MASTER THESIS

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering at the University of Applied Sciences Technikum Wien - Degree Program Smart City

Kubernetes on the Edge

By: Bernd KLAUS, BA

Student Number: 2010303012

Supervisors: Dipl.-Ing. Hubert Kraut
Dipl.-Ing. Andreas Happe

Wien, December 25, 2021

FH University of Applied Sciences TECHNIKUM WIEN

Declaration

“As author and creator of this work to hand, I confirm with my signature knowledge of the relevant copyright regulations governed by higher education acts (see Urheberrechtsgesetz /Austrian copyright law as amended as well as the Statute on Studies Act Provisions / Examination Regulations of the UAS Technikum Wien as amended).

I hereby declare that I completed the present work independently and that any ideas, whether written by others or by myself, have been fully sourced and referenced. I am aware of any consequences I may face on the part of the degree program director if there should be evidence of missing autonomy and independence or evidence of any intent to fraudulently achieve a pass mark for this work (see Statute on Studies Act Provisions / Examination Regulations of the UAS Technikum Wien as amended).

I further declare that up to this date I have not published the work to hand nor have I presented it to another examination board in the same or similar form. I affirm that the version submitted matches the version in the upload tool.“

Wien, December 25, 2021 Signature

Kurzfassung

Kubernetes wird als Schweizer Armemesser der Container-Orchestrierung bezeichnet. Auch im Bereich Edge-Computing bietet der Dienst eine Vielzahl an unterschiedlichen Werkzeugen und Tools an, welche Teils unterschiedliche Strategien und Ansätze verfolgen. Die Auswahl reicht von einem zentralen Kubernetes-Cluster der verteilte Geräte, sogenannte „Leafs“, steuert bis hin zu vielen einzelnen und verteilten kleinen Clustern an der Edge, welche zentral gesteuert werden. Entscheidend ist es den richtigen Anwendungsfall zu erheben, um sich für die optimale Lösung entscheiden zu können. Ebenfalls spielen sicherheitstechnische Aspekte bei derart komplexen Umgebungen eine wichtige Rolle. Die vorliegende Arbeit gibt Einblicke und Entscheidungsgrundlagen sowie Empfehlungen hinsichtlich der IT-Security. Belegt werden die Angaben durch Implementierung eines Proof-of-Concepts

Schlagworte: Kubernetes, Edge-Computing, distributed System, Proof-of-Concept

Abstract

Kubernetes is the de facto swiss-army-knfife for orchestrating conatiner-platforms. In addition, kubernetes is also offering a toolset necessary for deploying on the edge. However, there are different methods for archiving comparable results. On the one hand a possible solution is to build a central instance managing small distributed and independent cluster, on the other hand a centralized cluster with just leafs on the edge may is a better fit. The challenge is to dine the best solution for the desired environment. The following thesis is making use of "Design Science Research" to give introductions on how to choose the proper environment.

Keywords: Kubernetes, Edge-Computing, distributed System, Proof-of-Concept

Contents

1 Introcution

Because of IoT Devices becoming more and more common, the number of devices capable of communicating with the world wide web (WWW) increases rapidly. Consequently, also the overall traffic generated as well the amount of data which must be processed increases accordingly. Regarding this development Edge-Computing is the rising start trying to solve that issues. Thereby data is not processed centrally like in traditional datacenters, but it is tried to handle those data close to the user within several distributed systems. Because of this method only really necessary data is transmitted to a central instance for further treatment and those the processing-power as well as the bandwidth necessary for processing required data is reduced significant.

It is expected that the number of IoT devices will continue to grow fast[1] over the coming years. Concomitant Edge-Computing also will become more important in the future and play an important role in modern Information Technology (IT) architectures.

To be able to control distributed systems effectively Kubernetes (K8S) is providing a lot of useful tools and functions. Fundamentally there are two different approaches regrading the architecture of how To build an Edge-Computing environment using K8S:

- One centralized K8S Cluster controlling many Leaf-Devices on the Edge.
- Small and distributed K8S Clusters running independent on the Edge controlled by a centralized Master-Instance.

1.1 Problem area

Problems arise when trying to find the proper architecture for a specific use-cases. There is no clear winner when comparing the above-mentioned different variants. Each of the both architectures have their own pros and cons and may decide whether a project is successful or not. It is therefore all the more important to choose the proper architecture right before starting, changing the strategy in retrospect would take a lot of time and effort. However, there is no clear guidance on how to find the proper target environment, at least none which apply in general. Occasionally one finds recommendations for very specific use case, however the chance is slim low this findings fit your goals respectively enlighten the architecture decision. This leads us to the following research question.

1.2 Research question

This paper is going to answer the subsequent research questions:

1. What are the main differences between the both defined main variants regarding functionality, scalability, costs and security?
2. Which decision criteria must be defined respectively examined to create a catalog capable of making choose the proper architecture easier for IT managers as well as administrators.
3. Can two Proof-of-Concept environments, compared using the Design Science Research pattern, prove the accuracy of defined criteria accordingly.

1.3 Methodology

In the first part of the present work existing literature will be inspected. Related and relevant work will be examined accordingly and linked in the document. Also results will be incorporated to get out the most of it. In the second part a catalog with main criteria necessary for decision-making is defined. The last chapter is testing those criteria against real world examples making use of the Design Science Research methodology. The last chapter is getting the most focus because it is the area where new technics respectively architecture decision are finally verified and those proof if the catalog is working as expected or not.

Bibliography

[1] ARJOMANDI, F., M. TRIFIRO and J. SMITH: *State of the Edge 2021*.

List of Figures

List of Tables

List of Code

List of Abbreviations

IT Information Technology

WWW world wide web

K8S Kubernetes

A Anhang A

B Anhang B