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.

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Declaration of Authorship

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

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- I have acknowledged all main sources of help.
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Gossau SG, March 21, 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 zone[1]. 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].

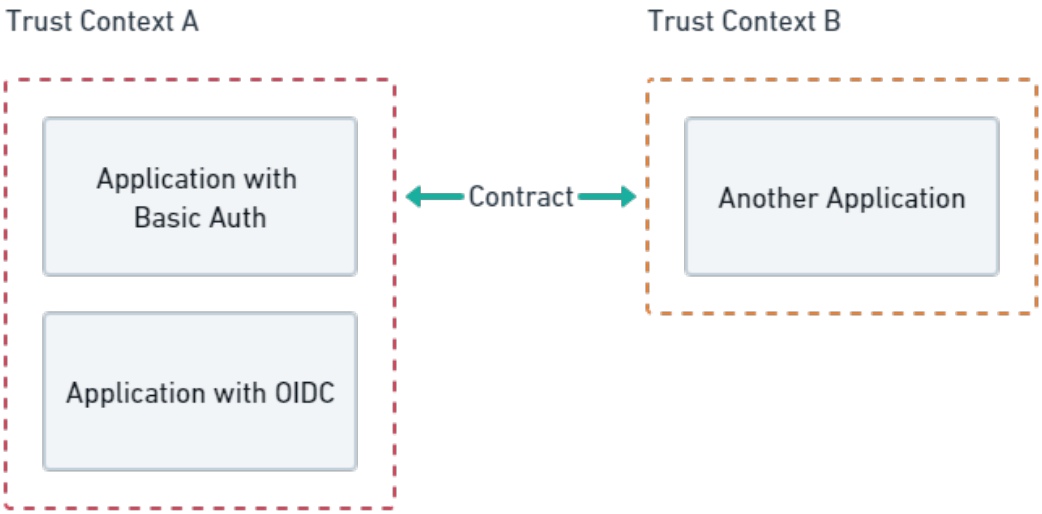

Figure 1: Multiple trust zones that share a contract between them. The contract enables the authentication mesh to verify callers from other zones.

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

[1] A space where applications can "trust" each other.
[2] Assuming 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 Kubernetes[3] 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 defined a general concept for 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.

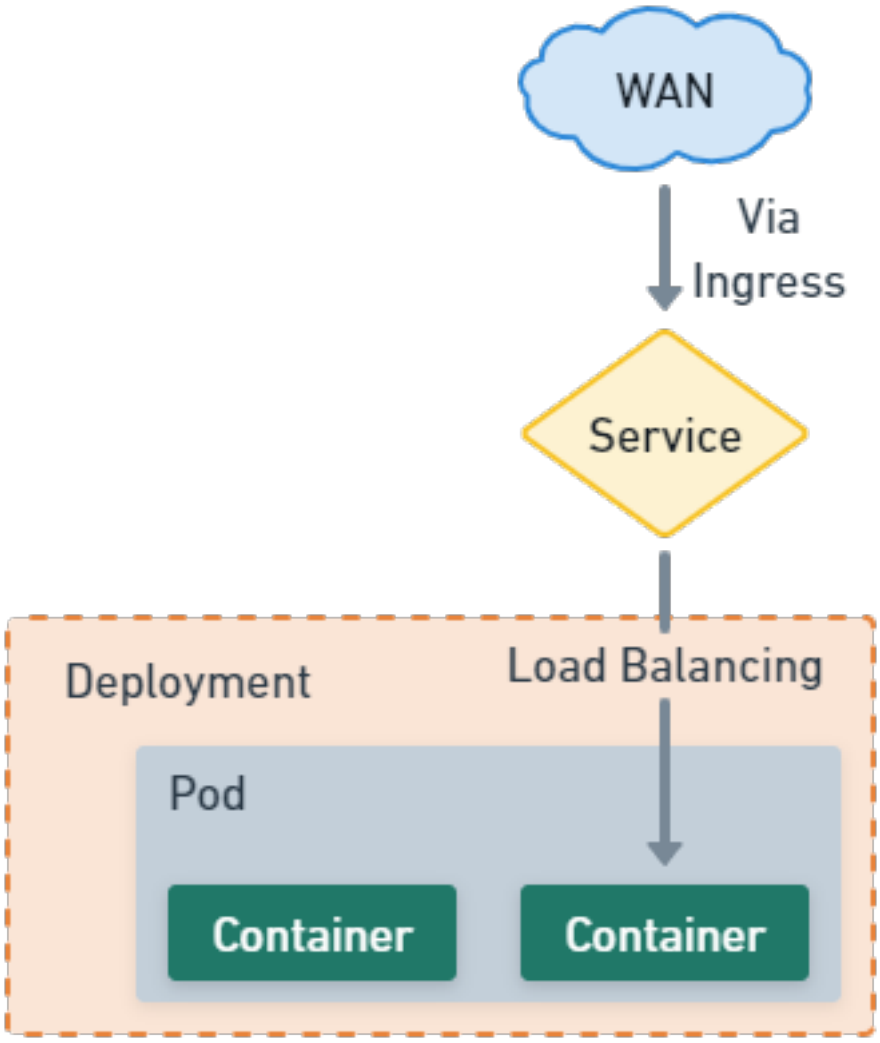

Figure 2: Basic Buildingblocks in Kubernetes

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

[4]https://www.docker.com/

represent a deployed application. They enable developers to move up to new versions of an application [3, Ch. 10]. In Figure 2, a Deployment contains the Pod which in turn holds containers. There exist multiple deployment specifications, such as `Deployment` and `Stateful Set` which have their own use-cases depending on the specification.

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 popular. 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

Site Reliability Engineering (SRE) is a specific software engineering technique to automate complex software. A team of experts uses certain practices and principles to run scalable and highly available applications [4]. The "Operator pattern" provides a way to automate complex applications in Kubernetes. An Operator can be compared to a Site Reliability Engineer because the Operator manages and automates complex applications with expert knowledge [5].

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 [3, Ch. 16]. The Operator "watches" for events regarding objects in Kubernetes. The events can contain the creation, modification, and deletion of such a watched resource. As an example, the "Postgres"[6] database operator reacts to the `Postgres` custom entity. When such an entity is created within Kubernetes, the Operator starts and configures the Postgres database system.

[5] https://www.nginx.com/
[6] https://www.postgresql.org/

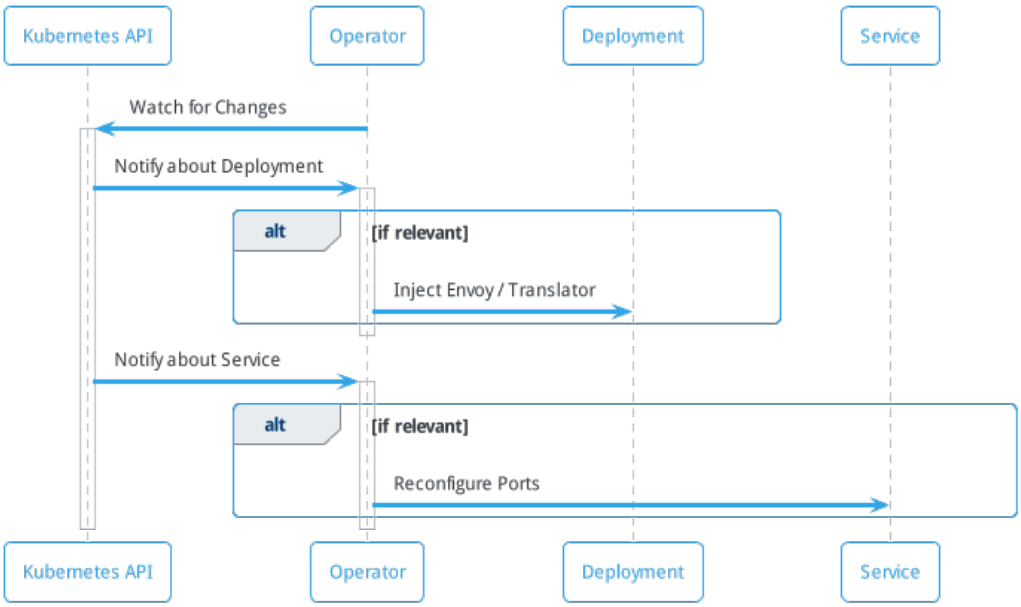

Figure 3: Basic Buildingblocks in Kubernetes

In the distributed authentication mesh, an Operator is used to automatically attach a deployment to the mesh and configure the corresponding services accordingly. As Figure 3 shows, the Operator injects the credential translator and the Envoy[7] proxy into the application (Deployment) and modifies the ports of the service to target the Envoy proxy [1].

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. [6]

[7] https://www.envoyproxy.io/

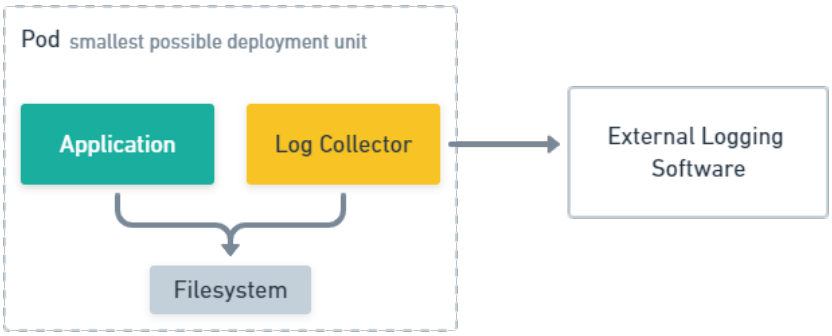

Figure 4: An example of a Sidecar

Figure 4 shows an example of a Sidecar. An application runs a Pod and writes log messages to `/var/logs/app.log` in the shared file system. A specialized "Log Collector" Sidecar can be injected into the Pod and read those log messages. Then the Sidecar forwards the parsed logs to some logging software like Graylog[8].

Sidecars can fulfil multiple use-cases. A service mesh may use Sidecars to provide proxies for service discovery. Logging operators may inject Sidecars into applications to grab and parse logs from applications. Sidecars are a symbiotic extension to an application [3, Ch. 5].

2.3 Security, Trust Zones, and Secure Communication

The distributed authentication mesh is a security application. Therefore, security is one of the main focus in this work. This section gives an overview of the relevant topics to understand further security related concepts. More in-depth knowledge is provided in Section 4.

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

The key argument of the distributed authentication mesh is the possibility to provide a secured identity over a service landscape that has heterogeneous authentication schemes

[8] https://www.graylog.org/

[1].

2.3.4.1 HTTP Basic Authentication The "Basic" authentication scheme is defined in **RFC7617**. `Basic` is a trivial authentication scheme which provides an extremely low security when used without HTTPS. Even with HTTPS, Basic Authentication does not provide solid security for applications. It does not use any real form of encryption, nor can any party validate the source of the data. To transmit basic credentials, the username and the password are combined with a colon (`:`) and then encoded with Base64. The encoded result is transmitted via the HTTP header `Authorization` and the prefix `Basic` [7].

2.3.4.2 OpenID Connect OpenID Connect (OIDC) is not defined in an RFC. The specification is provided by the OpenID Foundation (OIDF). OIDC extends OAuth, which is defined by **RFC6749**. The OAuth framework only defines the authorization part and how access is granted to data and applications. OAuth does not define how the credentials are transmitted [8].

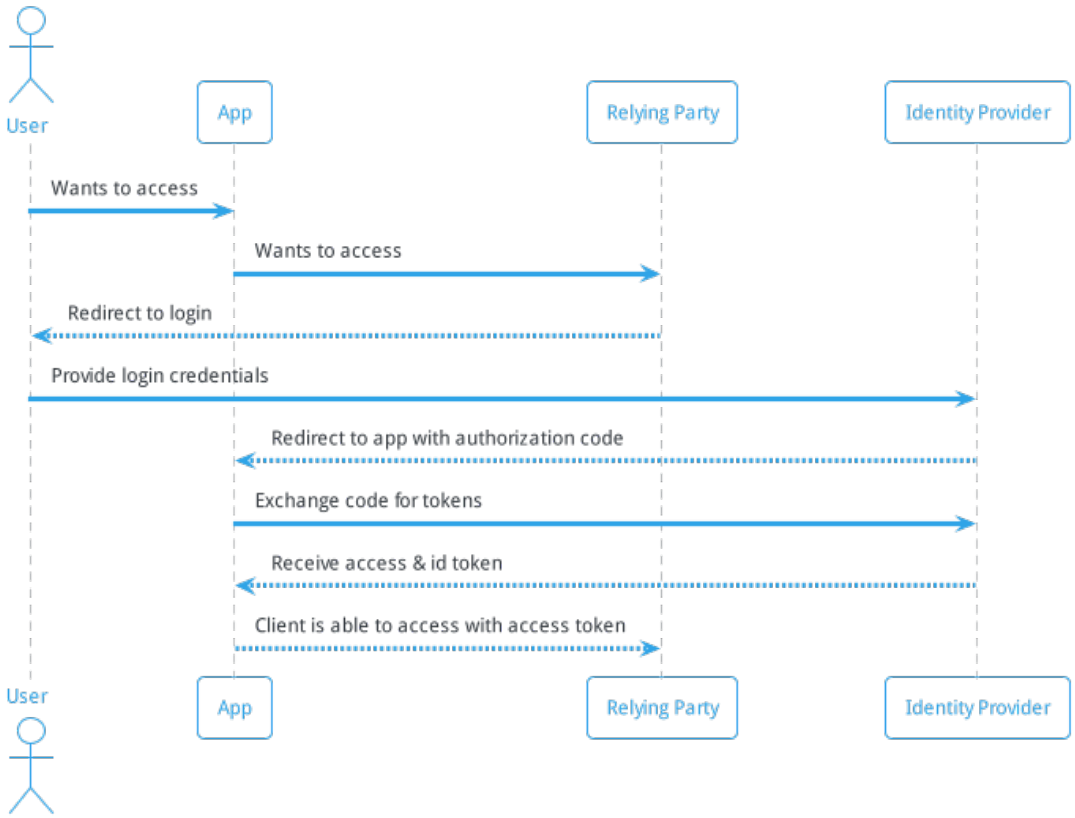

Figure 5: OIDC code authorization flow [9]. Only contains the credential flow, without the explicit OAuth part. OAuth handles the authorization whereas OIDC handles the authentication.

Figure 5 shows an example where a user wants to access a protected application. The user is forwarded to an external login page (Identity Provider) and enters his credentials. When they are correct, the user gets redirected to the web application with an authorization code. The code is used to fetch an access and ID token for the user. These tokens identify, authenticate and authorize the user. The application is now able to provide the access token to the API (Relying Party). The API itself is able to verify the presented token to validate and authorize the user.

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

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