



## Bachelorarbeiten 2023

# Bachelor of Science in Informatik



Preisstifter für den Studiengang  
Informatik

Abacus Research AG

bbv Software Services AG

Siemens Schweiz AG

Zühlke Engineering AG

# Vorwort



**Prof. Mirko Stocker**  
Studiengangleiter Informatik

## Sehr geehrte Damen und Herren

In einer zunehmend digitalisierten und vernetzten Gesellschaft spielt die Informatik eine unverzichtbare Rolle und prägt nahezu jeden Aspekt unseres täglichen Lebens. Von der Entwicklung künstlicher Intelligenz über die Gestaltung intuitiver Benutzeroberflächen bis hin zur sicheren Datenübertragung – die Informatik treibt Innovationen voran und schafft die Grundlagen für technologische Durchbrüche. Mit ihrer praxisnahen und fundierten Ausbildung legen unsere Absolventinnen und Absolventen den Grundstein für eine erfolgreiche Informatikkarriere.

Auch in diesem Jahr stehen bei unseren Bachelorarbeiten aktuelle und gesellschaftlich relevante Problemstellungen im Mittelpunkt, die unsere Studierenden mit viel Enthusiasmus und Ehrgeiz angegangen sind. Dabei spiegeln sie die enorme Bandbreite an Wissen und Fähigkeiten wider, die sie sich angeeignet haben. Wir sind sehr stolz darauf, dass unsere Studierenden innovative Lösungen von herausragender Qualität entwickelt haben, die den ausgezeichneten Ruf der Informatik an der OST stärken.

In dieser Broschüre präsentieren wir Ihnen die aktuellen Bachelorarbeiten, die die Breite und Tiefe dieser spannenden Disziplin widerspiegeln. Tauchen Sie ein in die faszinierende Welt der Informatik und entdecken Sie die neuesten Erkenntnisse, Ideen und Lösungen unserer Absolventinnen und Absolventen.

Rapperswil, im September 2023

**Prof. Mirko Stocker**  
Studiengangleiter Informatik

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- 34 Zahner Thomas
- 28 Zimmermann Ursin

# Plattform für Crowd-Sourced Accessibility Testing von Komponenten aus Web UI Libraries

Diplomand



Mathias Lenz

**Ausgangslage:** Bei der Entwicklung von Webanwendungen werden häufig Bibliotheken mit vorgefertigten User-Interface-Komponenten verwendet, sogenannte UI Libraries. Diese werden meist aufgrund des Aussehens und Funktionsumfangs ausgewählt.

Für Projekte mit Anforderungen im Bereich Accessibility ist es schwierig, eine passende UI Library auszuwählen, da UI Libraries sehr heterogen sind und es keine spezifischen Accessibility-Standards für sie gibt. Von den beiden tangierenden Standards zielen die Web Content Accessibility Guidelines auf fertige Webseiten ab und sind darum nur in einzelnen Bereichen für UI Libraries anwendbar. Die ARIA Authoring Practices Guidelines fokussieren sich in erster Linie auf die Spezifikation und Anwendung von zusätzlicher Annotation von UI-Komponenten für assistive Technologie, regeln aber nicht das Verhalten der UI-Komponenten selber.

**Vorgehen:** Um Entwicklungsteams bei der Auswahl einer UI Library zu unterstützen, wurde eine Webanwendung prototypisch entwickelt, die auf einem selbst entwickelten Kriterienkatalog für drei Typen von UI-Komponenten basiert.

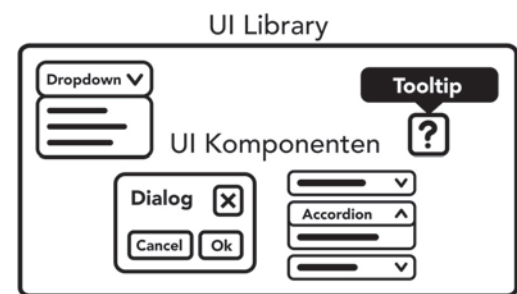
Die Kriterien wurden anhand der erwähnten Accessibility-Standards aufgestellt und wurden pro Komponente in zwei Gruppen aufgeteilt. Einmal liegt der Fokus auf der Bedienbarkeit mit der Tastatur und einmal auf der Benutzbarkeit mit dem Screenreader. Die Bewertung wird anhand der erfüllten und nicht erfüllten Kriterien vorgenommen. Die Anwendung bietet dafür einen Workflow, der ein schnelles und unkompliziertes Testen erlaubt. Jede Komponente und UI Library erhält einen Accessibility-Score, anhand dessen man ablesen kann, wie gut eine Library im Bereich Accessibility aufgestellt ist.

Um die präsentierten Resultate glaubwürdig zu machen und um die grosse Menge an potentiell zu prüfenden UI Libraries bewältigen zu können, wird auf Crowd-Sourcing gesetzt. Das heisst, interessierte Personen können selber UI Libraries hinzufügen und Tests beisteuern und der Vorgang ist transparent und nachvollziehbar. Um Testresultate einzelner Testpersonen zu validieren, können Tests mehrfach durchgeführt werden.

**Fazit:** Die entwickelte Webanwendung «Project Cactus» bietet Besuchern Informationen zur Accessibility verschiedener UI Libraries. Somit kann in Projekten die Evaluation einer UI Library unterstützt werden. Ebenfalls können durch die Webanwendung unterstützte Tests durchgeführt werden.

Der Prototyp wurde mittels Usability-Tests und einer Accessibility-Evaluation geprüft und konnte im Zuge dessen, abgesehen von verschiedenen kleineren Verbesserungen, validiert werden. Die Grundlage für die Entwicklung einer erweiterten Version mit ausgebautem Kriterienkatalog und erweitertem Funktionsumfang für Administration, Deployment, Sicherheit und Performance wurde damit geschaffen.

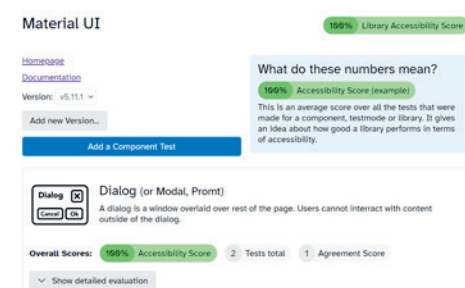
**Eine UI Library besteht unter anderem aus UI-Komponenten**  
Eigene Darstellung



**Startseite von Project Cactus**  
Eigene Darstellung



**Beispielansicht einer UI Library mit Testresultaten für die Dialog-Komponente**  
Eigene Darstellung



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Themengebiet  
Application Design,  
Internet-Technologien  
und -Anwendungen,  
Verschiedenes



# Conceptual Design of a Mobile-Based User Interface for Eye Workouts

## Graduate Candidate



Leonie Däullary

**Objective:** The objective of this thesis is to develop a mobile application that aims to make eye workouts more accessible to a wider audience, specifically targeting individuals suffering from headaches or migraines. The study focuses on investigating the research questions surrounding the development of the user interface and employs a user-centered approach to effectively address the challenge. By developing a mobile app that guides users through the process of specific eye exercises, the objective is to provide a convenient and accessible solution that can be practiced independently.

**Approach:** The study follows a conceptual design process that includes a literature study, competitor analysis, requirement identification, user-centered interface design, technology evaluation, prototype implementation, and final evaluation. Research questions addressed in this study are:

**Target Group:** Identify the target audience to tailor the app experience to their preferences and needs.

**Feedback Mechanisms:** Explore reliable feedback methods to ensure correct execution of workouts.

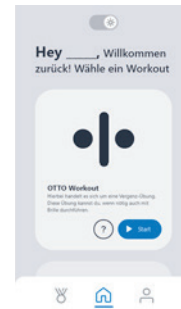
**User Retention:** Develop strategies to encourage regular app usage for long-term benefits.

**Conclusion:** A functional prototype, an angular web app, was created based on an extensive conceptualization. The implementation highlighted the importance of customization options to optimize eye workouts for different users. The study provides valuable insights for further development, focusing

on enhancing personalization, adherence to usability principles, and improving user engagement. The recommendations and evaluation findings serve as a foundation for future iterations and improvements of the application.

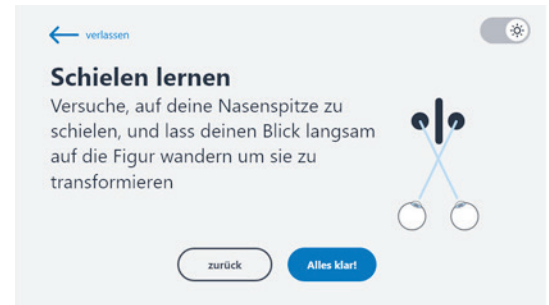
## Mock-up entry point

Own presentation



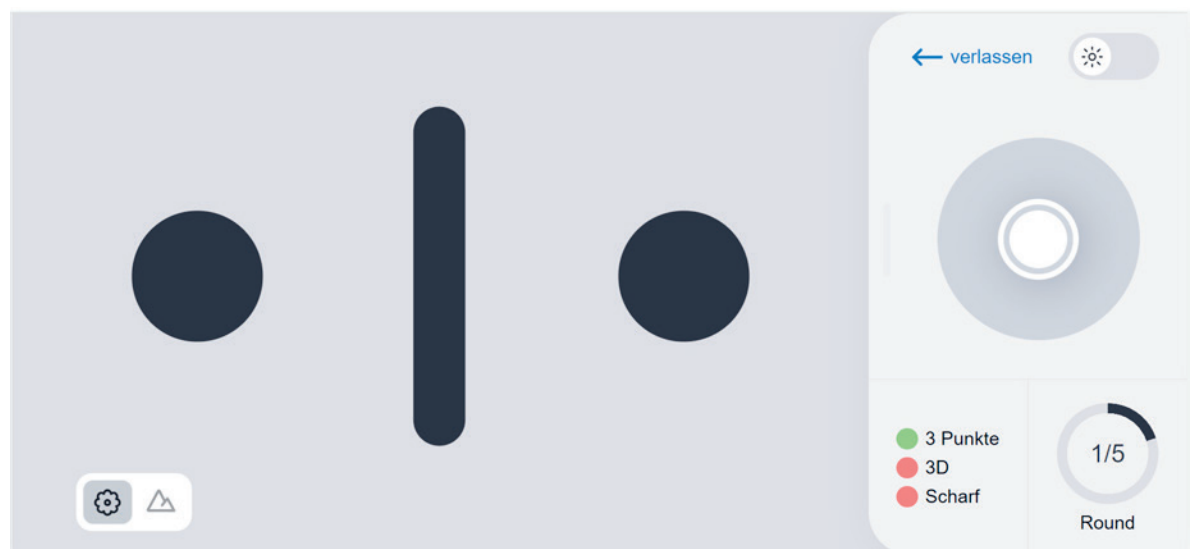
## Mock-up workout tutorial

Own presentation



## Screenshot workout

Own presentation



## Advisor

Prof. Dr. Frieder Loch

## Co-Examiner

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## Subject Area

Application Design,  
Software

## Project Partner

Prof. Dr. Karin Kovar,  
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Kauf, Zurich, ZH

# Test Result Viewer

## Graduate Candidates



Luzia Kündig



Olivier Lischer

**Problem:** Any kinds of tests in software are an important tool to improve software quality and robustness when changes must be made. Typically, automated tests can be run locally on the developer's machine or centrally using continuous integration, triggered by changes to a central repository. However, the benefits can only be leveraged if the test results are presented in a way that helps in the development process. In existing solutions that represent test results graphically it is often the assumption that test results are only relevant if something went wrong. In case of a successful execution, no details are presented to a developer except the final result «all passed». In the particular case at Sonova, running and evaluating tests is more complex than this. There are tests that depend on specific hardware to run, tests that run up to 100 times in one test execution, tests that only run during the night or on weekends because of their duration. The current test result visualization tools suffer from various deficiencies and need replacement.

**Approach/Technology:** Test results in different formats along with relevant metadata in a separate file are produced by the current infrastructure at Sonova. This data should be received, parsed and transformed into a unified schema using the Data Consumer component. Then the data is saved and displayed by the Test Result Viewer. According to our own research, some recommendations and experience present at Sonova, we chose Python for the Data Consumer and Elasticsearch and Angular to implement the Test Result Viewer.

**Conclusion:** We implemented a platform to display test results in various views fulfilling Sonova's

requirements. The common database schema we created largely depends on the data that is available in the different result formats and the data that is needed by the users of this tool. By using a separate file to provide metadata it will be easy to add more information in the future. The visualizations we created require good knowledge of the Elasticsearch querying tools and response formats. The abstraction of these specifics inside the front end allows creating additional views easily if needed.

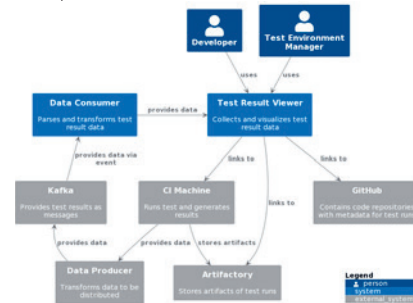
## Existing tool by Sonova

Sonova AG



## Architecture context

Own presentment



## Test Result Viewer

Own presentment

### Testcase History - Sonova Test Result Viewer

Filter Query

Search by Comment

Branch

Assignm...

# of Commits  
0

Apply

Query string syntax Database Schema

Select Timespan:

24 Hours

7 Days

Clear Query

Success
Failure
Ignored
Inconclusive
Error

Test Case	Health	Comment	Assignment
ComponentATests.IntegrationTests.Services.ConfigurationParams			
ComponentATests.IntegrationTests.Ser...	!	click to add...	click to add...
ComponentATests.SystemTests.ComponentD.OperationOperation			
ComponentATests.SystemTests.Comp...	x	click to add...	thomas.corbat@sonova.com
ComponentATests.SystemTests.Comp...	✓	See Issue #123	click to add...
ComponentATests.SystemTests.Comp...	✓	click to add...	click to add...

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# FlatFeeStack Go-live

## Graduate Candidates



Andy Pfister



Pascal Knecht



David Kalchofner

**Initial Situation:** FlatFeeStack is a platform that allows companies and individuals to sponsor open-source projects. Compared to other sponsoring platforms, FlatFeeStack has a fixed annual subscription of 125 dollars instead of paying for each project individually. FlatFeeStack will analyze the contribution of each project member using Git metrics and distribute the funds accordingly. Payouts are done in cryptocurrencies to keep the payout process simple and transparent.

The platform has been in development for several years but is mostly feature-complete. After adding remaining missing features, the platform should be launched, using a cloud provider to keep operation efforts low.

**Approach/Technology:** The project started by conducting functionalities already built into the platform, identifying missing or incomplete features. A list of tasks to complete was compiled in discussions with the advisor and expert, and a go-live date was set. DigitalOcean was chosen as a platform provider for the production instance. The different microservices which compose the FlatFeeStack platform were deployed as services under a common domain. For a simple deployment process, Docker images are built from GitHub Actions and pushed to the DigitalOcean registry. Metrics are collected using Prometheus and displayed using Grafana, completing a modern, cloud-native deployment.

The existing decentralized autonomous organization (DAO) should receive a new component to discuss proposals. The forum allows users to create posts and comments. The forum observes the Ethereum blockchain, taking action when certain events happen in the DAO, for example when a new proposal gets created. As different papers have been written about FlatFeeStack, as well as the advisor and expert working on the platform in their free time, a complete overview over features on the platform had to be created. These are documented now in the form of use case diagrams. A test plan was created to ensure those use cases worked, as well as bugs fixed that occurred during testing.

**Conclusion:** The platform was silently launched successfully on 2 June 2023. The first contributions to open-source projects were even distributed the very same day.

Given the time constraint, some work had to be excluded. For example, some major library updates still need to be done. This was either due to them being released late in the project (Hardhat toolbox v3) or other dependencies not yet ready for the new version like neow3j not having support for Gradle v8. Cryptocurrency pay-ins still need to be activated, as

the integration with the respective payment provider was not extensively tested.

The platform is now in good shape for potential users and developers to continue improving it. Users benefit from the changes and improvements made in the front end. The developers benefit from a good code base with up-to-date libraries and the designed continuous integration and continuous deployment. The chosen deployment with GitHub Actions, DigitalOcean, containers, and the monitoring infrastructure with Grafana and Prometheus are considered state-of-the-art in the industry. The forum component will help in the daily business of the DAO, allowing members to communicate with each other easily.

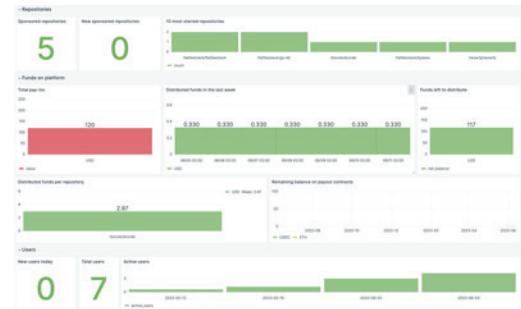
## C4 system context diagram

Own presentation



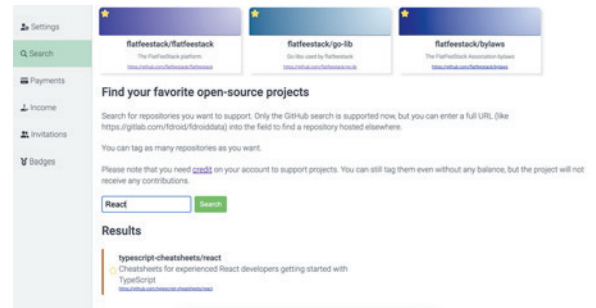
## FlatFeeStack Grafana dashboard

Own presentation



## FlatFeeStack search repository page

Own presentation



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**Subject Area**  
Internet Technologies and Applications, Software

# Optimization Swisscom Design System – Chart Components

## Graduate Candidates



Florian Blum



Niklas Kaesler

**Initial Situation:** Swisscom AG currently uses a design system known as Swisscom Digital Experience (SDX). This platform provides a repertoire of reusable components, along with well-defined guidelines, to facilitate the creation of static web pages and web applications specific to Swisscom AG. Within the SDX framework, three different types of chart components are provided: a pie chart, a horizontal bar chart and a vertical bar chart. As part of an ongoing effort, Swisscom AG is in the process of migrating these legacy chart components to more modern, standardised web components that have a consistent and unified structure. While the pie chart has already been optimised to conform to web component standards, the remaining chart implementations continue to rely on rudimentary technologies such as HTML, Sass and TypeScript. Furthermore, the use of these legacy chart components fails to enforce a consistent design and usage approach, resulting in inconsistent visual representations and confusing code readability. The objective of this thesis is to reimplement the legacy chart components into web components by leveraging the capabilities of the Stencil library, accompanied by the use of scalable vector graphics (SVG).

**Approach/Technology:** A comprehensive analysis of the legacy chart components was undertaken to clarify the required functionality and identify potential areas for improvement. This analysis focused on the horizontal and vertical bar charts. By examining the functional requirements of these chart components, a new design approach was formulated. The objective was to create chart components with a consistent design and improved usability. Swisscom AG specified the use of specific technologies to accomplish this task. Key technologies used include the Stencil library, which serves as the basis for implementing web components, SVG (scalable vector graphics), which is used to display scalable graphics, and anime.js, a library that facilitates the creation of appealing and seamless animations. A prototype of the proposed solution was developed for testing and familiarisation purposes. The implementation of the new web components was then started using an agile development process. Finally, usability and user experience (UX) tests were conducted to validate the viability of the chart components in terms of developer usability and user experience.

**Result:** To ensure timely delivery of a high quality product, only the horizontal bar chart component was implemented. This component handles input attributes and generates rendered output in the web browser, as shown in figure 3. It displays error messages for incorrect or inconsistent data input. The

visual design is consistent, responsive and improves user experience across desktop and mobile devices. All necessary information is visible without additional user interaction. Using SVG, the component displays colored stacked bars and associated labels. Design constraints outlined by SDX have been incorporated. Rigorous testing, including manual testing and a code test suite, verifies the correct behaviour of the web component. The component is delivered as a web component that can be initialised using a single HTML tag. This approach enhances the usability of the component within HTML, as depicted in figure 1. The results of usability testing indicate positive feedback regarding the use of the chart. In addition, UX testing shows improvements in readability and comprehension compared to the legacy chart component.

**Figure 1: Side-by-side view of legacy and new component initialisation code**

Author-created illustration

Legacy	New
<pre>&lt;div id="my-chart" class="bar-chart-horizontal bar-chart-horizontal-unlimited" data-max="500" data-unit="CHF" data-precision="2"&gt;   &lt;div class="js-data-list"&gt;     &lt;div class="js-data" data-value="199" data-color="turquoise"&gt;       Subscription     &lt;/div&gt;     &lt;div class="js-data" data-value="40" data-color="orchid"&gt;       Additional     &lt;/div&gt;   &lt;/div&gt;   &lt;div class="bar-chart__detail"&gt;     &lt;div class="detail-left"&gt;Sandra's Mobile XL&lt;/div&gt;     &lt;div class="detail-right"&gt;&lt;/div&gt;   &lt;/div&gt;   &lt;div class="bar-chart__progress"&gt;&lt;/div&gt; &lt;/div&gt;</pre>	<pre>&lt;sdx-horizontal-bar-chart   unit="CHF"   precision="2"   data={     {       "value": 5,       "category": "InOne mobile prepaid go",       "subcategory": "Subscription Cost",       "maxValue": 20     }, {       "value": 3.65,       "category": "InOne mobile prepaid go",       "subcategory": "Additional Cost"     }   }&gt; &lt;/sdx-horizontal-bar-chart&gt;</pre>

**Figure 2: Render of the legacy horizontal bar chart component**  
<https://sdx.swisscom.ch>



**Figure 3: Render of the new horizontal bar chart web component**  
Author-created illustration



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Schlieren, ZH

**Subject Area**  
Internet Technologies  
and Applications,  
Software

**Project Partner**  
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ZH

# Smart Knowledge Capture: Filter Editor

## Diplomanden



Daniel Frick



Zvonimir Serkinic

**Ziel der Arbeit:** Boole's Ausdrücke, welche auf mathematischen Grundlagen, nämlich der Booleschen Algebra, basieren, sind in der Informatik allgegenwärtig. Sie können unter anderem genutzt werden, um Filterausdrücke zu definieren. Solche Ausdrücke können beliebig lang als auch komplex werden.

Im Rahmen dieser Arbeit sollen Konzepte entwickelt werden, welche Nutzende bei der Erstellung solcher Filterausdrücke unterstützen. Die erarbeiteten Konzepte sollen dabei in einem Prototyp implementiert werden, sodass am Ende ein Filter-Editor entsteht, welcher es ermöglicht, Filterausdrücke auf möglichst benutzerfreundliche Weise zu erstellen.

**Vorgehen/Technologien:** In der ersten Phase der Arbeit wurde eine Literaturrecherche durchgeführt und es wurden parallel dazu erste Konzepte entwickelt. Basierend auf den erarbeiteten Konzepten konnte dann ein erster Prototyp mit Figma gebaut werden. Dieser Figma-Prototyp wurde anschliessend iterativ evaluiert und verbessert. Dabei wurde einerseits wiederholt Feedback von Fachleuten der STAR AG eingeholt und andererseits wurden User Tests mit Mitgliedern der technischen Redaktion der STAR AG als auch mit weiteren Testpersonen durchgeführt. Dies wurde so lange gemacht, bis ein zufriedenstellender Prototyp entstanden ist.

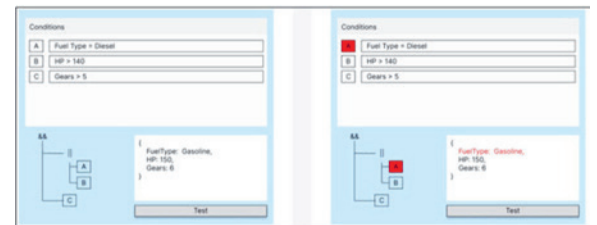
In der zweiten Phase der Arbeit wurde dann eine Web Component, welche auf dem entwickelten Figma-Prototyp basiert, entwickelt. Für die Implementierung wurden TypeScript und Stencil.js verwendet.

**Ergebnis:** Das Resultat ist ein Filter-Editor in Form einer Web Component. Der Filter-Editor bietet dabei

alle grundlegend notwendigen Funktionen, um einen beliebigen Filterausdruck zu erstellen. Für die Darstellung des Filterausdrucks gibt es zwei Ansichten: eine Baumansicht und eine Zeilenansicht. Die Baumansicht ermöglicht es, einen Filterausdruck auf einfache Weise per Drag-and-drop zusammenzustellen und zu verändern.

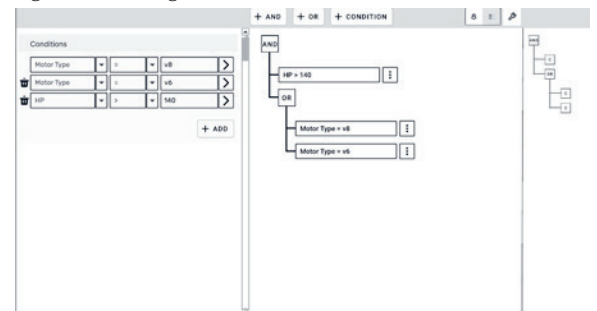
## Erstes Mock-up

Eigene Darstellung



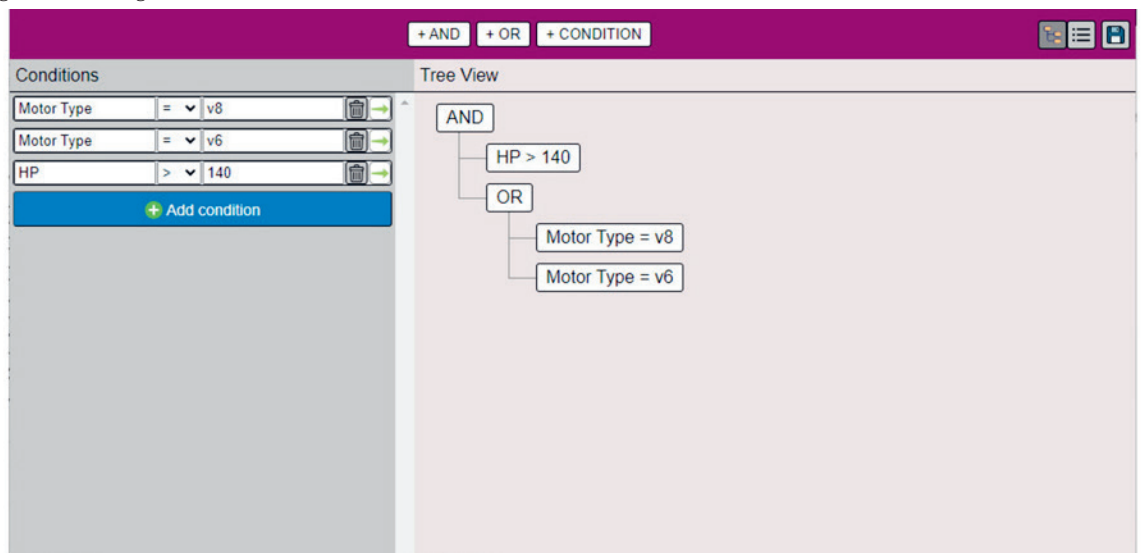
## Finale Version des Prototyps

Eigene Darstellung



## Filter-Editor als Web Component

Eigene Darstellung



## Referent

Prof. Dr. Frieder Loch

## Korreferent

Dr. Dominic Gorecky,  
Switzerland Innovation  
Park Biel / Bienne, Biel  
/ Bienne, BE

## Themengebiet

Internet-Technologien  
und -Anwendungen

## Projektpartner

STAR AG, Ramsen,  
Schaffhausen



# Vehicle Platooning Using Multi-Agent Reinforcement Learning

A study on autonomous driving in the CARLA simulator

Graduate Candidate



Benjamin Plattner

**Introduction:** The idea of autonomously driving vehicles has been around for many decades. While partial autonomy has been achieved, driverless vehicles on public roads emerged only in recent years, although in limited settings. In addition, the number of vehicles on public roads is steadily increasing, often leading to congested areas. One of the possibilities to improve the safety and to reduce congestion on public roads is platooning. In this setting, vehicles drive behind each other and form a moving queue. While platooning has been tested on highways, it mainly relies on control algorithmic approaches to mathematically model the world. In a complex traffic scenario often found in cities, not all real-life conditions can be modelled as a mathematical formula. A different approach is to use machine learning, specifically reinforcement learning, where an agent learns a task by repeating actions and receiving rewards depending on how good the outcome was.

**Objective:** Training a model using reinforcement learning requires thousands of iterations to make any significant progress. A simulated 3D environment is best suited to repeatedly train and test such a model. This thesis uses a state-of-the-art 3D environment simulator for autonomous driving, suitably called CARLA («car learning to act»). It is an open-source simulator especially designed for research that provides realistic maps of towns, real world physics, various vehicle types, and simulation of real-world traffic scenarios. In this thesis, we investigate how to train a model that enables a car to drive in a platoon.

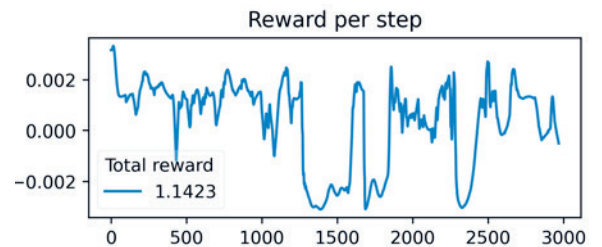
**Result:** We successfully trained a model using reinforcement learning that allows the follower to identify

the leader vehicle and follow it in a previously unseen simulated environment. It can adapt its behavior depending on the leader vehicle's actions, such as steering, slowing down and accelerating. It can operate in a multi-lane scenario and even manages to cross intersections. Building on this initial success, extensions such as obstacle avoidance, speed sign recognition, heavy traffic situations or a transfer to a real car can be further explored.

How the follower perceives the leader car through its camera  
Own presentment



An example of the positive and negative rewards received by the follower car in a vehicle platooning scenario  
Own presentment



Vehicle platooning situation in the CARLA simulator with the leader and follower car  
Own presentment



Advisor

Prof. Dr. Mitra Purandare

Co-Examiner

Dr. Sam Blakeman, Sony AI

Subject Area  
Miscellaneous

# Cloud Native Intent Automation

## Graduate Candidates



Lukas Schlunegger



Marc Eberhard



Laurent Dina

**Introduction:** Infrastructure providers, such as mobile providers, heavily rely on Kubernetes to orchestrate containerized applications. More modern and flexible cloud approaches have increased and outpaced the development of flexible infrastructure.

Nowadays, additional clusters are often being deployed manually, which is error-prone and leads to non-standardized infrastructure.

As running workloads on single clusters is manageable, having hundreds of clusters, each running different applications, depicts new challenges.

Deploying and running remote clusters brings up the need for high-performing, flexible, and private networking.

We evaluated Nephio as intent-based automation framework for service orchestration utilizing the concept of single source of truth using GitOps. Networks between the source and destination must be as flexible as the clusters to automatically ensure private and secure network routing.

This thesis aims to prove possible automation of these challenges with technologies like SRv6 packet-routing, Cilium CNI for Kubernetes, and the Nephio service orchestration platform.

**Approach/Technology:** In the first stage, the Kubernetes environments were deployed using a customized Ansible playbook based on Kubespray. The following deployment installed Cilium as CNI on the deployed Kubernetes control-plane node. Eventually, the third deployment integrated the Kubernetes environment into the central Nephio management cluster.

Nephio allowed us to deploy not only applications but network configurations as well. A substantial effort was put into network device configuration deployment to ensure networking between Kubernetes containers.

An additional optional use case was achieved by scaling Kubernetes clusters to the public cloud, which were connected to our on-premise environment.

**Result:** The Kubernetes deployment was executed successfully, enabling low-effort cluster deployments. Cilium networking was deployed, allowing new networking technologies, like source-determined routing called SRv6.

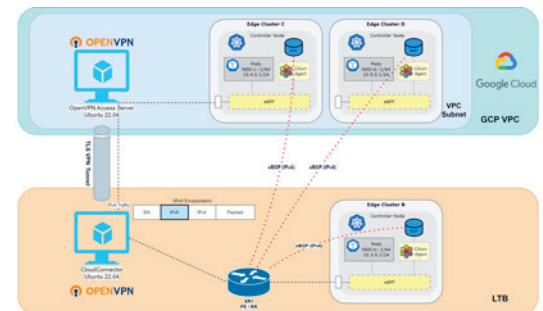
Nephio, which is still in a pre-launch condition, implements straightforward and effective workload

deployments for multi-cluster environments. As cloud-native infrastructure covers a wide range of topics, we were able to demonstrate the capabilities of further deployments like network devices or public cloud enrollment.

Our thesis, conducted as a proof of concept, demonstrates that many manually configured infrastructures may be automatically deployed.

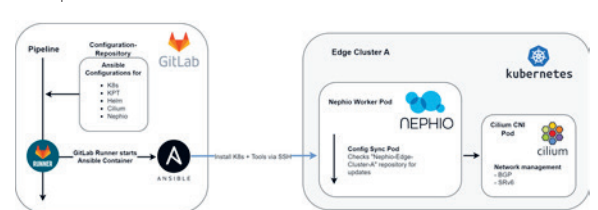
## Extension to public cloud

Own presentment



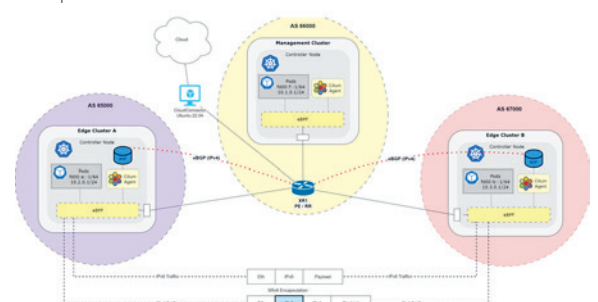
## Deployment workflow

Own presentment



## Network overview with SRv6

Own presentment



**Advisor**  
Prof. Laurent Metzger

**Co-Examiner**  
Philip Schmid,  
Wallisellen, ZH

**Subject Area**  
Networks, Security &  
Cloud Infrastructure

# Model-based Generation of Service Provider Network Topologies

## Creation of network topologies with service provider network characteristics using the MOST model

### Graduate Candidates



Lukas Ribí



Pascal Christen

**Objective:** Researchers and network engineers working for service providers need to validate network technologies to see how they scale on networks of varying sizes. Currently, these test networks are often created based on random graphs. Due to their randomness, they often lack characteristics found in real service provider networks. The goal was to develop an approach to generate network topologies with specific characteristics of these service provider networks. Furthermore, the existing graph analyzer system created during the previous term project had to be expanded to include edge weights in graph property calculations. In addition, a new graph property indicating robustness needed to be implemented.

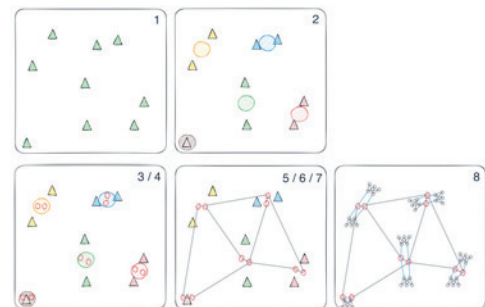
**Approach:** The MOST model (mesh-oriented service provider topology) has been developed to facilitate the generation of network topologies that structurally resemble service provider networks. The model consists of eight steps and is parameterised to provide flexibility in the generation process. The model is inspired by existing methodologies and uses approaches that lead to characteristics matching service provider networks. A Gabriel graph is used to create the topology with additional optimisations to ensure redundancy. In other published papers, it has been documented that this type of graph reflects backbone networks well. The newly created Graph Generator application uses the MOST model to generate topologies. An API provides the ability to interact with it. The front end of the graph analyzer system has been extended to integrate the Graph Generator. It allows the seamless generation and visualisation of topologies using adjustable model parameters. The generated result can subsequently be imported into the graph analyzer system. Graph property calculations have been extended by incorporating edge weights from imported topology data. An approach using a targeted attack on high-degree nodes was chosen to calculate the robustness of a graph.

**Conclusion:** During the bachelor's thesis, the MOST model was developed to generate network topologies with service provider network characteristics. Due to the underlying use of the Gabriel graph, the number of edges is minimised while still providing redundancy through alternative paths. This property reflects service provider network requirements from a cost and availability perspective. Known issues of the Gabriel graph, such as stub links, are mitigated through applied optimisations. The model has been integrated into the graph analyzer system as a separate application. This separation allows the straightforward integration of the MOST model via the Graph

Generator application into other systems and contexts. In addition, the results can be imported into other applications by providing the generated topologies in the commonly used GEXF and GraphML file formats. The resulting graph analyzer system provides an easy way to examine how networks are structured and can generate new topologies through the Graph Generator application. The source code is publicly available and published under the permissive MIT license.

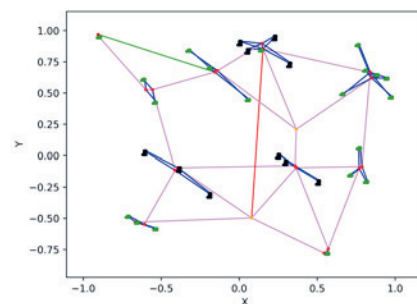
### Simplified MOST model process visualisation

Own presentment



### Generated network topology

Own presentment



### Application of the model on random Swiss city locations

Own presentment [map source: © swisstopo]



### Advisor

Prof. Laurent Metzger

### Co-Examiner

Marcel Witmer, Cisco Systems (Switzerland) GmbH, Wallisellen, ZH

### Subject Area

Networks, Security & Cloud Infrastructure, Software

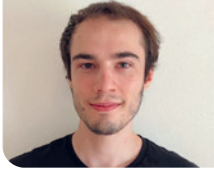
### Project Partner

Cisco Systems, Machelen, Belgium

# Crypto Agility

## Transition to post-quantum safe algorithms for secure key exchange and certificate generation

### Graduate Candidates



Christopher Hilfing



Lara Gubler



Petra Heeb

**Introduction:** The quantum era is arriving, which poses a significant threat to traditional encryption and public-key cryptography standards.

Quantum computing breaks many cryptographic algorithms as the underlying mathematical problems could be solved by quantum computers within a short time. With the arrival of quantum computers, cryptographic algorithms have also evolved. New quantum-safe algorithms have been recently standardised, but only a few applications already use them. To ensure a secure environment this will need to change.

Faced with these challenges and the rapid improvements in the area of quantum computing, the global cybersecurity landscape plunges into a highly precarious state.

**Approach:** This bachelor thesis aims to demonstrate how two recently standardized post-quantum secure algorithms can be used by testing their compatibility with a Hardware Security Module (HSM) in a controlled environment. To demonstrate how these could be implemented in a quantum-safe manner at a later stage, two different use cases will be realized. The used quantum-resistant algorithms CRYSTALS-Kyber and CRYSTALS-Dilithium are based on the module lattices problem.

First, two Proof of Concepts (PoCs) were implemented, that demonstrate the compatibility between the HSM and the two CRYSTALS algorithms. The use case: Bring Your Own Key (BYOK) demonstrates how locally generated keys can be imported into the HSM in a quantum-safe manner. In this demonstration, the Key Encapsulation Mechanism (KEM) CRYSTALS-Kyber is used to generate a shared secret so that the client application can communicate to the HSM using the Advanced Encryption Standard (AES).

The second use case focuses on a Public Key Infrastructure (PKI) based on a post-quantum secure infrastructure. The HSM is used as a key store to secure the identity of the Root Certificate Authority (CA), which acts as the root of trust. This ensures that keys are never exposed in clear text in memory. Furthermore, the quantum-safe signature scheme CRYSTALS-Dilithium is used to sign certificates which further increases security.

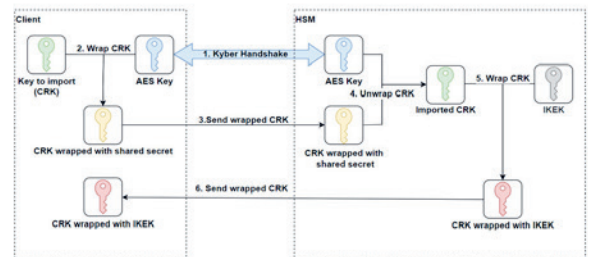
**Result:** The outcomes of this research provide valuable insights into the implementation of quantum-safe algorithms in practical high-security scenarios. In addition, the implementations facilitate the replication of a similar use case for an enterprise archi-

ture and the transition from today's legacy algorithms to the new secure post-quantum algorithms with increased efficiency.

Both the BYOK and PKI implementations could also be extended to provide more functionality, and higher security standards based on the algorithm versions or protocol used. The PKI implementation could also be further improved by using a quantum-safe variant of Transfer Layer Security (TLS).

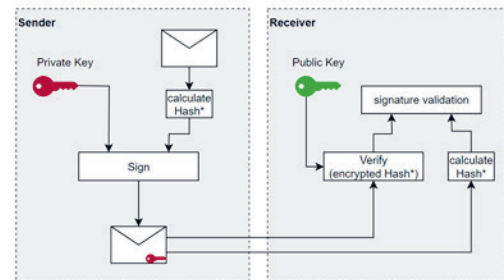
### Bring Your Own Key (BYOK) vision (simplified)

Own presentation



### Signature process

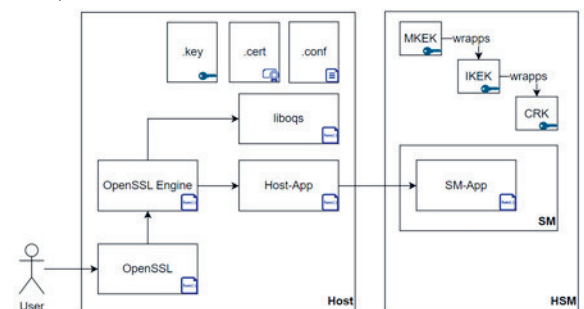
Own presentation



\* Hashing is optional for a signature, Dilithium internal hashes the message before signing.

### Public Key Infrastructure (PKI) vision

Own presentation



**Advisor**  
Prof. Dr. Mitra Purandare

**Co-Examiner**  
Dr. Bernhard Tellenbach, Cyber-Defence Campus, Zurich, ZH

**Subject Area**  
Security

**Project Partner**  
IBM Research Europe, Zurich, ZH

# Open-Source Intelligence Training in Hacking-Lab

Graduate Candidate

Damian Dasser

**Initial Situation:** In cyber security the topic of open-source intelligence (OSINT) plays a major role. With OSINT security defender a researcher may find valuable information about cybercrime and attackers. OSINT helps to understand the effects of sharing public information. OSINT is not yet part of the curriculum at OST. An e-learning platform called Hacking-Lab already exists and is used at OST. In Hacking-Lab, students can apply what they have learned in the lecture in a controlled environment in the form of practical hands-on exercises.

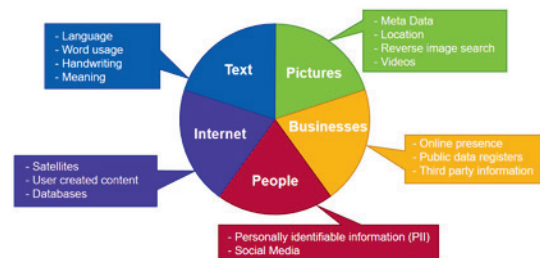
**Objective:** The goal of this thesis was to create ten OSINT challenges in the Hacking-Lab for students to solve and practice. In every OSINT challenge, students are given a set of tasks and summative assessment questions. The students are guided through the proposed steps in order to answer the posed questions in form of a write-up. Each OSINT challenge is framed by a story to make it more engaging. These stories were chosen in a way that many different OSINT techniques are applicable and can be practiced by the students. In OSINT there is not only one way to find the correct answer hence the students are also encouraged to find their own way to reach the expected solution. To guarantee a high quality of the challenges, multiple quality assurance tests were conducted with students and colleagues working in IT. The results of these quality tests are an indicator whether the goal was reached.

**Result:** As a result of this work, the goal of creating ten OSINT challenges in Hacking-Lab was achieved. These challenges provide some insight into the topic of OSINT without getting lost in details and technical-

ities. This project provides a foundation which a lecturer can build upon by creating a lecture on OSINT. This lecture could be integrated in a course on cyber security. Social media was purposely neglected in this project because social media is difficult to maintain and to make future-proof, which makes it incompatible with the project's requirements. Therefore, it could also be a future project to expand upon these challenges with a focus on social media as it is an indispensable part of OSINT.

## OSINT categories used in this thesis

Own presentation























## Challenge example: What did the sign this CCTV camera is mounted on say in 2018?

Center Harbor Inn



## The created challenges in the Hacking-Lab

Hacking-Lab AG

#	Name	Categories	Level	#	Name	Categories	Level
1	 01 - Scamming Personal Information b39b6263-141a-4f0c-8927-302011005909		easy	6	 06 - Show What You Have Learned 69d55549-87a8-40fa-bb2a-08be8fdd6d2		medium
2	 02 - The Propagandist's Information 825a00be-5474-402c-aaf3-2911a4ee0929		medium	7	 07 - Vulnerability Information 45432868-540a-490e-8684-2d4873490c76		novice
3	 03 - Time for Waste 00dc1ee0-5b05-4e0c-ad34-9c0d3225c845e		easy	8	 08 - Run After Ransomware 3306164a-5b4a-4c6e-b1fc-79d2998e0956		medium
4	 04 - Validate Internet Post 88df05bc-aaa5-4c2c-84f6-8985dcb07bfa		easy	9	 09 - A Car's History 65033668-4b98-4b22-b790-1dbbeefb6a7e		novice
5	 05 - Third Party Software Contributions 8be49b43-5afe-490c-9477-5b06808763a7		easy	10	 10 - Malicious Gamer 739cb77-fff6-43c4-883f-3141d8e9e0d8		easy

Advisor  
Ivan Bütler

Co-Examiner  
Vanessa Procacci,  
Kantonspolizei Aargau  
/ IT-Forensik &  
Cybercrime IFC,  
Rapperswil, AG

Subject Area  
Security

# Cyber Shield

## Automated responses to cybersecurity threats

### Graduate Candidates



Dominik Ehrle



Marco Agostini

**Initial Situation:** Cybersecurity threats continue to pose a major challenge to organizations. There is an abundance of technologies and products assisting the detection and investigation of cybersecurity threats. However, supporting security operation teams to respond to threats has received limited attention. Modern Intrusion Prevention Systems (IPS) provide the possibility to react in real time to cybersecurity threats but still lack the ability to predict the impact of the responses on the IT infrastructure.

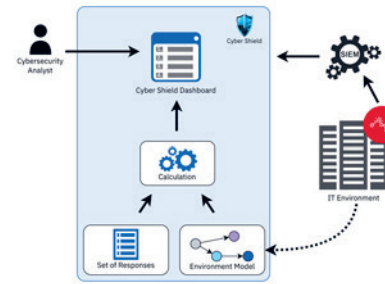
**Approach:** The work focuses mainly on supporting the cybersecurity analyst in the decision-making process to select the best-suited response to a cybersecurity threat. The decision-making process is enhanced by additional information regarding the IT infrastructure. The responses of a predefined set are compared to the alert attributes to determine the possible responses and their impact on the IT environment. Additionally, the possible responses are prioritized by calculating their impact cost. Consequently, the analyst can decide on the preferred response, considering the impact on the IT environment. The application consists of a front end, back end and persistency tier. The front end provides a dashboard, containing relevant information about the alert in order to decide on the best-suited response. Furthermore, it allows the triggering of the desired response. The back end implements an API providing all the required end points for interaction, e.g., creating the abstract environment model of the IT infrastructure and persisting it in a graph database.

**Result:** The Cyber Shield application implements procedures to handle cybersecurity threats. It pro-

vides automated response determination capabilities, where the responses of the predefined set are matched to the alert, identifying the possible responses to the alert based on its attributes. Moreover, the impact calculation evaluates the impact of a response on the IT infrastructure being represented by the environment model. Finally, the possible responses are prioritized by calculating their impact cost with the defined cost function.

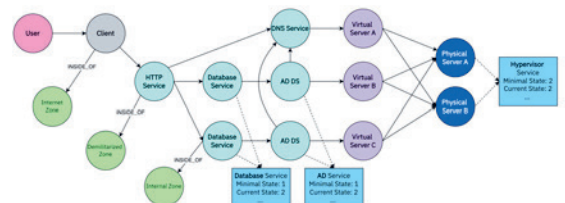
### Cyber Shield application overview

Own presentation



### Cyber Shield environment model

Own presentation



### Cyber Shield dashboard

Own presentation

IBM

#### Alert Details

**Alert:**

**Timestamp:** 9/19/2022, 1:31:56 PM

**Event Type:** access

**Event Category:** process

**Severity:** 3

**MITRE ATT&K ID:** [T1055.001](#)

**Description:** Suspicious In-Memory Module Execution

**Hostname:** dns1.ic01.jc.crp

**Server Details:**

**Server IP:** 10.1.1.2

**Hosted Services:** • Domain Name Service

**Possible Responses:**

- Kill the process with the corresponding process ID (Affected: 1 Entity)
 

**Targeted Server:** dns1.ic01.jc.crp, IP: 10.1.1.2 Trigger Response

Affected Entity:			
Type	Name	IP	Has redundancy
Service	Domain Name Service	Hosted by: 10.1.1.2	Yes, 1
- Isolate the host from any network connections (Affected: 1 Entity)

**Advisor**  
Prof. Dr. Mitra Purandare

**Co-Examiner**  
Dr. Claudiu Duma, Credit Suisse, Zurich, ZH

**Subject Area**  
Security, Software

**Project Partner**  
IBM Research Europe, Zurich

# Reverse Engineering Lab

## Graduate Candidates



Thomas Kleb



Gianluca Nenz



Ronny Müller

**Introduction:** This bachelor thesis is based on a previously created «Reverse Engineering Lab» term project by the team, which consists of beginner level hands-on exercises (challenges) for students at OST to get into software reverse engineering. However, some important aspects were not covered in the previous lab. This bachelor thesis is geared towards advanced reverse engineering in order to go deeper and into in-depth reverse engineering techniques.

This bachelor thesis extends the existing «Reverse Engineering Lab», adding ten more complex practice labs and exercises by introducing new reversing methods, tools, and frameworks. The new and advanced exercises can then be used by the teachers at OST to lecture on the subject of reverse engineering. This gives the students a better insight into the subject and a more enriched, practical, and hands-on experience.

**Approach:** First, we created a collection of topics not yet covered in the previously created «Reverse Engineering Lab». These topics were then evaluated by the team and the advisor based on personal interest, usefulness, and importance in the field of reverse engineering. This evaluation was used to discuss which topics we should create challenges for. During the semester we used Scrum to iteratively create the challenges. Whenever a challenge was finished, it was tested by us, fellow students, and other volunteers. This process ensured the high quality of the challenges.

**Result:** The goal of this bachelor thesis, the creation of ten new reverse engineering challenges covering new methods, tools, and frameworks, was successfully achieved. All the challenges are hosted on Hacking-Lab, an online platform for cybersecurity training and ethical hacking. Hacking-Lab provides students with everything they need to improve their reverse engineering skills.

The aim was to teach students techniques that would reveal potential attack vectors. The final product is a collection of many advanced reverse engineering topics, providing deeper insight and teaching problem-solving skills.

## Advisor

Ivan Bütler

## Co-Examiner

Dr. Benjamin Fehrensens, Berner Fachhochschule, Bern, BE

## Subject Area

Security, Software

## Automation of cloud abuse report handling

### Graduate Candidates



Anina Bytyçi



Myriam Assunção

**Introduction:** In recent years, cybersecurity attacks have become an important issue in the Internet world.

There are various attacks such as phishing, malware, denial of service, etc. that aim to breach data. Public cloud providers are most affected with this issue and have to deal with it. Therefore, each cloud provider has a point of contact where issues or suspicious activity in the cloud can be reported via email, and each of these reported issues is analysed and investigated.

IBM Cloud has a dedicated team of analysts who analyse incoming reports of various types of suspected abuse in the cloud. The process of analysing the reports and deciding on the next steps consists of many repetitive tasks that are very time-consuming for any analyst. This is where an automated solution is needed to save valuable time.

**Approach:** The goal of this bachelor thesis is to implement a proof of concept that automates the manual and time-consuming tasks performed by analysts. At the beginning of the project, a detailed analysis and elaboration was performed, collecting all requirements together with the main stakeholder of the project, IBM Research Zurich. After prioritising the features to be implemented, implementation was started in the construction phase.

Throughout the project, regular meetings were held with stakeholders to receive feedback and new suggestions for improvement. The proof of concept created as the final product was then presented as a demo to analysts at IBM Cloud.

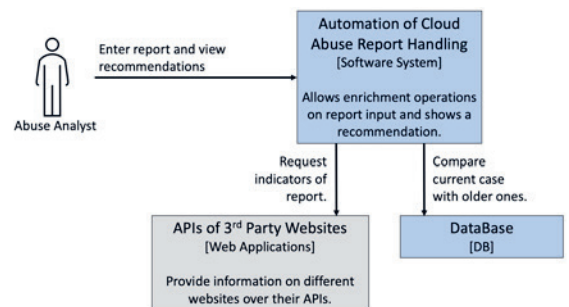
**Result:** As a result, a web application is developed where key information extracted from reports manually from emails is entered on the user interface. This information is then analysed and enriched on the back end of the product using an external API. The enriched information is then displayed on the user interface along with a screenshot of the suspicious website provided by an additional external API.

Considering different types of information such as hashes, domain names, etc. that can be extracted from reports, a major focus of this project was to build a flexible architecture for the product that would allow it to be easily extended in the future and add new functionality for new indicator types. This was achieved via message queues and task workers on the back end.

**Keywords:** cloud abuse reports, enriched reports, security analysis, FastAPI, React, MongoDB, RabbitMQ, Celery, VirusTotal API, screenshot API

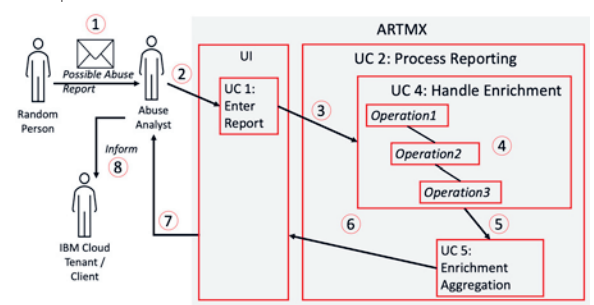
### Context diagram

Own presentation



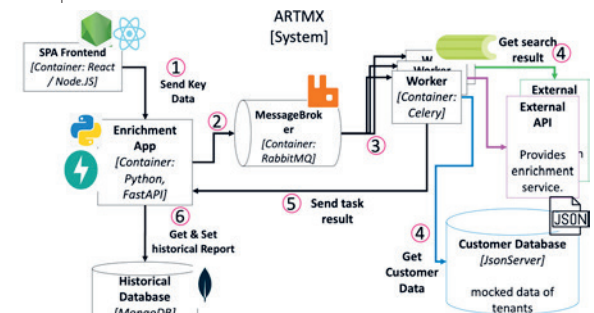
### Process flow

Own presentation



### Container diagram with all used technologies

Own presentation





# The Impact of Aggregated Leaks on Privacy

Graduate Candidates

**Introduction:** Das Internet ist für uns alle Neuland. (The Internet is uncharted territory for all of us.) – Angela Merkel, former German Chancellor

Caspar Martens

This statement still is arguably true. We still have no reference of what happens after a lifetime of usage. As we spend more time on the Internet it gets increasingly likely that a used service loses control over the data it collected. Over the decades, we add more and more data to our digital footprint. The likelihood of our private information being exposed increases, leading to potential consequences that are difficult to predict. This raises the question of whether the surging availability of personally identifiable information will increase the possibility of linking such information together and how this could be prevented.

Simon Kindhauser

**Approach/Technology:** To answer these questions we developed two complimentary approaches for analyzing a synthetic dataset based on data leaks in the real world. For this we use metadata provided by «Have I been Pwned» describing over 650 distinct leaks containing a total of 12 billion records. We further enrich this information with statistical knowledge from other sources regarding the distribution of attributes.

Both approaches analyze the data using the linkage algorithms depicted in figure 1 as well as various different mitigation strategies. They produce statistical information regarding the accuracy of the algorithms as well as the effectiveness of the mitigation strategies using the average discovery ratio as illustrated in figure 3.

The first approach generates a subset of the entire dataset with only US citizens based on a Snake-make pipeline and Python library. This dataset is then loaded into Neo4j for analysis where a user-defined procedure was created, implementing the first- and second-order algorithms. With this approach we are able to verify our algorithms and record the true-positive, true-negative and false-negative values as shown in figure 2.

The second approach simulates all records of a person – their entire attack surface – within the synthetic dataset in real time. The advantage is a generally lower memory footprint whilst providing competitive performance. This allows for the implementation of all three linkage algorithms. The main limitation is that false-positives are not possible which results in an incapacity to measure the accuracy of the algorithms.

**Result:** We show that our linkage algorithms can link 90% of leaked records, effectively creating clusters belonging to a specific person. We evaluated differ-

ent mitigation strategies regarding their levels of protection against the presented attacks as can be seen in figure 3. Using unique email addresses is the most effective single mitigation strategy against first-order linkage. However, against more sophisticated attacks we recommend a combination of unique email addresses and passwords as well as user-initiated differential privacy. Using this combined mitigation strategy can decrease the linkage effectiveness by up to 50% while being relatively easy to implement thanks to existing and well-established tooling such as password managers.

Figure 1: Linkage algorithms

Own presentation

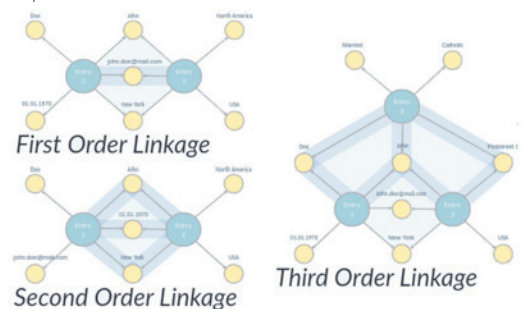


Figure 2: Confusion matrix of linkage algorithms

Own presentation

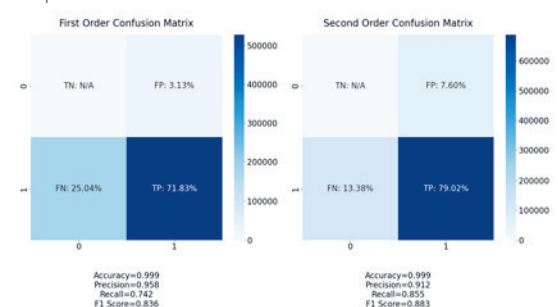
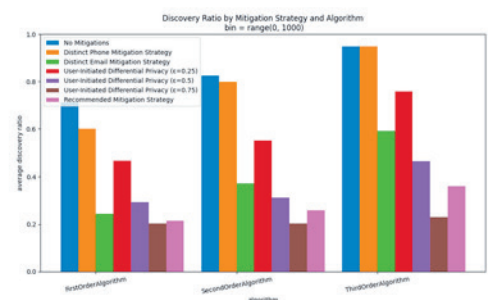


Figure 3: Effectiveness of mitigation strategies

Own presentation



Advisor

Prof. Dr. Mitra Purandare

Co-Examiner

Dr. Andreas Wespi, IBM Research – Zurich, Niederhasli, ZH

Subject Area

Security, Software, Miscellaneous

## SSoT-based network service deployment

### Graduate Candidates



Dejan Jovicic



Dominic Walther

**Introduction:** Network automation is a key aspect in modern-day networks, allowing for accurate, repeatable procedures. Single Source of Truth (SSoT)-based network deployment is often the ultimate goal. However, many of the current open-source tools fall short in terms of features, usability, or quality. NetBox is one such tool that is excellent at documenting network infrastructure, but does not offer a way to automate the deployment of the documented network.

**Approach:** This project seeks to extend NetBox's functionality by adding support for network services and implementing a mechanism for automated configuration deployment.

We chose MPLS Layer 3 VPN as our target service, which builds upon the LDP, VRF, and BGP protocols, of which only VRF was previously supported. After comparing various tools for network device configuration, we decided to use Napalm for device interactions and configuration management, with Nornir serving as a parallelization layer.

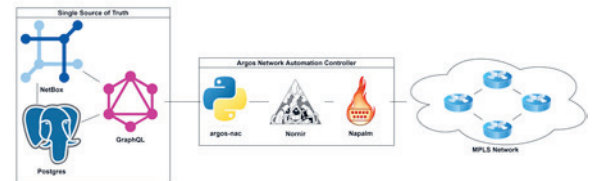
The focus throughout development was to ensure ease of extensibility and a straightforward deployment process, either interactively or as part of a script.

**Result:** The resulting software is comprised of two parts: the Argos-NetBox plug-in, which extends NetBox and adds support for the aforementioned protocols, and Argos-NAC, which queries the necessary data from NetBox and handles the generation and deployment of the various device configurations. Argos-NetBox can be used standalone and is vendor-independent, making Argos-NAC an optional addition to it.

The implemented protocols can be used separately and are designed to be interchangeable, should alternatives to them be added in the future.

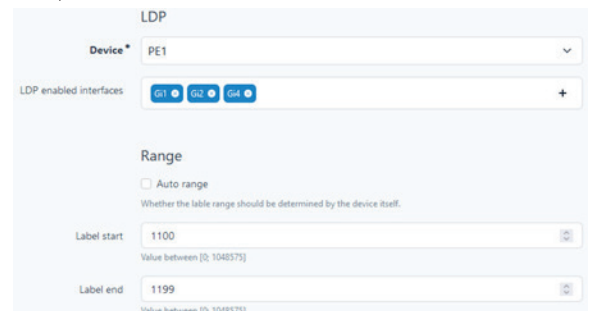
### Component overview

Own presentation



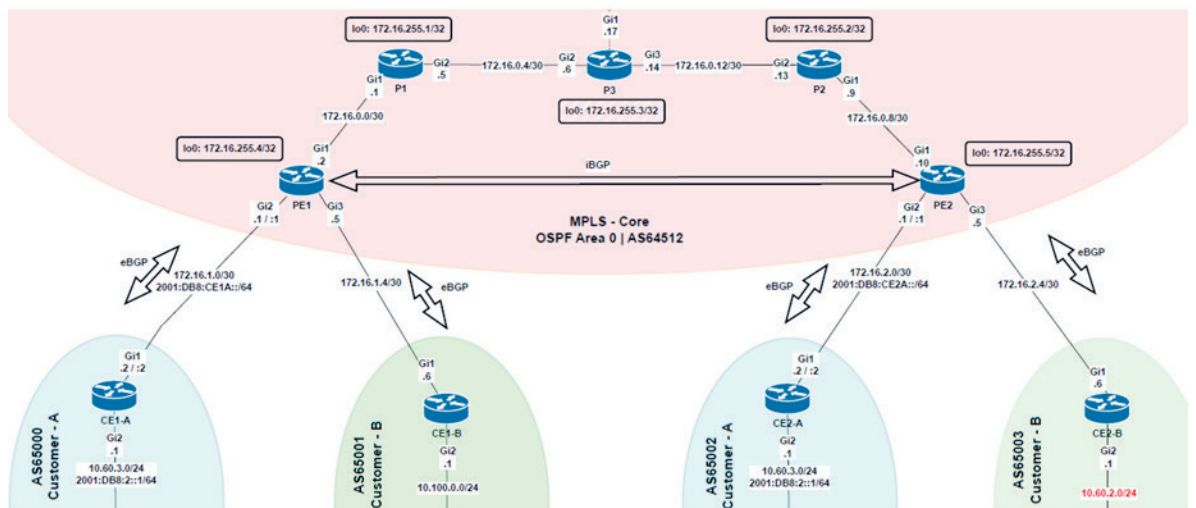
### LDP NetBox page

Own presentation



### Overview MPLS L3 VPN Lab

by Institute for Network and Security



**Advisor**  
Urs Baumann

**Co-Examiner**  
Patrick Mosimann,  
Cisco Systems  
(Switzerland) GmbH,  
Wallisellen, ZH

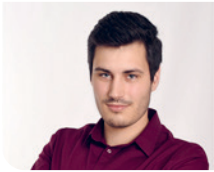
**Subject Area**  
Software

# City Trip Planner: Kurztrip-Planer für Fussgänger

## Diplomanden



Lukas Grigis



Jan Ruch

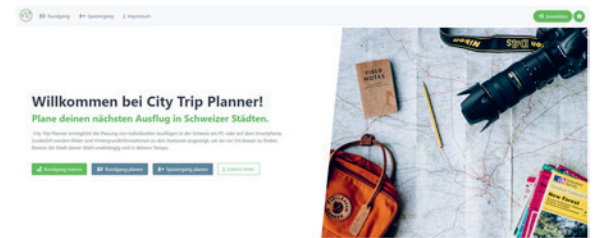
**Ausgangslage:** Die Planung von optimalen Routen findet in vielen Bereichen Anwendung. Dazu existieren zahlreiche Dienste von teils namhaften Anbietern, welche spezialisierte Lösungen erfolgreich zur Verfügung stellen. Dienste für die Planung von Fussgängerrouden gibt es vergleichsweise wenig. Mit diesem Thema setzt sich die vorliegende Arbeit auseinander. Eine Aufarbeitung von existierenden Produkten hat ergeben, dass es bislang keine Softwarelösung auf dem Markt gibt, die es Benutzer:innen ermöglicht, eine Route mit kategorisierten Interessen im städtisch-urbanen Raum zu planen. Der City Trip Planner soll diese Lücke schliessen und Tourist:innen aus dem In- und Ausland eine Plattform zur Planung solcher Fussgängerrouden bieten. Diese Arbeit basiert auf der gleichnamigen Studienarbeit und erweitert sie.

**Ziel der Arbeit:** Das Ziel der Bachelorarbeit ist es, die Erkenntnisse aus der Studienarbeit umzusetzen und in Zusammenarbeit mit Schweiz Tourismus ein weiteres Minimal Viable Product (MVP) zu erstellen. Die Hauptbestandteile der Erweiterung sind Einwegtrips (sog. Spaziergänge), ein User-Login und eine responsive Webapplikation. Als Datengrundlagen dienen namentlich OpenStreetMap (Schweiz) und als Technologien u. a. TypeScript, Angular, Python, PostgreSQL/PostGIS sowie die Routing Engines OSRM, GraphHopper und openrouteservice.

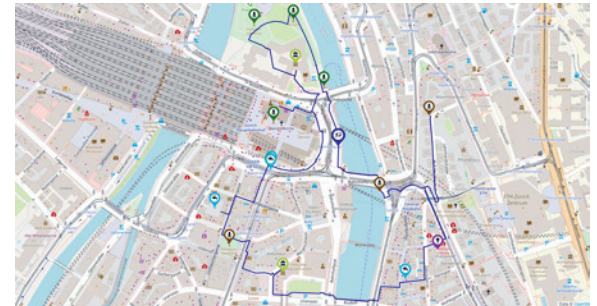
**Ergebnis:** Das MVP konnte realisiert werden u. a. mit zehn Kategorien. Besonders hinsichtlich Darstellung und Bedienung auf mobilen Geräten konnte die Applikation verbessert werden. Vorgeschlagene Stationen können einzeln entfernt werden und es

wurden zwei zusätzliche Routing Engines erfolgreich integriert. Ausserdem wurde die Kartendarstellung überarbeitet, sodass eine Unterscheidung zwischen Startpunkt und Station auf den ersten Blick ersichtlich ist. Zusätzlich wurde die notwendige kartographische Generalisierung auch auf die Stationen angewandt. Um eine geräteübergreifende Synchronisation der persönlichen Anpassungen der Applikation und die Speicherung individueller Routen zu ermöglichen, wurde ein User-Login realisiert.

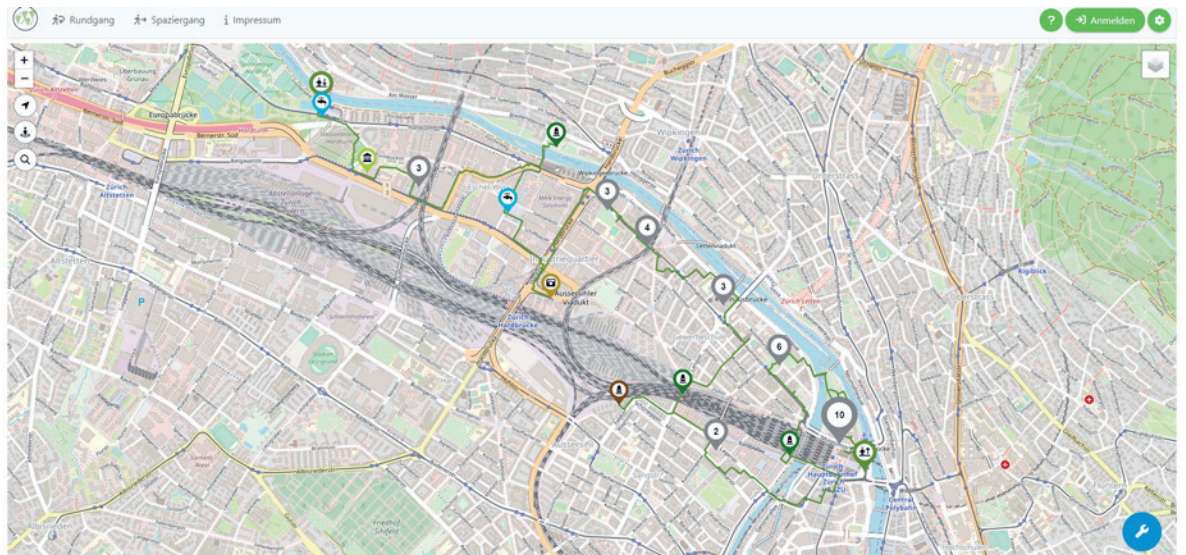
**Startseite der responsiven Webapplikation City Trip Planner mit der Wahl «Rundgang» oder «Spaziergang»**  
Eigene Darstellung



**Beispiel eines Rundgangs ausgehend vom Zürich HB mit der Kategorie «Tourismus» und einem Umkreis von 500 Metern**  
Eigene Darstellung



**Beispiel eines Spaziergangs mit maximaler Distanz und gruppierten Stationen, um die Lesbarkeit zu verbessern**  
Eigene Darstellung



**Referent**  
Prof. Stefan F. Keller

**Korreferent**  
Claude Eisenhut,  
Eisenhut Informatik  
AG, Burgdorf, BE

**Themengebiet**  
Software Engineering –  
Core Systems

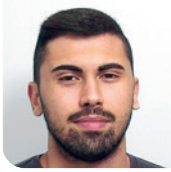
**Projektpartner**  
Schweiz Tourismus,  
Zürich, ZH

# Nutzerzentrierte Entwicklung eines digitalen Bestellprozesses für Rohmaterialien

## Diplomanden



Ursin Zimmermann



Abdullah Almaz

**Ausgangslage:** Die SFS Group AG verarbeitet interne Bestellungen von Rohmaterial zwischen der Produktion und dem Lager über einen Papierprozess. Dabei werden Bestellformulare von der Produktion in Behältern deponiert und vom Lager abgeholt, das dann die Bestellung bearbeitet und an die Produktion liefert. Dieser Prozess soll in Zukunft durch eine Software abgelöst werden, da er aktuell träge, wenig effizient und fehleranfällig ist. Im Rahmen dieser Arbeit sollte ein nutzerzentrierter Prototyp geplant, entwickelt und der SFS Group AG zur Weiterentwicklung übergeben werden.

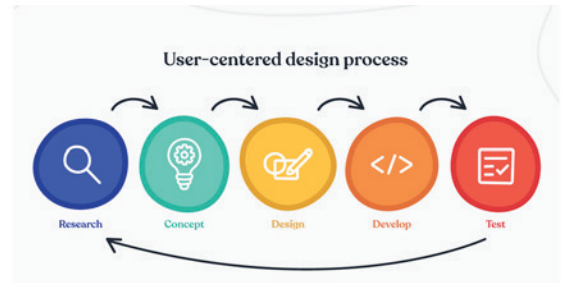
**Vorgehen:** Gemäss dem User-Centered-Design-Prozess wurde als vorgängige Analyse bei der SFS Group AG ein Contextual Inquiry durchgeführt, im Rahmen derer die Mitarbeiter und zukünftigen Nutzer der Software bei der Arbeit beobachtet und befragt wurden. Basierend auf den gesammelten Informationen wurden erste konkrete Anforderungen festgehalten und Wireframes erstellt. Diese wurden im Austausch mit der SFS Group AG und den zukünftigen Nutzern optimiert und wo nötig erweitert. Anschliessend wurde der Prototyp mit den vereinbarten Technologien entwickelt, getestet und auf einem Testserver zur Verfügung gestellt. Mit Usability-Tests bei der SFS Group AG wurde er von den Endnutzern auf Tauglichkeit geprüft. Das Feedback war positiv und die daraus entstandenen Optimierungen wurden umgesetzt oder zur Weiterentwicklung dokumentiert.

**Ergebnis:** Der entwickelte Prototyp entspricht dem geplanten Umfang und es werden weitere Anforderungen der SFS Group AG eingehalten, beispielsweise die Erfüllung der Twelve Factors und das

Schaffen einer Basis für das Deployment mit Docker Images. Bei einer gemeinsamen Evaluation mit der SFS Group AG wurde sichergestellt, dass die technischen Fragen und Unklarheiten geklärt sind und der Prototyp vom Unternehmen weiterentwickelt werden kann. Die Integration mit den Umsystemen der SFS Group AG sowie das Deployment der Applikation auf die Cloud-Umgebung werden auf Wunsch der Firma von dieser selbst durchgeführt.

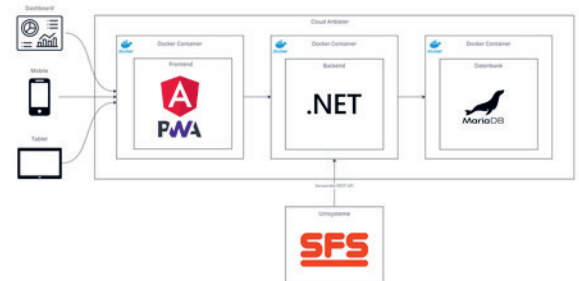
## User-Centered-Design-Prozess

<https://www.wowmakers.com/>



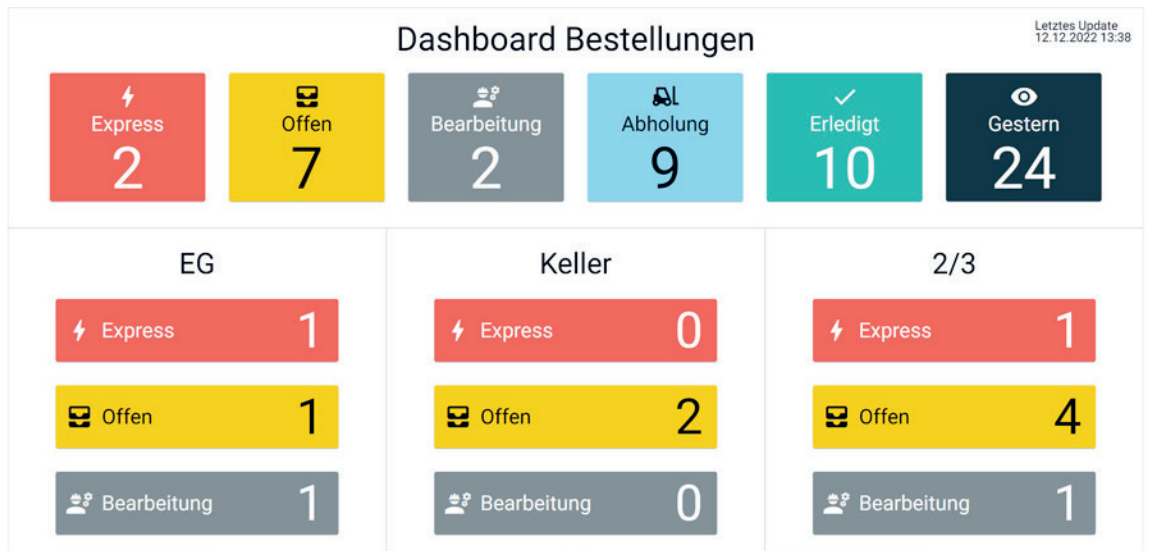
## Architektur-Übersicht

Eigene Darstellung



## Dashboard-Ansicht im Lager

Eigene Darstellung



Referent  
Prof. Dr. Frieder Loch

Korreferent  
Marius Orfgen,  
Gipfelsprint GmbH

Themengebiet  
Software Engineering –  
Core Systems

Projektpartner  
SFS Group, Heerbrugg

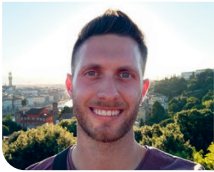
# Showroom für den zukunft.bahnhof Lichtensteig

## Entwicklung und prototypische Umsetzung eines Konzepts für ein interaktives Besuchererlebnis

### Diplomanden



Linard Vincenz



Simon Canal

**Ziel der Arbeit:** Das Ziel dieser Arbeit ist es, in einem Showroom das Projekt zukunft.bahnhof in digitaler Form erlebbar zu machen. Dazu gehören sowohl die Entwicklung eines Konzepts für ein interaktives Besuchererlebnis wie auch die prototypische Implementierung in Form einer Applikation. Zudem soll der gewählte Lösungsansatz kritisch reflektiert werden, um Möglichkeiten zur Weiterentwicklung und iterativen Verbesserung aufzuzeigen.

**Vorgehen/Technologien:** Mithilfe einer Literaturrecherche wurden mögliche Realisierungsansätze sowie Technologien erfasst. Eine Nutzwertanalyse sowie ein Workshop mit einer Fokusgruppe dienten dem Vergleich der Ansätze sowie der Wahl eines zu realisierenden Produkts.

Als Teil eines Gesamtkonzepts für den Showroom wurde eine Virtual-Reality-Applikation in Form einer Web-App realisiert. Die Applikation besteht dabei aus einem NGINX Reverse Proxy, welcher sowohl das React-Front-End wie auch das ASP.Net Core-Back-End bereitstellt. Das Areal von Lichtensteig ist in einem Unity Projekt modelliert. Die Daten werden in einer PostgreSQL-Datenbank via Entity Framework Core persistiert. Alle Komponenten werden mittels Continuous Delivery getestet, gebuildet und in Docker-Containern ausgeliefert.

**Ergebnis:** Der Prototyp dieser VR-Applikation für den Showroom ermöglicht es den Besuchenden, auf eindrucksvolle und spielerische Art Informationen zum Projekt zukunft.bahnhof zu erhalten.

Benutzende können dabei das Projektareal in Lichtensteig virtuell betrachten und sich spezifisch zu den einzelnen Teilen des Projekts informieren. Durch

die Möglichkeit der eigenen Arealgestaltung sowie Kommentar- und Feedback-Funktionen können sich Besuchende des Showrooms partizipativ im Projekt einbringen.

Da der Prototyp als Web-App realisiert wurde, kann die Applikation auch auf mobilen Geräten genutzt werden. Somit kann das Nutzererlebnis auch nach einem Besuch im Showroom noch fortgeführt werden.

### Mögliche Realisierung des Showrooms

<https://www.kreative-eventcontainer.de>



### Überblick über die verwendeten Technologien und Frameworks

<https://www.wikipedia.com>



### Sicht auf das VR-Modell der Arealgestaltung zukunft.bahnhof

Eigene Darstellung

The screenshot displays the VR application interface. On the left, there is a navigation menu with options like 'Start', 'Gestaltungen', and 'Feedback'. Below it, a table lists different 'Arealgestaltung' items with their respective actions (eye, comment, heart). The main view shows a 3D aerial view of the 'Areal Zukunft.Bahnhof' with various buildings and green spaces. A 'Chössi Theater' information panel is overlaid on the right, showing details about the theater and its use as a showroom. The panel includes a 'Kommentare' section and a 'Speichern' button. A 'Edit Modus' panel is also visible on the right, allowing users to create and edit objects in the scene.

### Referent

Prof. Dr. Frieder Loch

### Korreferent

Adrian Scherrer, SFS  
Group Schweiz AG

### Themengebiet

Software Engineering –  
Core Systems

### Projektpartner

ATMA.life

# Improving the Usability of the Haskell Substitution Stepper

Graduate Candidate



Carlo Del Rossi

**Initial Situation:** With functional programming languages becoming more widespread and being taught at universities, many programmers will eventually get in contact with them. Since functional programs can be very different from imperative ones, especially due to the heavy reliance on recursion, this could be very interesting for all the people that are not yet familiar with Haskell's concepts.

**Problem:** While functional languages like Haskell have debuggers, they are not as user-friendly and don't offer as much insight as debuggers for imperative languages. The internal state of the program is usually not displayed very comprehensively, which leads to it not being very useful for learning processes.

**Result:** The goal of the Haskell Substitution Stepper is to provide the user with the capability to step through a Haskell program and to be able to see what happens in the background when a function is executed. This is supposed to solve the usability problems that the regular Haskell debugger has.

For this, we came up with an application where the user can specify a function that he would like to step through and the application would load this function and then use Haskell's rules to step through. The user can see the whole internal state of the term that is being stepped through and the highlighting of the changes makes it easy to see what happens in each step. The user can choose between different modes of derivation and can control the flow of the derivation. The addition of helpful commands also allows the user to skip certain

parts of the derivation that might not be interesting to them.

**Stepping via the GHC compiler's interactive debugging mode**  
Own presentation

```
Carlo@DESKTOP-UFWZVAS MINGW64 ~/Documents/SubStep/core-stepper/test (main)
$ ghci Stepped.hs
GHCi, version 9.2.5: https://www.haskell.org/ghci/ :? for help
[1 of 1] Compiling Stepped (Stepped.hs, interpreted)
OK, one module loaded.
ghci> :set stop :!list
ghci> :step
not stopped at a breakpoint
ghci> :step test
Stopped in Stepped.test, Stepped.hs:9:8-28
,result :: Nat = ...
# test :: Nat
9 test = fib (S (S (S Z)))
10
[Stepped.hs:9:8-28] ghci> :step
Stopped in Stepped.test, Stepped.hs:9:13-27
,result :: Nat = ...
# test :: Nat
9 test = fib (S (S (S Z)))
10
[Stepped.hs:9:13-27] ghci> :step
Stopped in Stepped.test, Stepped.hs:9:16-26
,result :: Nat = ...
# test = fib (S (S (S Z)))
10
[Stepped.hs:9:16-26] ghci> :step
Stopped in Stepped.fib, Stepped.hs:71:17-33
,result :: Nat = ...
# !: Nat =
70 fib (S Z) = S Z
71 fib (S (S n)) = fib (S n) + fib n
72
[Stepped.hs:71:17-33] ghci>
```

**The sketch of a possible styling for the solution (from the task description)**

Own presentation

```
sum [1,2,3]
= { applying sum }
  1 + sum [2,3]
= { applying sum }
  1 + (2 + sum [3])
= { applying sum }
  1 + (2 + (3 + sum []))
= { applying sum }
  1 + (2 + (3 + 0))
= { applying + }
  6
```

**Stepping via the Haskell Substitution Stepper (The selected subterms are shown in green while the diff is underlined)**  
Own presentation

```
Carlo@DESKTOP-UFWZVAS MINGW64 ~/Documents/SubStep/core-stepper/src (main)
$ stack exec -- corestepper-exe -m manual -F ../test/Stepped.hs -v 1 -f test
(fib) (S (S (S (S Z))))
```

(Subterm 1/1)

Please enter a command:

```
((fib) (S (S (S Z)))) + fib (S (S Z))
```

(Subterm 2/3)

Please enter a command:

```
((fib (S (S Z))) + fib (S Z)) + (fib) (S (S Z))
```

(Subterm 5/5)

Please enter a command:

```
((fib (S (S Z))) + fib (S Z)) (+) (fib (S Z)) + fib Z
```

(Subterm 1/7)

Advisor

Prof. Dr. Farhad D. Mehta

Co-Examiner

Dr. Joachim Breitner

Subject Area

Software, Application Design

# Entwicklung einer Single-Page Application in React TS für personalisierte Campingtouren

## Diplomanden



Liliana Stratan



Amanda Wetter

**Ausgangslage:** Unabhängiges Reisen mit Camper ist Trend und wird durch die sozialen Medien gestärkt. Es wird ein Gefühl von Freiheit und Einfachheit vermittelt. Die Realität sieht oft anders aus. Stellplätze sind beschränkt, Wildcampen ist verboten und die Suche nach einem geeigneten Platz aufwendig. Eine Applikation soll dem Vanlifer bei der Planung einer geeigneten Campingtour unterstützen. Bereits im Rahmen der Studienarbeit (SA) im HS 2022 wurde diese Idee verfolgt sowie ein Prototyp für eine Applikation entwickelt.

Die Nutzung der Applikation ist für drei Akteure vorgesehen: Vanlifer, Host und Travel Agent. Für diese Arbeit liegt der Fokus primär auf der Umsetzung von Features des Vanlifer-Bereichs. Ziel ist es, individuelle Touren für einen gewünschten Zeitraum und eine gegebene Region zu generieren sowie dem Vanlifer übersichtlich zu präsentieren. Der User soll seine gewählte Tour nach Bedarf anpassen können. Ein weiteres Ziel innerhalb der Arbeit ist die Operationalisierung der Applikation in der Azure Cloud. Die umfangreiche Applikation wird von zwei Teams entwickelt, wobei die Aufgabenbereiche in Front- und Back-End aufgeteilt sind. Diese Arbeit thematisiert den Bereich Front End.

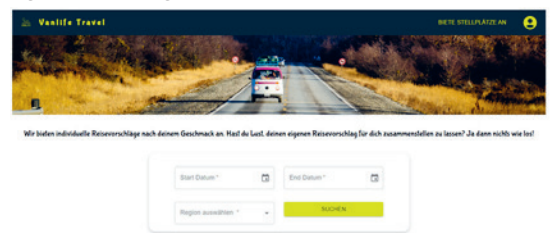
**Vorgehen/Technologien:** Um von der Idee zur Realisierung einer funktionalen Applikation zu gelangen, wurde als Vorgehensmodell Scrum gewählt. In der Initialisierungsphase der Arbeit wurden Anforderungen evaluiert und priorisiert sowie in den Backlog aufgenommen.

Eine umfangreiche Wireframe-Studie half bei der Entscheidung der Umsetzung des Buchungsprozesses. Eine weitere Studie zu Karten-Komponenten unterstützte die Wahl einer geeigneten Karten-API für die Darstellung der Touren. Dabei fiel die Wahl auf Here. In einer Implementierungsphase wurde die Applikation im Vanlifer-Bereich schrittweise mit Features ausgebaut. Parallel wurden Entwicklungen im Host-Bereich und der Registrierungsprozess verbessert. Die Applikation wird aufbauend auf der React Library und TypeScript als Programmiersprache entwickelt. Die Zustände der Website werden mit Redux Store verwaltet und die Anbindung zum Backend geht über REST. Für die Gestaltung der einzelnen Elemente und Widgets kommt die Material-UI-Komponenten-Library zum Einsatz. Zusätzlich ist die Applikation als Teil einer Docker-Compose-Architektur zusammen mit dem Back End auf eine Azure VM angewendet worden.

**Fazit:** Dank einer geordneten Vorgehensweise nach Scrum konnten die wichtigsten Anforderungen realisiert werden. Der iterative Prozess erlaubte

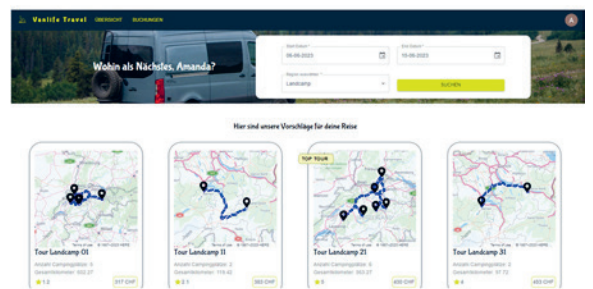
das fortwährende Einholen von Kundenfeedback sowie dessen zeitnahe Umsetzung. Die Applikation konnte stetig ausgebaut werden, wobei Initial auf das Gesamtbild geachtet wurde und in späteren Sprints der Detaillierungsgrad vertieft wurde. Das dynamische Vorgehen, insbesondere die Möglichkeit, weitere Anforderungen zu definieren, brachte Herausforderungen mit sich. Die Priorisierung und die Definition der geplanten Tasks bildeten ein Spannungsfeld zwischen Kunden, Back-End-Team und Front End.

## Landing Page Eigene Darstellung

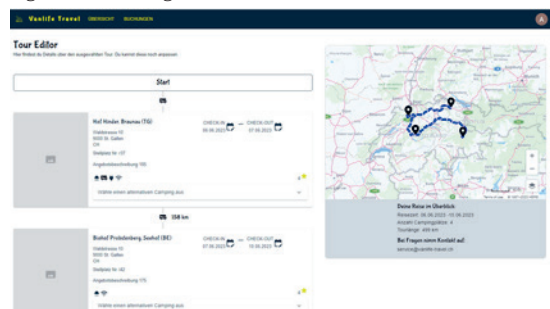


Über Vanlife Travel  
Spontane Vanreisen: Du bist interessiert an einer von uns generierten Tour? Gib ein, wohin und in welchem Zeitraum du reisen.  
Reise anpassen: Die Reise gefällt dir, aber du möchtest an einem Standort länger bleiben? Dann hast du die Möglichkeit.  
Buchung, bezahlen und genießen: Nachdem du mit deiner zusammengestellten Reise zufrieden bist, kannst du die Reise buchen und

## Ansicht des Touren-Generators Eigene Darstellung



## Touren-Editor Eigene Darstellung



**Referent**  
Prof. Dr. Daniel Patrick Politze

**Korreferent**  
Ramon Schildknecht,  
SBB AG, Olten 1, SO

**Themengebiet**  
Software, Application Design, Internet-Technologien und -Anwendungen

# On-Site Search Integration Framework und Anwendung im Swisscom Design System

## Analyse, Design und Umsetzung

### Diplomanden



Rolf Oberhänsli



Manuel Weber

**Ausgangslage:** Swisscom betreibt eine Website, genauer ein Design System mit dem Namen «Swisscom Digital Experience» oder kurz SDX. Es besteht aus einer Komponentenbibliothek, UX-Prinzipien, Designrichtlinien und Regeln, die eingehalten werden müssen, um den Swisscom-Look zu erhalten. Zur Navigation auf der SDX-Website ist ein Menü auf der linken Seite vorhanden, welches eine Auflistung aller in SDX verfügbaren Websites enthält. Benutzer müssen somit gesuchte Inhalte der SDX-Website über das Menü identifizieren, wobei sie anhand der Begriffe im Menü entscheiden müssen, ob eine Website für das Erfüllen eines Suchbedürfnisses infrage kommt oder nicht. Dies ist vor allem für Benutzer, die neu mit SDX arbeiten, mit erhöhtem Zeitaufwand verbunden.

In dieser Bachelorarbeit wurde eine Suchfunktionalität für die SDX-Website konzipiert und umgesetzt. Die Suche soll dem Nutzer einen erhöhten Komfort bei der Suche nach Inhalten sowie bei der Navigation innerhalb von SDX bieten. Durch die Suche soll schnell auf alle erwarteten und zusätzlich relevanten Inhalte, die man mit der Navigation übersehen würde, zugegriffen werden können.

**Vorgehen:** In einem ersten Schritt wurden eine Basisanalyse zum Thema On-Site Search sowie eine Anforderungsanalyse mit der Swisscom durchgeführt. Darauf aufbauend wurden Anforderungen definiert, Prototypen entwickelt und Wireframes ausgearbeitet. Anschliessend wurde ein Konzept zur Umsetzung der Suche, welches die Bedürfnisse der Swisscom erfüllt, erstellt. Das Konzept basiert auf einer clientseitigen Architektur, was bedeutet, dass die Suchfunktionalität im Browser des Benutzers ausgeführt wird. Während der Implementierung wurde die Lösung durch automatisierte Tests sowie Usability-Tests ausgiebig getestet. Das Ergebnis dieser Bachelorarbeit ist ein generisches Search Integration Framework, welches die Bereitstellung einer Suche auf einer Website einfach und schnell ermöglicht. Abschliessend wurde mithilfe des Frameworks eine Suche in die SDX-Website integriert.

**Fazit:** Usability-Tests sowie Gespräche mit der Swisscom haben gezeigt, dass es möglich ist, mit dem entwickelten Search Integration Framework eine Suche für die SDX-Website zur Verfügung zu stellen, die den benötigten Zeitaufwand für das Befriedigen von Suchbedürfnissen signifikant reduziert. Es ist möglich, mit geringem Aufwand eine Suche in eine bestehende Website einzubetten. Für ein optimales Ausnutzen der entwickelten Funktionalität wurden Empfehlungen bezüglich Optimierungen an der Struktur der SDX-Website an die Swisscom über-

geben, welche die Website nicht nur für die integrierte On-Site Search, sondern auch für Suchmaschinen besser durchsuchbar gestaltet. Während des Projektverlaufs wurden zusätzliche Features für das Search Integration Framework spezifiziert, welche im Anschluss an die Bachelorarbeit umgesetzt werden können. Das Search Integration Framework wurde über npm publiziert und kann somit auch in anderen Websites Anwendung finden. Um die Integration und die Individualisierung einer Suche so einfach wie möglich zu gestalten, wurde nebst einer Projektdokumentation auch eine ausführliche Entwicklerdokumentation verfasst.

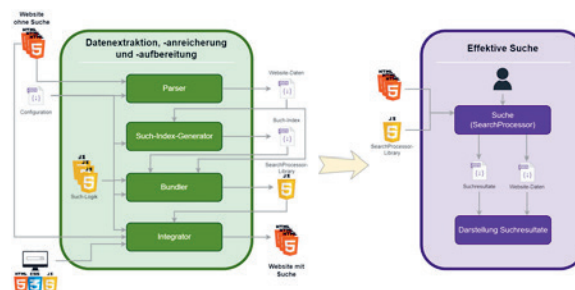
### Projektplan nach RUP und SCRUM

Eigene Darstellung



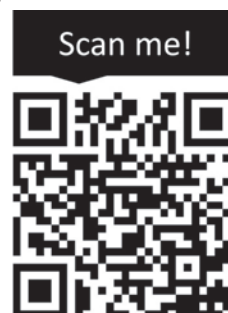
### Konzept des erstellten Such-Framework

Eigene Darstellung



### QR-Code zum publizierten npm-Paket

Eigene Darstellung



### Referent

Prof. Dr. Markus Stolze

### Korreferent

Markus Flückiger,  
Zühlke Engineering AG,  
Schlieren, ZH

### Themengebiet

Software, Application  
Design, Internet-  
Technologien und  
-Anwendungen

### Projektpartner

Swisscom, Zürich, ZH



# Fitness Gamification

## Gamifying physical exercise using a mobile application

### Graduate Candidates



Lucas von Niederhäusern



Joel Suter

**Initial Situation:** In today's world, gamification is used and implemented in more and more aspects of daily life. The purpose of gamification is to motivate users to do certain things. Another growing market is physical exercise, especially with young people. An increasing amount of people are trying to do more physical exercise. Everyone agrees that physical exercise is the key to a healthy life, but the main problem is that people often need more motivation. So we see massive potential in solutions that address this problem. A potential solution to motivate people to do more sports is a platform that gamifies physical exercise and makes it a fun, competitive game that can be played between friends and other users. The need for physical exercise and the motivation to do it will draw people to platforms and solutions like this.

**Objective:** With this project, we aim to build a platform mobile app of this type. The main goal is to create an initial version of such a platform. That means we want to create an app that allows users to challenge their friends and other users to do physical exercises. We will implement various gamification aspects, such as allowing users to achieve milestones, track their data, and display that to other users. We plan to use a turn-based approach for the challenges, allowing users to play with users in an async fashion. That means participants can be online at different times.

**Conclusion:** In this project, we created a prototype for a mobile app that gamifies physical exercise. We created this mobile app using React Native and Expo in our front end and Firebase as our back end. Our app allows users to create an account using their phone number and challenge anyone in their contact list or a random user. The user can select the challenge type and duration one has to perform in the challenge. Challenges then get completed in a turn-based fashion. A user performs a challenge and it gets sent to his opponent. The opponent can then perform and it will get sent back. This goes back and forth until one user cannot beat the other user's score. We will track various statistics for the user, which will be displayed in his profile and displayed to other users to generate a more competitive and gamified environment. We implemented one challenge type for this initial version, «pull-ups». In the future, this should be extended to allow the user to perform various challenges and can generally be expanded upon due to the modularity we considered while implementing it.

### Advisor

Prof. Frank Koch

### Co-Examiner

Prof. Hansjörg Huser,  
Menzingen, ZG

### Subject Area

Software, Application  
Design, Miscellaneous

### Project Partner

AdaptIT GmbH,  
St.Gallen, SG

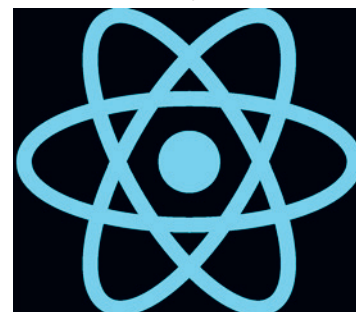
### Firebase

<https://firebase.google.com/images/social.png>



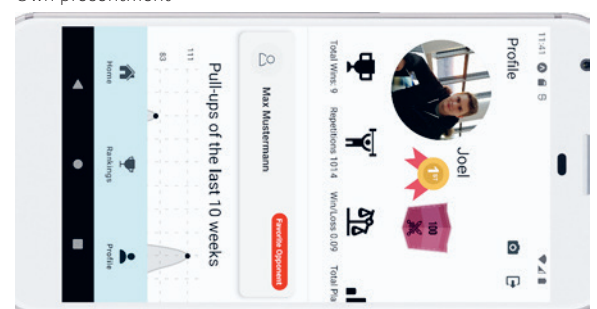
### React Native

<https://shorturl.at/coyBI>



### User profile screen

Own presentment



# Link Management Tool with Internet Archive Integration

## Graduate Candidates



Benny Joe Villiger



Thomas Zahner

**Introduction:** In today's digital age, the World Wide Web has become the indispensable platform for accessing and sharing information. At the heart of the Web are hyperlinks, also known as URLs or simply links. They are the threads that connect web pages and allow users to traverse the landscape of online content.

However, online content tends to be short-lived, and changes often go unnoticed. The phenomena of disappearing content and unannounced changes are known as link rot and content drift. Rotten or dead links are URLs pointing to resources that show obvious signs of malfunction. Content drift can result in linked information that is misleading or that differs significantly from the original intent of the linker. They can undermine the accuracy and credibility of websites, degrade the user experience and damage the reputation of the website or organisation. Checking and fixing links manually on a regular basis is time-consuming and error-prone.

**Approach:** We develop a command-line tool called Link Management Tool (LMT) providing a semi-automatic approach to detecting and fixing rotten links and drifted content. Additionally, we extend lychee, a free and open-source link checker. We integrate the Wayback Machine, a digital Web archive, into LMT and lychee to obtain access to archived snapshots of websites taken in the past.

**Result:** LMT was released to the public on GitLab under the MIT licence. Its metadata snapshot functionality enables the detection of potential content drift on web pages. The modular design of LMT allows integrating it into scripts, providing the flexibility to schedule the link checking process at strategic intervals such as before each publication or release. Scheduling the link checking supports the continuous monitoring of links.

In addition, lychee was extended with a new feature that offers recommendations for broken URLs by utilising snapshots from the Wayback Machine.

Early user feedback and testing confirmed the reliability of LMT to identify and resolve broken links.

**Advisor**  
Prof. Dr. Olaf  
Zimmermann

**Co-Examiner**  
Dr. Hans-Peter Hoidn

**Subject Area**  
Software, Internet  
Technologies and  
Applications

## A broken link which leads to an unreachable site

Own presentation



### This site can't be reached

www.servicedesignpatterns.com's server IP address could not be found.

Try:

- Checking the connection
- Checking the proxy, firewall, and DNS configuration

ERR\_NAME\_NOT\_RESOLVED

## The same broken link retrieved in the Wayback Machine

Own presentation



Home The Book Talks Insights Contact

Service APIs Client-Service Interactions Request and Response Management Service Implementation Service Infrastructures Service Evolution API Patterns

### Design Solutions for SOAP/WSDL and RESTful Web Services

## LMT in action: Find and fix broken links in a completely automated manner

Own presentation

```
→ documentation lmt check *.md
Checking links 100.00% ██████████ 7.1s 75/75
[01_introduction.md]:
https://www.google.com/jobs.html

71 total ✓ 70 OK ✗ 1 Error
→ documentation lmt fix 01_introduction.md
Checking links 100.00% ██████████ 0.5s 3/3
Suggesting links 100.00% ██████████ 1.0s 1/1
{
  "https://www.google.com/jobs.html": "http://web.archive.org/web/20
070623165349/http://www.google.com/jobs.html"
}
→ documentation lmt check *.md
Checking links 100.00% ██████████ 7.7s 75/75
71 total ✓ 71 OK ✗ 0 Errors
```

# OSMyBiz–Business Profile Editor for OpenStreetMap

## Graduate Candidates



Khoa Tran



Dominic Ritz



André Blöchlinger

**Introduction:** OpenStreetMap My Business (OSMyBiz) is an editor for the collaborative, open mapping project OpenStreetMap (OSM). There are many editors available for OSM. However, none of them allow new or inexperienced users to manage their business (shop, restaurant, etc.) on OSM without knowledge of the OSM-specific data structure. OSMyBiz already allows users to create and update businesses on OSM. However, some understanding of the opening hours syntax was still required, and updated businesses were not stored directly in OSM.

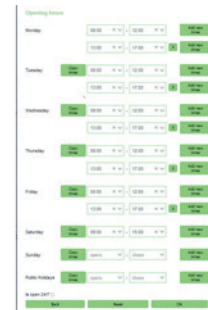
**Objective:** Expanding on a previous student research project, the goal of this work is to further improve the user experience and functionality. This should be achieved by introducing a new dialog for entering opening hours that can be used by novice users without any experience. Direct editing of nodes is another important goal. Further, OSMyBiz should record the date when the opening hours have last been checked. Existing functionality should be improved, like the watch list or the dialog for unsaved changes. In addition, the software maintenance effort for the application should be reduced.

**Result:** A new opening hours editor dialog has been introduced that does not require the user to know the opening hours syntax. OSMyBiz now recognizes the `check_date:opening_hours` tag, allowing consumers of OSM data to determine how up to date the hours are. A changed business no longer needs to be manually copied and saved to OSM by another mapper using another editor. The watch list has received some new features: it will notify users when the opening hours have not been checked for more than a year. Businesses can be added to the watch list without editing the business. In addition, the

back end has now been migrated to Python 3.11 and dependencies have been updated. Several issues have been identified and fixed, such as the log-in process not handling errors correctly. Unsaved changes are now detected properly, and the unsaved changes dialog now appears when it was supposed to. The overall user interface style of OSMyBiz has been overhauled. The user preferences have been updated and other minor issues have been fixed.

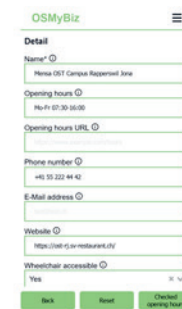
## New opening hours editor dialog as part of the editing dialog on a desktop device for easy entry

Own presentation



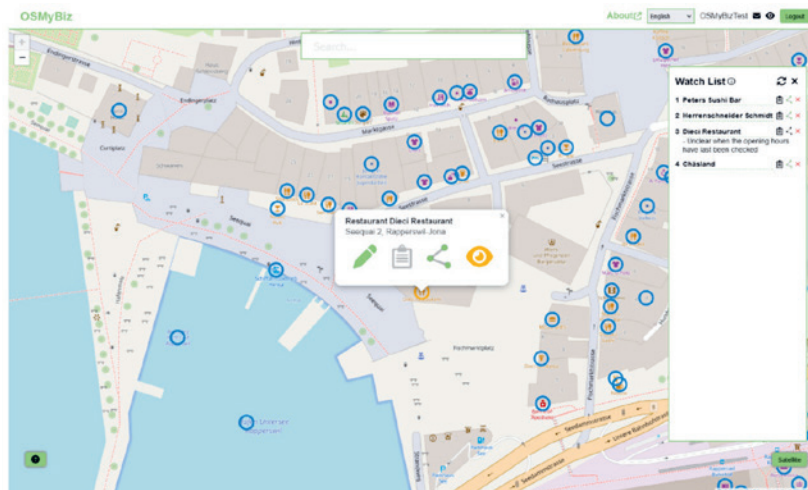
## Editor dialog showing the properties of a business on a mobile device

Own presentation



## OSMyBiz main page on a desktop device showing the old town of Rapperswil and the watch list with some entries

Own presentation



## Advisors

Prof. Stefan F. Keller,  
Joël Schwab

## Co-Examiner

Dr. Ralf Hauser,  
PrivaSphere AG, Zurich,  
ZH

## Subject Area

Software, Internet  
Technologies and  
Applications

## Project Partner

OpenStreetMap  
Community

# Lab Topology Builder K8s Operator

## Implementation of a Kubernetes operator to manage the deployment of emulated network topologies

### Graduate Candidates



Tsigereda Nebai Kidane



Jan Untersander

**Initial Situation:** Lab Topology Builder (LTB) is an application developed by the Institute for Network and Security (INS) and is used for research and teaching purposes. It can create networking labs which are emulated network topologies with multiple interconnected nodes (servers, switches, routers, etc.). It is a key component of multiple courses at OST and is used by students to practice and learn about cloud, networking and security concepts. Currently, the application is based on a React front end and a Django Python back end in combination with KVM/Docker for the deployment of the labs. This solution has grown organically over the years, with multiple contributions from term projects and bachelor theses. Maintaining the application has become increasingly challenging, because of technical debt and missing documentation. Therefore, making it open-source would require a substantial refactoring effort.

**Objective:** With the overall goal of open-sourcing the application, the objective of this project is to create an LTB-inspired Kubernetes operator which can be used to deploy and manage the aforementioned labs on a Kubernetes cluster. A Kubernetes operator offers automation, dynamic resource allocation, and seamless integration with a wide range of tools. Thus, making it ideal for managing complex applications while enabling effortless scaling and orchestration. The operator should be able to manage labs consisting of pods with containers and KubeVirt virtual machines and should accept a lab definition in the form of a YAML file. The different lab nodes should be able to communicate with each other via a layer 3 connection. The operator should also provide a feature to query the status of a lab. Additionally, the lab nodes should support out-of-band management through various protocols. Optionally, access to a lab should be restricted to specific users using access control policies.

**Result:** The project resulted in a Kubernetes operator for the LTB application, which takes three different custom resources (CRs) as input: [item]Lab templates/[item][item]Lab instances/[item][item]Node types/[item].

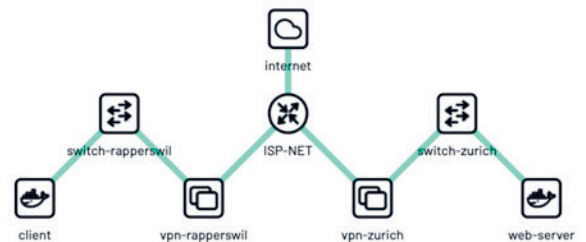
The lab templates define the lab topology i.e., the connection between the nodes and the configuration of the nodes. The node types define the different types of nodes that can be used in a lab. Finally, the lab instances are the actual labs that are deployed. Lab instances reference a lab template, which in turn references node types. There is support for layer 3 networking between the lab nodes limited to a single physical Kubernetes node. Access to the out-of-band management of

the lab nodes is provided via a web-based terminal or a freely configurable port which will be forwarded to the lab node. Information regarding the lab's status and remote access details can be obtained via a command-line interface (CLI). Although access control has not been implemented, a groundwork has been laid by separating lab instances into their own namespaces. This allows for the use of Kubernetes' built-in role-based access control (RBAC) to restrict access to lab instances.

In summary, the LTB Kubernetes operator enables users to deploy and efficiently manage labs within a Kubernetes cluster.

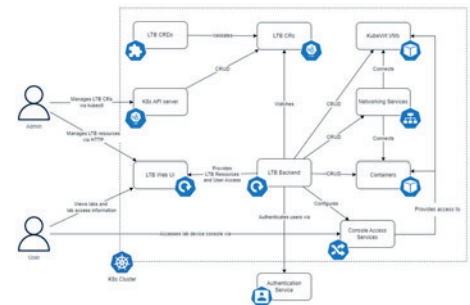
### Lab topology

Current lab topology builder UI



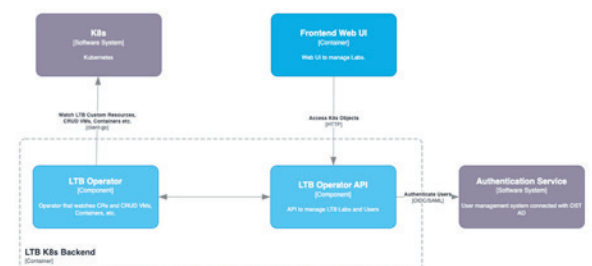
### Architecture

Own presentation



### Components

Own presentation



### Advisors

Urs Baumann, Yannick Zwicker

### Co-Examiner

Philip Schmid, Isovalent, Wallisellen, ZH

### Subject Area

Software, Networks, Security & Cloud Infrastructure

# SAMT: Compiler and Tools for an Extensible API Modeling Language

## Graduate Candidates



Pascal Honegger



Marcel Joss



Leonard Schütz

**Initial Situation:** Zürcher Kantonalbank maintains various services built on diverse technologies. A custom domain-specific language is used to model the interfaces between these services. Types and operations are modeled in a technology-independent way, with code generation tools providing the technology-specific endpoints.

The language is built on top of the Xtext framework, which provides the core infrastructure for language analysis and a sophisticated development environment. However, because the maintenance road map for Xtext is uncertain, Zürcher Kantonalbank faces a long-term maintainability risk and is looking for a sustainable solution.

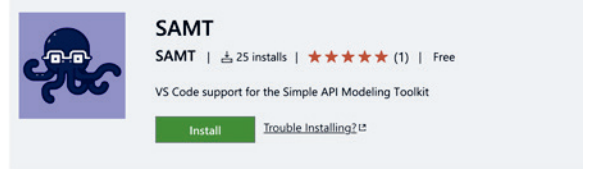
**Approach:** The goal of this project is to design and develop a new open-source domain-specific language called Simple API Modeling Toolkit, or SAMT for short. It retains the core aspects of the existing language and improves upon it by providing a more pleasant developer experience. An extensible architecture allows API modellers to add support for new technologies. A Visual Studio Code extension provides an easy-to-use and modern development experience. The development process started with a requirements engineering and language design phase, guided by developers familiar with the existing language. The subsequent implementation was carried out iteratively, with regular progress reviews.

**Result:** All must-have requirements were met, with substantial should-have and could-have requirements also realized. The project successfully developed the core systems of the new language, including a proof-of-concept code generator for the

Kotlin-based Web framework Ktor. The SAMT Visual Studio Code Extension was developed and published on the official Visual Studio Marketplace to make it as accessible as possible. Usability tests with employees of Zürcher Kantonalbank resulted in positive feedback. Future work includes implementing all remaining language features, improving upon the generator architecture, and implementing more features in the editor extension.

## SAMT Visual Studio Code extension in the Visual Studio Marketplace

Own presentation



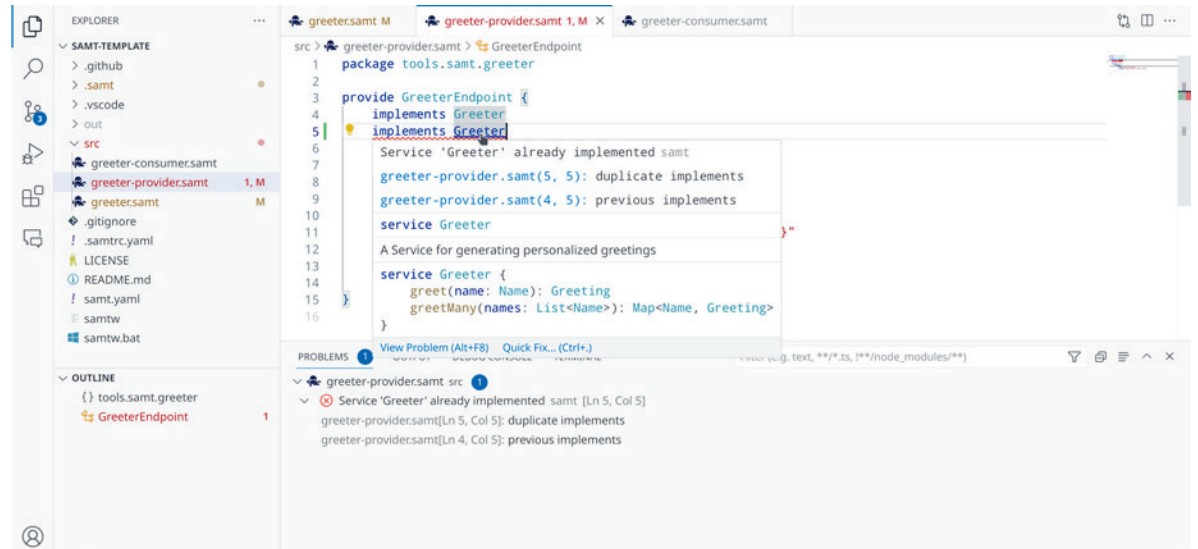
## SAMT CLI dump next to source code

Own presentation



## SAMT source code inside Visual Studio Code

Own presentation



**Advisor**  
Prof. Dr. Olaf Zimmermann

**Co-Examiner**  
Dr. Daniel Lübke

**Subject Area**  
Software, System Software

**Project Partner**  
Zürcher Kantonalbank

# Entwicklung einer Animationsbibliothek für SimPy

## Diplomanden



Moritz Schiesser



David Kühnhanss

**Ausgangslage:** Simulationen werden verwendet, um reale Situationen unter reproduzierbaren, steuerbar variierenden Bedingungen nachzubilden und damit Verhaltensweisen und Systeme zu untersuchen und vorherzusagen. SimPy ist ein schlankes Python Framework für diskrete Ereignissimulation. JupyterLab bietet die Möglichkeit, sogenannte Notebooks zu erstellen. Notebooks stellen eine webbasierte interaktive Programmierumgebung zur Verfügung, in welcher unter anderem SimPy-Simulationen geschrieben und verwendet werden können. Zur Verifikation der Ergebnisse einer solchen Simulation ist es wünschenswert, eine zur Simulation passende Animation zur Hand zu haben. Momentan bietet SimPy noch keine integrierte Möglichkeit, eine Simulation zu visualisieren und zu animieren.

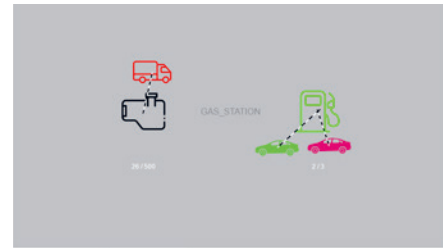
**Ziel der Arbeit:** Aufbauend auf eine vorhergehende Studienarbeit soll eine Bibliothek für die Animation von Simulationsmodellen entwickelt werden. Die in der Studienarbeit gewonnenen Erkenntnisse sowie die darin erarbeiteten Konzepte sollen infrage gestellt, angepasst, erweitert und übernommen werden wo möglich. Die Bibliothek soll, integriert in eine JupyterLab Extension, als Open-Source-Projekt veröffentlicht werden, inklusive der Distribution über die gängigen Paketverwaltungssysteme. Weiter sollen als Beispiele für die Verwendung der Bibliothek die Beispiele SimPys um eine Animation erweitert werden.

**Ergebnis:** Bestehend aus drei veröffentlichten Komponenten, namentlich `simplay`, `simplay-web` und `simplay-jupyter`, existiert ein Open-Source-Projekt, gehostet auf GitHub, welches es ermöglicht, SimPy-Animationen in JupyterLab zu animieren, und öffent-

lich dokumentiert ist. Die Komponenten sind über die gängigen Paketverwaltungssysteme installierbar. Die Beispiele aus SimPy sind um eine Animation erweitert und dienen als Anwendungsbeispiel. User-Tests zeigen, dass die Komponenten einfach zu installieren und zu verwenden sind. Die API des Python Package `simplay` ist verständlich für Entwicklerinnen und Entwickler, welche mit SimPy vertraut sind.

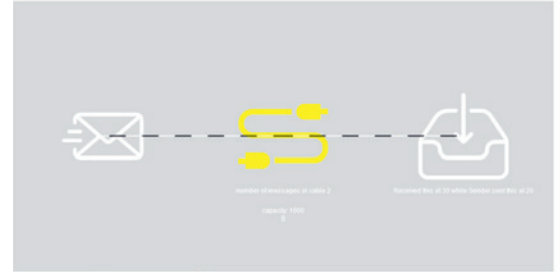
## Simulation einer Tankstelle

Icons von <https://www.flaticon.com>, <https://m3.material.io/>



## Simulation von Ereignisübermittlung

Icons von <https://www.flaticon.com>, <https://m3.material.io/>



## Simulation einer Fabrikhalle mit anfallenden Wartungsarbeiten

Icons von <https://www.flaticon.com>, <https://m3.material.io/>



## Referenten

Prof. Dr. Andreas Rinkel, Marc Sommerhalder

## Korreferent

Knut Schmah, Minimax Viking Research & Development GmbH, Bad Oldesloe, SH

## Themengebiet

Software, Verschiedenes

# CuSharp

## A GPU compute framework for .NET

### Graduate Candidates



Adrian Locher



Jason Benz

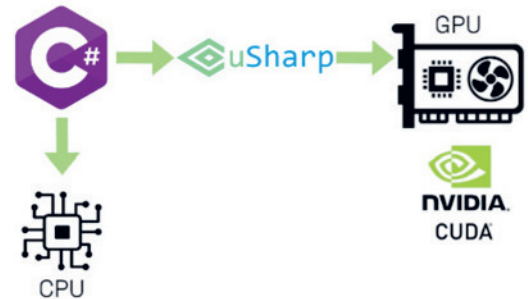
**Introduction:** The number of computationally intensive applications is growing. For many easily parallelizable problems, GPUs offer better performance than CPUs. As a result, GPUs are now used not only for graphical applications, but also for machine learning and cryptography. GPU-accelerated programs have traditionally been written in C, C++ for high-performance applications such as physics simulations and graphical applications and more recently in Python to optimize machine learning algorithms. Most GPU APIs, including NVIDIA CUDA, restrict their developers to using C, C++ or Python to write programs targeting those APIs.

**Result:** In this thesis a framework called CuSharp has been developed that allows developers to build and run GPU-executable kernels directly in C#. This is achieved by using existing toolchains complemented by a specifically developed cross-compiler. The C# kernel is compiled to Microsoft Intermediate Language (MSIL) by the existing Roslyn compiler. Subsequently, the CuSharp compiler cross-compiles MSIL to NVVM IR, a platform-independent intermediate representation. Finally, NVVM IR is translated to PTX ISA, an assembly-like language for NVIDIA GPUs, using the NVVM compiler library (libNVVM). The architecture also allows for future development efforts to add cross-platform support. CuSharp supports the compilation of static methods, written in a specific C# subset, either just in time or ahead of time. For a kernel that computes matrix multiplications, a performance slowdown between 1.4% and 4.8% was measured for CuSharp-compiled kernels compared to NVCC-compiled kernels (GPU execution time of the kernel only).

**Conclusion:** This thesis shows the challenges of interfacing with the LLVM compiler infrastructure and the NVIDIA CUDA API. In addition, it provides an overview of the complex landscape of APIs that can be used to interface with GPU devices in general, by comparing their toolchains and languages. Furthermore, it demonstrates that GPU kernels can be written in a high-level language such as C# while suffering only minor performance degradation.

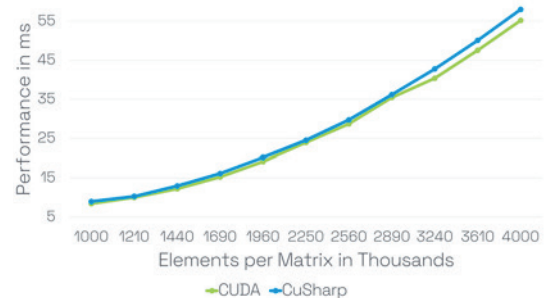
### Overview of CuSharp interacting with external systems

Own presentation



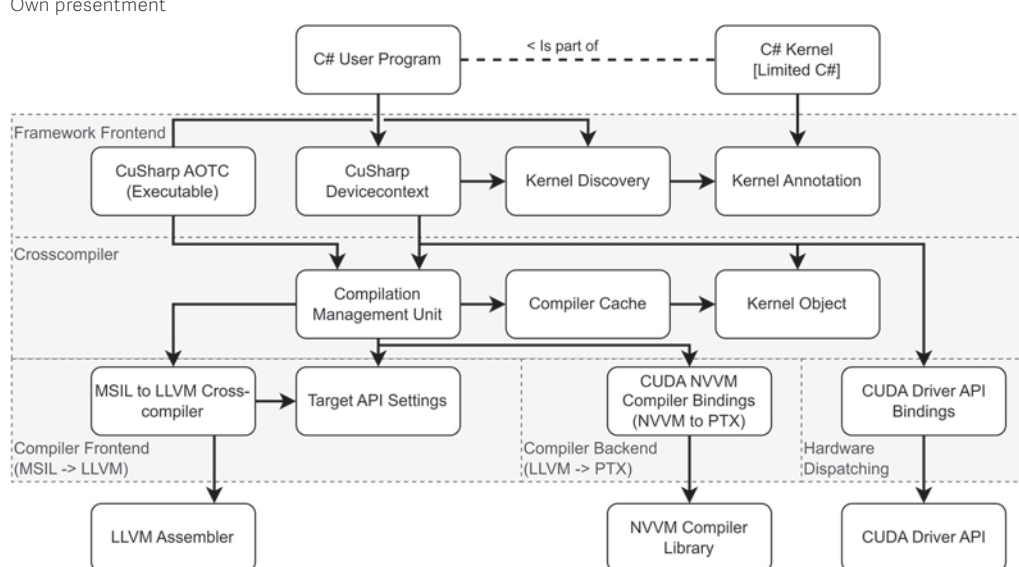
### Performance results of a double-type matrix multiplication

Own presentation



### Software architecture of the CuSharp framework

Own presentation



Advisor  
Philipp Kramer

Co-Examiner  
Christian Marrocco,  
Arni AG, AG

Subject Area  
System Software,  
Software, Software  
Engineering - Core  
Systems

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