

TODO*

Definition and Implementation of a Common Identity for Secure Transport

Christoph Bühler

Spring and Autumn Semester 2022

University of Applied Science of Eastern Switzerland (OST)

TODO

*I would like to express my appreciation to Mirko Stocker for guiding and reviewing this work. Furthermore, special thanks to Florian Forster, who provided the initial inspiration and technical expertise of the topic.

Contents

Declaration of Authorship	3
1 Introduction	4
2 Definitions and Clarification of the Scope	6
2.1 Scope of this Project	6
2.2 Introduction into Kubernetes	6
2.2.1 Basic Terminology	7
2.2.2 What is an Operator	8
2.2.3 What is a Sidecar	9
2.3 Security, Trust Zones, and Secure Communication	9
2.3.1 The CIA Triad	9
2.3.2 Trust is Important	9
2.3.3 Zones and Zero Trust	9
2.3.4 Securing Communication between Parties	9
3 State of the Art	10
4 Creating a Trust Context for the Authentication Mesh	11
4.1 Sign a Contract between Participants	11
4.1.1 Using a Block Chain	11
4.1.2 Using a Master Key	11
4.1.3 Distribute Contracts via Git	11
4.2 Define the Contract	11
5 Conclusions and Outlook	12
Bibliography	13

List of Figures

1	Multiple Trust Zones with Contract	4
2	Basic Buildingblocks in Kubernetes	7

Declaration of Authorship

I, Christoph Bühler, declare that this MASTER THESIS titled “TODO” and the work presented in it are my own.

I confirm that:

- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. Except for such quotations, this MASTER THESIS is entirely my own work.
- I have acknowledged all main sources of help.
- Where the MASTER THESIS is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Gossau SG, March 14, 2022

Christoph Bühler

1 Introduction

The concept of the “Distributed Authentication Mesh” [1] creates a foundation for dynamic authentication and authorization with diverging authentication schemes. Further, “Common Identities in a Distributed Authentication Mesh” [2] defines and implements the common identity that is transported between services. The mentioned projects show with their respective Proof of Concepts (PoC), that it is possible to authenticate a user and transfer that identity over to other applications that do not share the same authentication mechanism. However, both projects only use one trust zone¹. While still allowing “zero trust”², the projects do not enable true “distribution”.

In the current state, applications within the same trust zone can communicate with each other and a user only needs to enter his credentials (such as username/password) once. When the user is authenticated, the identity (user ID) is encoded in a JWT for other outgoing calls and the receiving party can validate that the user is already authenticated. Then the receiver uses the transmitted information to encode the identity in the corresponding authentication scheme of the destination [1], [2].

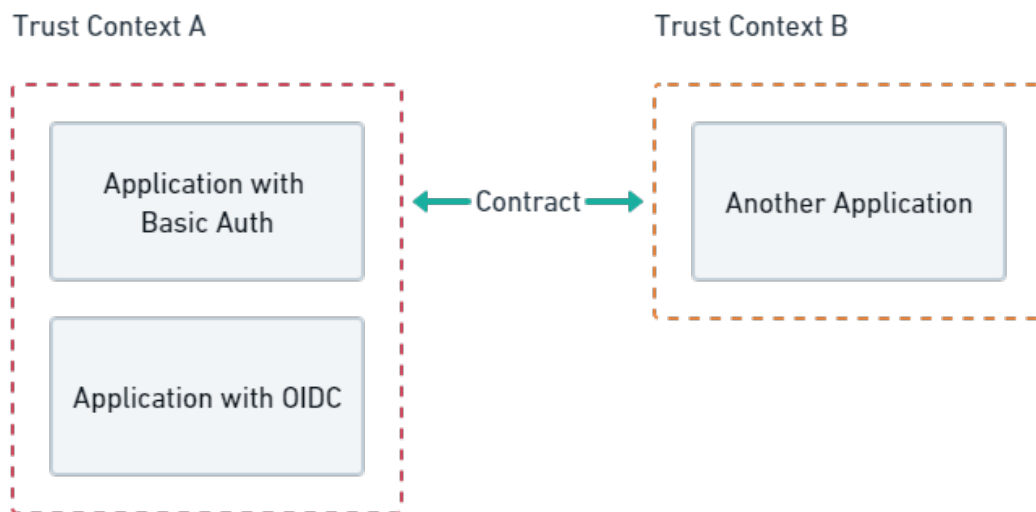


Figure 1: Multiple trust zones that share a contract between them. The contract enables the authentication mesh to verify callers from other zones.

To achieve true distribution, a contract as shown in Figure 1 must exist. The contract defines how multiple parties can trust each other. This project shall define and implement

¹A space where applications can “trust” each other.

²Assuming that each call can be compromised, so all credentials must be verified for each call.

the contract between multiple authentication meshes, such that the distributed authentication mesh can communicate with other trusted zones. To complement the conceptual addition, an open-source implementation of the authentication mesh is provided. The implementation runs on Kubernetes³ and is automated by a Kubernetes Operator.

The remainder of this thesis describes prerequisite knowledge, used technologies and other topics that are required to understand the work. Section 3 shows the current state of the distributed authentication mesh project and which elements are missing for the true distribution between security contexts. The implementation section, Section 4, provides knowledge about the possible technologies for the contract, defines the contract, and implements the contact along with other implementations needed for the working software. The conclusions section then gives an overview of the results and provides an outlook into future work.

³<https://kubernetes.io>

2 Definitions and Clarification of the Scope

This section provides the scope, context and prerequisite knowledge for this project. It also gives an overview of the used technologies as well as an introduction into the security topic of the project. Note that a deeper introduction into other security related technologies is given in the implementation section.

2.1 Scope of this Project

This project builds upon two former projects “Distributed Authentication Mesh” [1] and “Common Identities in a Distributed Authentication Mesh” [2]. The past work did define a general concept for a distributed authentication [1] and the definition and implementation of a common identity that is shared between the applications in the mesh [2].

The goal of this project is to achieve a truly distributed mesh. To reach a distributed state in the mesh and to be able to trust other trust zones, a contract between each zone must exist. This project defines and implements the contract and provides the tools that are necessary to run such a mesh in Kubernetes. In this project, we analyze different options to form a contract between distant parties and define the specific properties of the contract. After the analyzation and definition, an open-source implementation shall show the feasibility and the usability of the distributed authentication mesh.

Service mesh functionality, such as service discovery even for distant services, is not part of the authentication mesh nor of this project. While the authentication mesh is able to run alongside with a service mesh, it must not interfere with the resolution of the communication. The applications that are part of the mesh must be able to respect the `HTTP_PROXY` and `HTTPS_PROXY` variables, since the Kubernetes Operator will inject those variables into the application. This technique allows the mesh to configure a local sidecar as the proxy for the application.

2.2 Introduction into Kubernetes

Since the provided implementation of the distributed authentication mesh runs on Kubernetes, this section gives a brief overview of Kubernetes and the used patterns. Kubernetes is a workload manager that can load balance tasks on several nodes (servers). The explained patterns allow developers to extend the basic Kubernetes functionality.

2.2.1 Basic Terminology

To understand further concepts and Kubernetes in general, some basic terminology and concepts around Kubernetes must be understood.

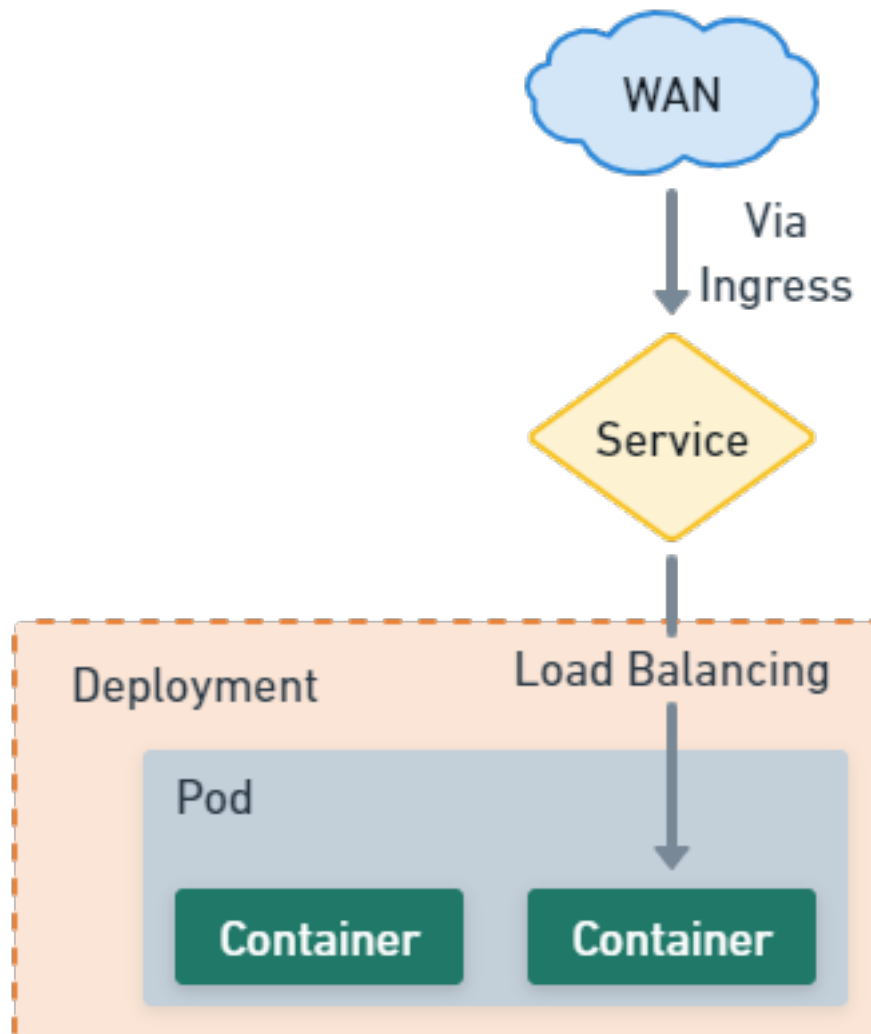


Figure 2: Basic Buildingblocks in Kubernetes

A **Pod** is the smallest possible deployment unit and contains a collection of application containers and volumes [3, Ch. 5]. Figure 2 shows a Pod that contains two containers. Containers are definitions for workloads that must be run. To enable Kubernetes to run

such a container, a containerized application and a container image must be present. Such an image-format is “Docker”⁴, a container runtime for various platforms.

Deployments manage multiple Pods. A Deployment object manages new releases and represent a deployed application. They enable developers to move up to new versions of an application [3, Ch. 10]. In Figure 2, a Deployment holds the Pod which in turn holds the containers.

A **Service** makes ports in Pods accessible to the Kubernetes world. They provide service discovery via Kubernetes internal DNS services [3, Ch. 7]. The service in Figure 2 enables access to one of the containers in the Pod. A service load balances access if multiple containers match the service description.

Ingress objects define external access to objects within Kubernetes. Kubernetes uses “Ingress Controllers” that configure the access to services and/or containers [3, Ch. 8]. As an example, “NGINX”⁵ is an ingress controller that is often used. When an Ingress is configured to allow access to the service in Figure 2, NGINX is configured that the respective virtual host forwards communication to the given service (reverse-proxying).

2.2.2 What is an Operator

The “Operator pattern” provides a way to automate complex applications in Kubernetes. An Operator can be compared to a Site Reliability Engineer (SRE) because the Operator manages and automates complex applications with expert knowledge [4].

An Operator makes use of “Custom Resource Definitions” (CRD) in Kubernetes. These definitions extend the Kubernetes API with custom objects that can be manipulated by a user of the Kubernetes instance. The Operator “watches” for events regarding objects in Kubernetes. The events can contain the creation, modification, and deletion of such a watched resource.

In the distributed authentication mesh, an Operator is used to automatically attach a deployment to the mesh and configure the corresponding services accordingly. The Operator modifies the ports of the service to target an Envoy⁶ proxy and injects the credential translator into the application (Deployment) in question [1].

A partial list of operators available to use is viewable on <https://operatorhub.io>.

⁴<https://www.docker.com/>

⁵<https://www.nginx.com/>

⁶<https://www.envoyproxy.io/>

2.2.3 What is a Sidecar

A Sidecar is an extension to an existing Pod. Some controller (for example an Operator) can inject a Sidecar into a Pod or the Sidecar gets configured in the Deployment in the first place. [5]

2.3 Security, Trust Zones, and Secure Communication

2.3.1 The CIA Triad

2.3.2 Trust is Important

2.3.3 Zones and Zero Trust

2.3.4 Securing Communication between Parties

3 State of the Art

4 Creating a Trust Context for the Authentication Mesh

4.1 Sign a Contract between Participants

4.1.1 Using a Block Chain

4.1.1.1 Introduction

4.1.2 Using a Master Key

4.1.3 Distribute Contracts via Git

4.2 Define the Contract

5 Conclusions and Outlook

Bibliography

- [1] C. Bühler, “Distributed Authentication Mesh - A Concept for Declarative Ad Hoc Conversion of Credentials,” University of Applied Science of Eastern Switzerland (OST), Aug. 2021. Available: <https://buehler.github.io/mse-project-thesis-1/report.pdf>
- [2] C. Bühler, “Common Identities in a Distributed Authentication Mesh - Definition and Implementation of a Common Identity for Secure Transport,” University of Applied Science of Eastern Switzerland (OST), Feb. 2022. Available: <https://buehler.github.io/mse-project-thesis-2/report.pdf>
- [3] B. Burns, J. Beda, and K. Hightower, *Kubernetes*, Second Edition. Dpunkt Heidelberg, Germany, 2018.
- [4] J. Dobies and J. Wood, *Kubernetes operators: Automating the container orchestration platform*. O’Reilly Media, 2020.
- [5] B. Burns and D. Oppenheimer, “Design patterns for container-based distributed systems,” Jun. 2016. Available: <https://www.usenix.org/conference/hotcloud16/workshop-program/presentation/burns>