Reference Configuration - K3s

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Contents

Preface

The purpose of this document is to provide an overview and procedure of implementing SUSE (https://www.suse.com) ® and partner 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 Kubernetes [1] 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 (CNCF [2]) conformant [3] and certified [4] 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.

Once on such a digital transformation journey, some of the next focus areas are:

- Compute Platform

1 https://kubernetes.io/

2 https://www.cncf.io/

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

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

- To optimize availability, performance, scalability and integrity, assess current system platforms or acquire and utilize new variations from:
  - Independent Hardware Vendors (IHV), like Supermicro (https://www.supermicro.com/en) ® , as the platform for physical, baremetal, hypervisors and virtual machines

1.2 Scope

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

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.

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 complext.

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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 managment 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, organization's are equipped with an easy, complete and reliable management solution for Kubernetes at the edge.

With this increased consistency of the managed Kubernetes infrastructure clusters, organizations benefit from an even higher level of the Cloud Native Computing model where each layer only relies upon the API and version of the adjacent layer. For example:

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:

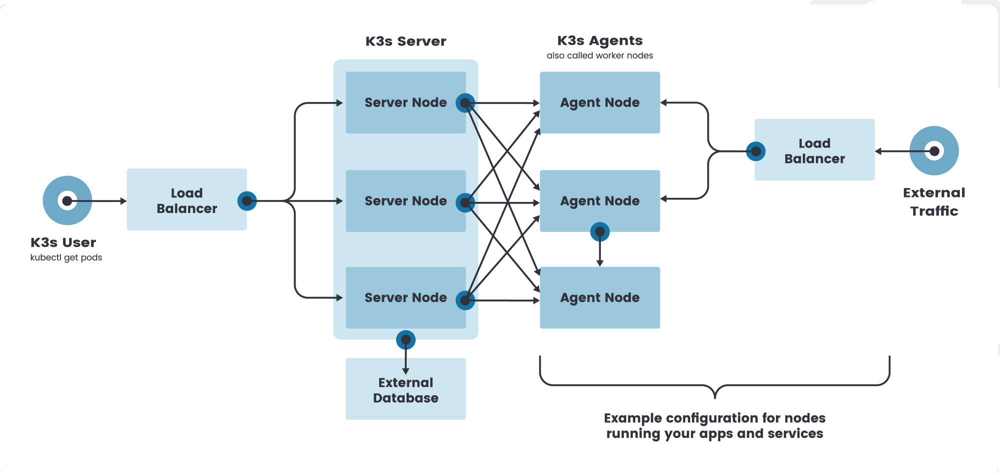

FIGURE 3.1: FIXME - ARCHITECTURE OVERVIEW - K3S

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

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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:

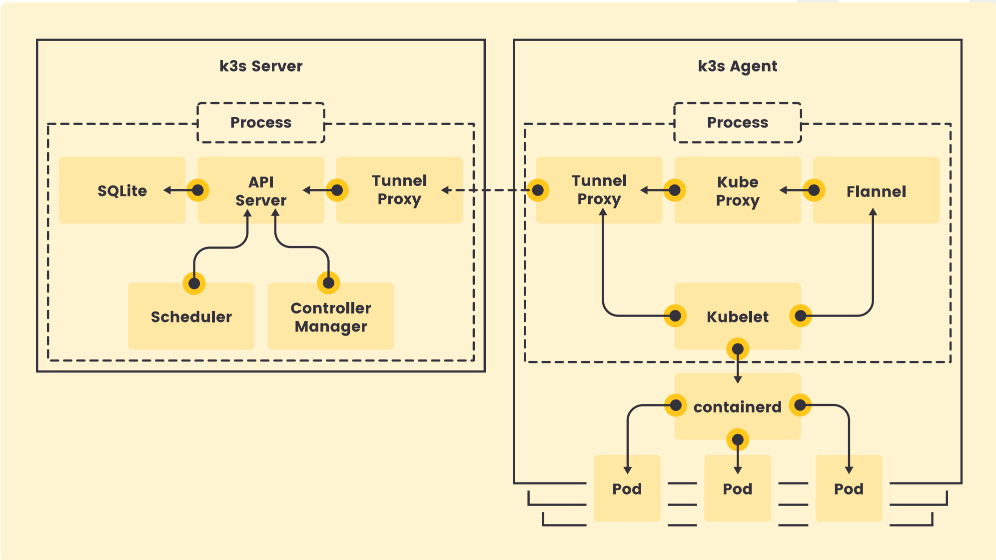

FIGURE 4.1: OVERVIEW OF K3S

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/) or if the organization already has subscriptions, both install media and updates can be obtained from SUSE Customer Center (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:

Note

A sample bill of materials, in the *Appendix A, Appendix*, cites the necessary quantites of all components, along with a reference to the minimum resource requirements needed by the software components.

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:

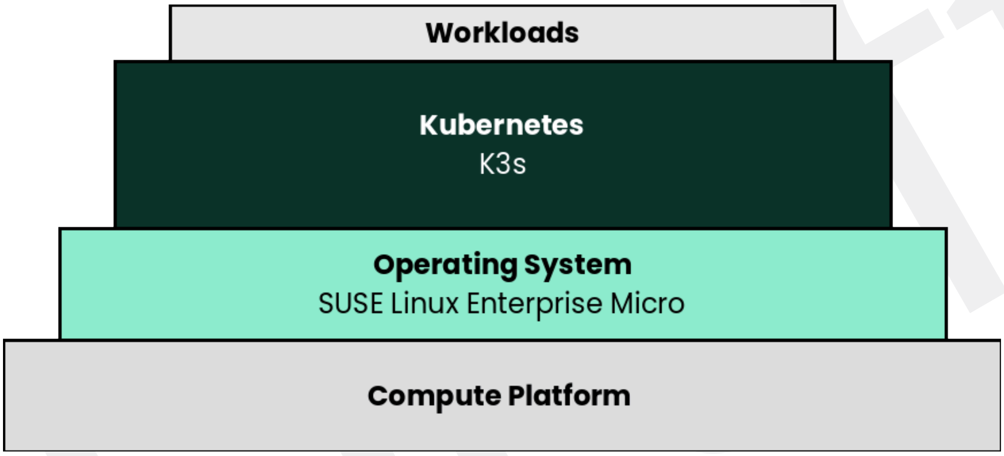

FIGURE 5.1: K3S DEPLOYMENT STACK

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

5.2.1 SYS-120C-TN10R Rack Servers

https://www.supermicro.com/en/products/system/Cloud/1U/SYS-120C-TN10R

Ultimate Flexibility • CPU: Up to 270W and 40 cores • Memory: 4TB DDR4-3200 memory in 16 DIMM slots w/ support of Intel Optane PMEM 200 series • Storage: Up to 10x all hybrid drive bays (NVMe/SAS/SATA) + Flexible internal storage options (dual NVMe M.2 / SATADOM) • Expansion: Up to 2 standard PCIe 4.0 FHHL expansion slots + 2 AIOM for OCP 3.0 NIC; Building block solution for different applications and environment • 860W Platinum level redundant PWS

Efficient and Cost-Effective • Cost optimized for large volume deployment • Tool-less mechanical design for rapid deployment • Hot-swap storage and PWS for easy maintenance. • IPMI, serial port and service tag for easy management

Compact • Compact system design makes no waste of internal space • < 600mm chassis depth • Fully utilized system resource with 12 NVMe, 4 PCIe 4.0 x16 + 2 PCIe 4.0 x8 expansion

Secure • Security is top priority • TPM 1.2/2.0, signed firmware, Silicon Root of Trust • Secure Boot, System Erase • FIPS Compliance, Trusted Execution Environment

Application Ready • Balanced architecture between CPUs and optimized for scalable compute, database, GPU, tiered storage and I/O intensive applications • Support open standards like OpenBMC and OCP 3.0

```
 Keep it Green
•       Optimized thermal design
•       High efficiency Platinum level PWS (AC/DC)
•       Reduced waste with bulk packaging and customizable accessories
:modelSupermicro-server-node: SYS-120C-TN10R
:modelSupermicro-server-node-URL: https://www.supermicro.com/en/products/system/Cloud/1U/
SYS-120C-TN10R
:modelSupermicro-agent-node: SYS-620C-TN12R
:modelSupermicro-agent-node-URL: https://www.supermicro.com/en/products/system/Cloud/2U/
SYS-620C-TN12R
```

5.2.2 SYS-620C-TN12R Rack Servers

https://www.supermicro.com/en/products/system/Cloud/2U/SYS-620C-TN12R

Ultimate Flexibility • CPU: Up to 270W and 40 cores • Memory: 4TB DDR4-3200 memory in 16 DIMM slots w/ support of Intel Optane PMEM 200 series • Storage: Up to 12 all hybrid drive bays (NVMe/SAS/SATA) + Flexible internal storage options (dual NVMe M.2 / SATADOM) • Expansion: Up to 6 standard PCIe 4.0 expansion slots + 2 AIOM for OCP 3.0 NIC; Up to 2 FHFL DW GPUs or 6 LP GPUs • Building block solution for different applications and environment • 1200W Titanium level redundant PWS

Efficient and Cost-Effective • Cost optimized for large volume deployment • Tool-less mechanical design for rapid deployment • Hot-swap storage and PWS for easy maintenance. • IPMI, serial port and service tag for easy management

Compact • Compact system design makes no waste of internal space • < 650mm chassis depth • Fully utilized system resource with 12 NVMe, 4 PCIe 4.0 x16 + 2 PCIe 4.0 x8 expansion

Secure • Security is top priority • TPM 1.2/2.0, signed firmware, Silicon Root of Trust • Secure Boot, System Erase • FIPS Compliance, Trusted Execution Environment

Application Ready • Balanced architecture between CPUs and optimized for scalable compute, database, GPU, tiered storage and I/O intensive applications • Cost and performance optimized down to component level • Support open standards like OpenBMC and OCP 3.0

We Keep it Green • Optimized thermal design • High efficiency Titanium level PWS (AC/DC) • Reduced waste with bulk packaging and customizable accessories

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/) 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) (SCC) or
- an organization's 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) (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).

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/) 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)

> **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)

  - 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)

5.4 K3s

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   - Software Update Service - access to a network-based repository for software update packages. This can be accessed directly from each node via registration to

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- an organization's 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) (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).

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/) 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/) ↗ 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/) ↗ 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/))

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    - 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 Configuration

A guide with the basic steps to deploy the layered stack of components from both the SUSE and partner portfolios. This is considered a fundamental basis to demonstrate a specific, tested configuration of components.

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.

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

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

Availability [3]

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

Integrity [4]

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.

Security [5]

Security is about ensuring freedom from or resilience against potential harm, including protection from destructive or hostile forces. To minimize risks, one mus 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-Concept [6]

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 (MVP [7]) that has just enough features to satisfy an

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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

A.2 Software Bill of Materials

Role	Qty	SKU	Component	Notes
Operating System	1-3	874-007864	SUSE Linux Enterprise Micro, • x86_64, • Priority Subscription, • 1 Year	Configuration: • per node (up to 16 cores, stackable)
Kubernetes	1	R-0003-PS1	K3s, • x86-64 or aarch64 • Priority Subscription, • 1 Year	Configuration: • 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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