaluating a new, transitional technology. Sometimes it starts as a Minimum Viable Product (MVP⁷) that has just enough features to satisfy an

3 link: Availability (https://en.wikipedia.org/wiki/Minimum_viable_product) ↗

4 link: Data Integrity (https://en.wikipedia.org/wiki/Data_integrity) ↗

5 link: Security (<https://en.wikipedia.org/wiki/Security>) ↗

6 link: Proof of Concept (https://en.wikipedia.org/wiki/Proof_of_concept) ↗

7 link: Minimum Viable Product (https://en.wikipedia.org/wiki/Minimum_viable_product) ↗

initial set of requests. After such insights and feedback are obtained and potentially addressed, redeployments may be utilized to iteratively branch into other realms or to incorporate other known working functionality.

Production

A deployed environment that target customers or users can interact with and rely upon to meet their needs, plus be operationally sustainable in terms of resource utilization and economic constraints.

Scaling

The flexibility of a system environment to either vertically scale-up, horizontally scale-out or conversely scale-down by adding or subtracting resources as needed. Attributes like capacity and performance are often the primary requirements to address, while still maintaining functional consistency and reliability.

A Appendix

The following sections provide a bill of materials listing for each component layer.

A.1 Compute Platform Bill of Materials

Role	Qty	SKU	Component	Notes
System	1-3	n/a	<ul style="list-style-type: none">• Virtual Machine,• Single Board Computer (SBC) or• Industry Standard Server	Configuration <ul style="list-style-type: none">• see source profiling (https://rancher.com/docs/k3s/latest/en/installation/installation-require-

Role	Qty	SKU	Component	Notes
				ments/re-source-pro-filing/) ↗

A.2 Software Bill of Materials

Role	Qty	SKU	Component	Notes
Operating System	1-3	874-007864	SUSE Linux Enterprise Micro, <ul style="list-style-type: none"> • x86_64, • Priority Subscription, • 1 Year 	Configuration: <ul style="list-style-type: none"> • per node (up to 16 cores, stackable)
Kubernetes	1	R-0003-PS1	K3s, <ul style="list-style-type: none"> • x86-64 or aarch64 • Priority Subscription, • 1 Year 	Configuration: <ul style="list-style-type: none"> • provides support of 10 nodes



Note

For the software components, other durations of support terms are also available.

A.3 Documentation Configuration / Attributes

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