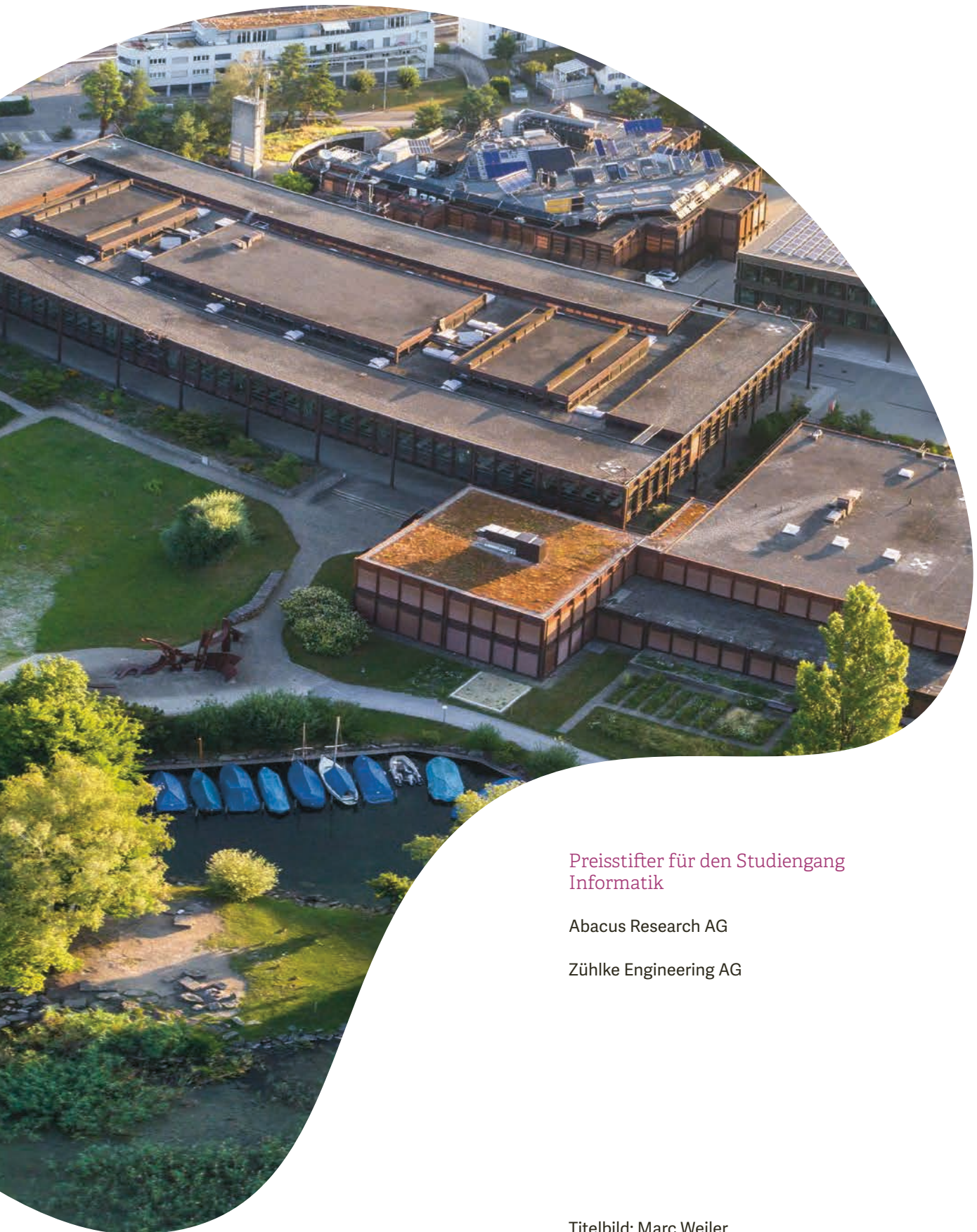




Bachelorarbeiten 2024
**Bachelor of Science in
Informatik**



Preisstifter für den Studiengang
Informatik

Abacus Research AG

Zühlke Engineering AG

Titelbild: Marc Weiler

Vorwort



Prof. Mirko Stocker
Studiengangsleiter 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 widerspiegeln.

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 2024

Prof. Mirko Stocker
Studiengangsleiter Informatik

Überblick

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- Software, Application Design
33 Konzeption und Prototyp eines Storefrontsystems mit Plugin- und Theme-Architektur
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38 3D-Visualization of Utility Lines in the Browser using Augmented Reality on Tablets

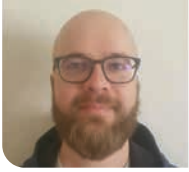
Überblick

Bachelors, Diplomandinnen und Diplomanden

19	Bister Ramon	13	Kenzler Arnaud
22	Brändli Michael	11	Kissling Marc
26	Bühler Janosch	28	Lehmann Pascal
14	Castelberg Dominik	36	Lenherr Fabio
22	Ceriani Leandro	16	Löffler Kevin
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38	Domeisen Lukas	26	Maissen Samuel
33	Ebnetter Ramon	12	Messmer Lukas
18	Enzler Michael	17	Metzler Manuel
21	Falkner Florian	31	Pfister Kevin
12	Fischler Mathias	37	Rohrer Florian
30	Flepp Jann Marco	23	Salutt Corsin
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34	Götti Nick	23	Thirunavukkarasu Thajakan
38	Habegger Kaj	36	Tran Felix
20	Havrilla Marc	33	Vogel Gian-Luca
28	Hofmann Michael	9	Willi Andrew
17	Häring Sascha	9	Wymann Momoko
34	Hürzeler Joshua Beny	29	Zahnd Vina
15	Joos Andri	37	Zimmermann Lucien
		32	Zubler Laurin

Einkaufshelfer Android App

Diplomanden



Fabian Freitag



Josip di Benedetto

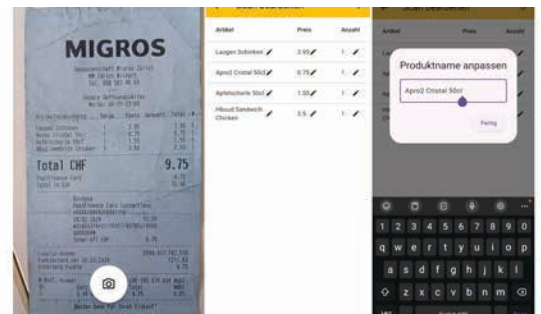
Ziel der Arbeit: Das Ziel dieser Bachelorarbeit ist die Entwicklung einer Android-App, die Verbrauchern hilft, Ihre Einkaufserlebnisse durch effiziente Preisvergleiche und die Verfolgung von Preisentwicklungen zu optimieren. Im Kontext der steigenden Inflation und Preisvolatilität steht die Notwendigkeit für einkommensschwache Bevölkerungsschichten im Vordergrund, Preise von Produkten aus verschiedenen Geschäften zu vergleichen. Dies wird durch die Erstellung einer App ermöglicht, die mittels Optical Character Recognition (OCR) Technologie die Produktnamen und Preise aus Kassenscheinen extrahiert und vergleicht. Wesentliche Aspekte dieser Arbeit umfassen die Evaluation geeigneter Technologien für die automatische und manuelle Erkennung der relevanten Bereiche auf dem Kassenschein und die Textzeichenerkennung mittels einer OCR-Bibliothek. Die App soll es den Nutzern ermöglichen, ohne Vorkenntnisse Kassenscheine scannen zu können, damit die App automatisch Preisänderungen ermitteln kann.

Ergebnis: Folgende Probleme wurden gelöst: die Erkennung von Textzeichen, relevanten Textbereichen auf Kassenscheinen und Preisdifferenzen gleichnamiger Produkte aus dem gleichen Laden. Der entwickelte Prototyp ermöglicht es Nutzern, Belege in der App zu erfassen und Preisschwankungen seit dem letzten Einkauf zu sehen. Dabei werden nur selbst erfasste Daten genutzt, ohne Berücksichtigung von Rabattaktionen. Anfangs wurde für die Texterkennung die OCR-Library des Google ML Kit verwendet, wobei der Benutzer den relevanten Textbereich zuschneiden musste. Mit einer Regex wurden die Informationen strukturiert ausgelesen. Um die Texterkennung zu verbessern, wurde experimentell festgestellt, dass homogene Beleuchtung wichtig ist, um einen effizienten Binarisierungsalgorithmus anzuwenden, der den Text vom Rest des Bildes löst. Da der Ansatz mit OCR und Regex ein bestimmtes Format der Kassenscheine erfordert, wurde später die Google Gemini API verwendet. Gemini führt Texterkennung und automatische Bereichserkennung durch, sodass verschiedene Belegstrukturen besser ausgelesen werden können. Der Benutzer muss den relevanten Bereich nicht mehr manuell zuschneiden. Experimentell wurde festgestellt, dass Gemini besser mit Bildern bei schlechter Beleuchtung umgehen kann, wahrscheinlich durch eigene Bildverarbeitungsschritte wie Binarisierung. Die Nachteile von Gemini sind die erforderliche Internetverbindung und die längere Verarbeitungszeit. In einer Weiterentwicklung könnten die erfassten Daten anonymisiert gesammelt und allen Benutzern zur Verfügung gestellt werden, um aktuelle Preisänderungen anzuzeigen. Dies eröffnet Möglichkeiten für ein Empfehlungssystem, z.B. ob ein Produkt an einem anderen Standort güns-

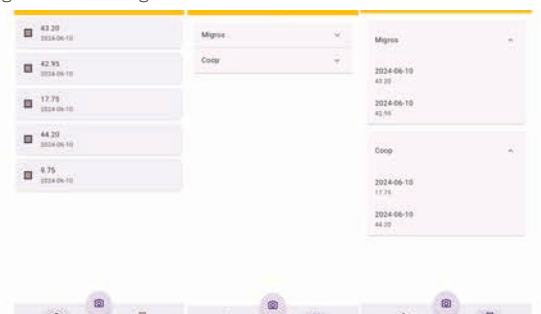
tiger ist, ob ein Rabatt wirklich ein Rabatt ist oder ob zuvor der Preis erhöht wurde.

Fazit: Die Entwicklung einer App, die Kassenscheine scannen und relevante Informationen daraus extrahieren kann, ist eine grosse Herausforderung, da Kassenscheine sehr unterschiedliche Formate haben und die Daten beliebig strukturiert sein können. Modelle, die maschinelles Lernen verwenden, sind besonders vielversprechend, um mit den verschiedenen Kassenschein-Formaten umgehen zu können. In der Arbeit wurde eine Grundlage erarbeitet, mit der ein schnelles und robustes System zur Lösung der genannten Probleme entwickelt werden kann.

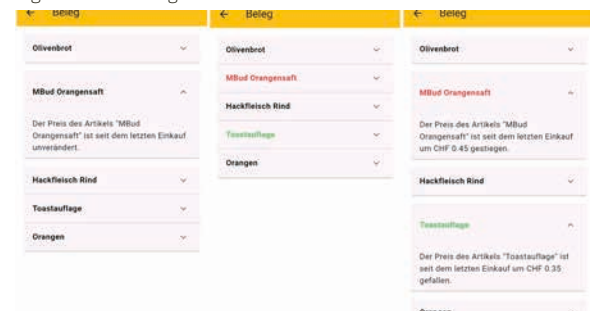
In der App wird zuerst ein neuer Beleg erfasst. Aus diesem werden dann die Artikel, ihre Mengen und Stückpreise geholt.
Eigene Darstellung



Auf der Homepage können die letzten Belege oder eine Liste aller Belege betrachtet werden.
Eigene Darstellung



Wird ein Beleg ausgewählt, können die Preise der Artikel verglichen werden. Preisänderungen werden farblich markiert.
Eigene Darstellung



Referent
Prof. Dr. Markus Stolze

Korreferent
Markus Flückiger,
Zühlke Engineering AG,
Schlieren, ZH

Themengebiet
Application Design

Document Management using Large Language Model

Graduate Candidates



Momoko Wymann



Andrew Willi

Initial Situation: The management and retrieval of documents can be challenging due to the unstructured nature of their content. Traditional search methods, which rely on document names, are often inefficient and ineffective. With the rise of Transformers based on Large Language Models (LLMs) which significantly enhance our everyday tasks, there is an opportunity to improve the search and management of these documents. The integration of LLMs can transform unstructured data into structured metadata, making documents more accessible and organized.

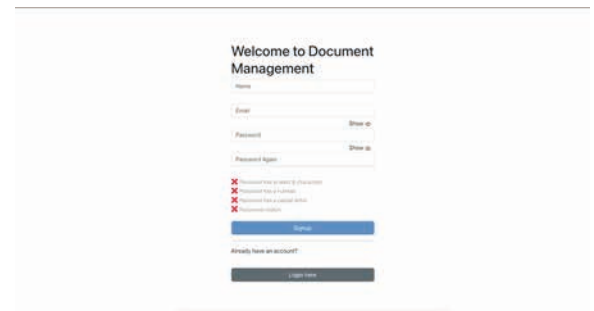
Objective: Within the scope of this project we aim to build a Single Page Application of this type. We created a prototype application that is able to store, read and process PDF documents with unstructured data, and generating metadata using an LLM. This metadata improves document search and management, as well as streamlining repetitive tasks such as sending an email reminder to a customer. The prototype is designed to be easily expandable to facilitate the continuous development and implementation of new features.

Conclusion: In this project, we developed a prototype application utilizing React and TypeScript for the frontend, while using Node.js with TypeScript for the backend. We integrated external services such as Huggingface and Zapier. The application enables users to upload PDF documents, extract a suitable title, summary and tags using a Large Language Model (LLM), and search for documents based on this metadata. Additionally, it includes a feature for sending email reminders to customers for specific

files. Designed with scalability in mind, the application allows for easy addition of new features in the future. Such as integrating various file type like pictures, which could utilize the LLM. This proof of concept demonstrates the potential of using LLMs to enhance document management and retrieval.

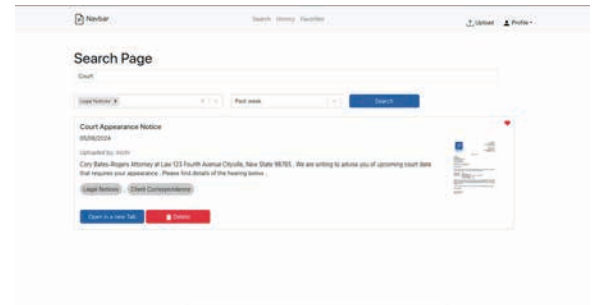
Register Page

Own presentation



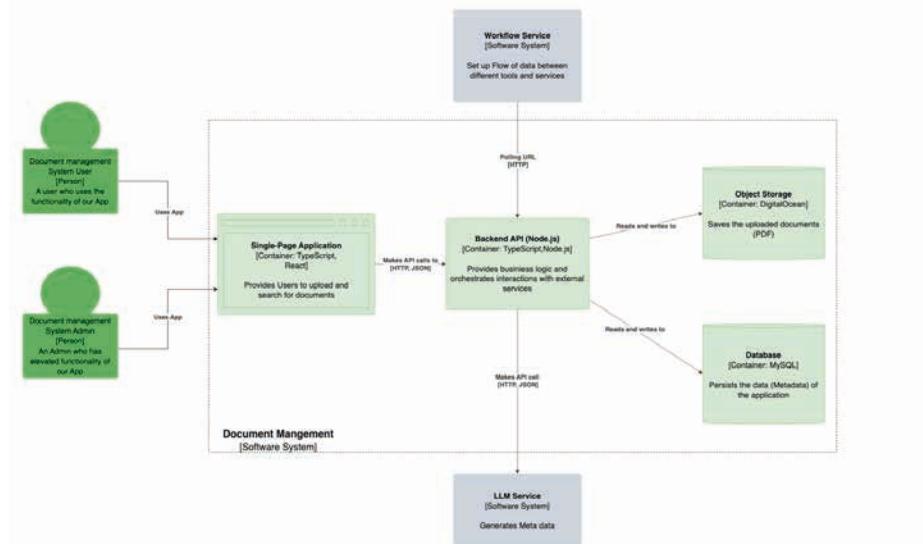
Search Page

Own presentation



Container Diagram

Own presentation



Advisor
Prof. Frank Koch

Co-Examiner
Prof. Hansjörg Huser,
Menzingen, ZG

Subject Area
Application Design,
Artificial Intelligence,
Software

Project Partner
AdaptIT GmbH, Jona,
SG

Order Management Tool für 3D-Druck Dienstleistungen

Graduate Candidates



Joel Sauvain



Noah Stalder

Problem: When a startup is founded, the focus is usually put on getting orders instead of implementing an adequate order management solution.

As the startup grows in orders and employees, the initial make-do solution may become insufficient and slow the business down in the long run. This was the case for our partners Change 3D who provide various services in the 3D-printing environment. Their make-do solution consisted of printing out cards for each order. The printed cards were then filled in with details such as order number, title, and client name, and ultimately hung on a whiteboard.

As their business grew, the whiteboard became too full, making it more difficult to find orders and keep up with deadlines. This challenge led to the realization that a new solution is needed.

Approach / Technology: To solve the problems and alleviate the pain points of our partner, we set out to develop a tool that displays their orders on a kanban board. In close collaboration with our partners, we followed the principles of user-centered design that enforces an iterative process and focuses on an understanding of the users and their context in all stages. This enabled us to gain a deep understanding of their problem and allowed us to build an application tailored to their needs. Through a scheduler, written as a microservice in Kotlin, we integrated their Bexio where we fetch the orders from, to eliminate the necessity of manually creating an item for the board. The core of the application is a backend written in Kotlin, which receives the orders from the scheduler and stores them in a MongoDB. Additionally, the states and state transitions are managed in the backend, which automatically triggers actions on Bexio, further eliminating manual steps of the previous process. The frontend is written in Angular, communicating with the backend through a RESTful API which allows for live updating using SSE.

Result: The result provides a substantive improvement for the day-to-day business and order management of our partner, as determined by user tests. The core functionality is the board, which responsively displays the items in columns representing the states. Through drag and drop, an item can be moved into another state, which triggers the applicable action on Bexio. To improve the usability of the board and make it more practical for more use cases, there are various view options implemented, such as sorting, filtering, and grouping the items. On top of that, what is shown on each card is configurable and pieces of information can be hidden to further remove clutter from the board. Additional informa-

tion can be stored and found on the detailed view of each card, such as assigning the item to someone, the history of the item, or an interactive 3D render of the piece that is being produced. After an item has gone through all the steps and the order is completed, it can be moved into the archive, which provides an insight into the orders that were completed across a timeline.

Board Grouped-By Assignee

Own presentation



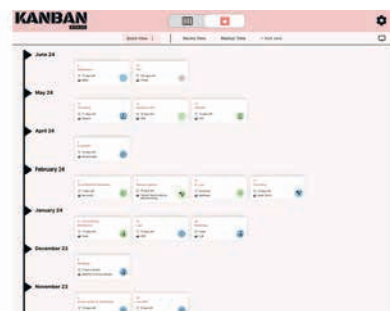
Detail Information of an Item

Own presentation



Archive View

Own presentation



Advisor

Prof. Dr. Frieder Loch

Co-Examiner

Dr. Felix Ocker, Honda Research Institute Europe GmbH, Frankfurt am Main, HE

Subject Area

Application Design, Internet Technologies and Applications, Networks, Security & Cloud Infrastructure, Software Engineering - Core Systems

Project Partner

Change 3D, Siebnen, SZ

Middleware-Plattform zur Harmonisierung von Smart Home- und IoT-Systemen

Diplomand



Marc Kissling

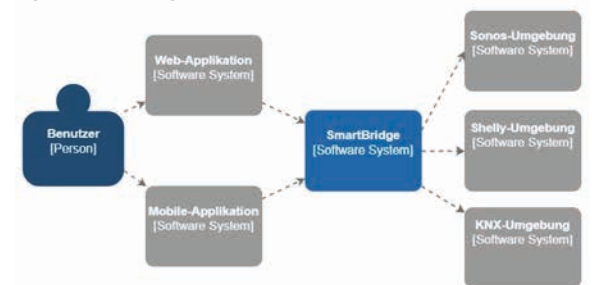
Einleitung: Die zunehmende Digitalisierung und Vernetzung von Haushaltsgeräten hat zu einer Vielzahl proprietärer Smart Home- und IoT-Systemen von verschiedenen Herstellern geführt. Diese Vielfalt stellt erhebliche Herausforderungen für Nutzer dar, die ein nahtloses und einheitliches Smart Home-Erlebnis anstreben. Nutzer müssen oft verschiedene Apps und Plattformen verwenden, um ihre Geräte zu steuern, was zu einer fragmentierten und ineffizienten Handhabung führt. Gleichzeitig stehen Entwickler von Geräteherstellern vor der Schwierigkeit, universelle Schnittstellen zu erstellen, die mit den unterschiedlichen Kommunikationsprotokollen und Datenformaten der proprietären Systeme kompatibel sind. Inkompatibilitäten behindern die Schaffung einer kohärenten Benutzererfahrung und erschweren die Integration neuer Geräte und Funktionen.

Ziel der Arbeit: Die Bachelorarbeit zielt darauf ab, eine Middleware-Plattform namens «Smart-Bridge» zu entwickeln. Diese Plattform soll die Integration und Harmonisierung verschiedener Smart Home- und IoT-Systeme erleichtern, indem sie eine einheitliche Schnittstelle bereitstellt. Diese Schnittstelle ermöglicht es Frontend-Entwicklern, benutzerfreundliche Visualisierungen und Steuerungen zu erstellen, ohne sich mit den technischen Details der verschiedenen Systeme auseinandersetzen zu müssen. Darüber hinaus erlaubt es die Smart-Bridge Geräteherstellern, sich auf Innovationen zu konzentrieren. Da die Hersteller unterschiedliche Herangehensweisen verfolgen, ist eine eigene Abstraktionsschicht wichtig.

Fazit: Die konzipierte Middleware-Plattform «Smart-Bridge» löst erfolgreich die Herausforderungen bei

der Integration verschiedener Smart Home- und IoT-Systeme (Sonos-, Shelly- und KNX-Umgebung). Sie bietet eine skalierbare, flexible und benutzerfreundliche Lösung, die die Interoperabilität zwischen verschiedenen Geräten und Systemen verbessert. Ein Proof of Concept bestätigt die technische Machbarkeit und zeigt auf, dass eine systemunabhängige Middleware die Nutzererfahrung im Smart Home-Bereich verbessern kann. Wichtig ist, bei der Architektur die Module nicht zu feingranular zu gestalten, um die Effizienz zu steigern.

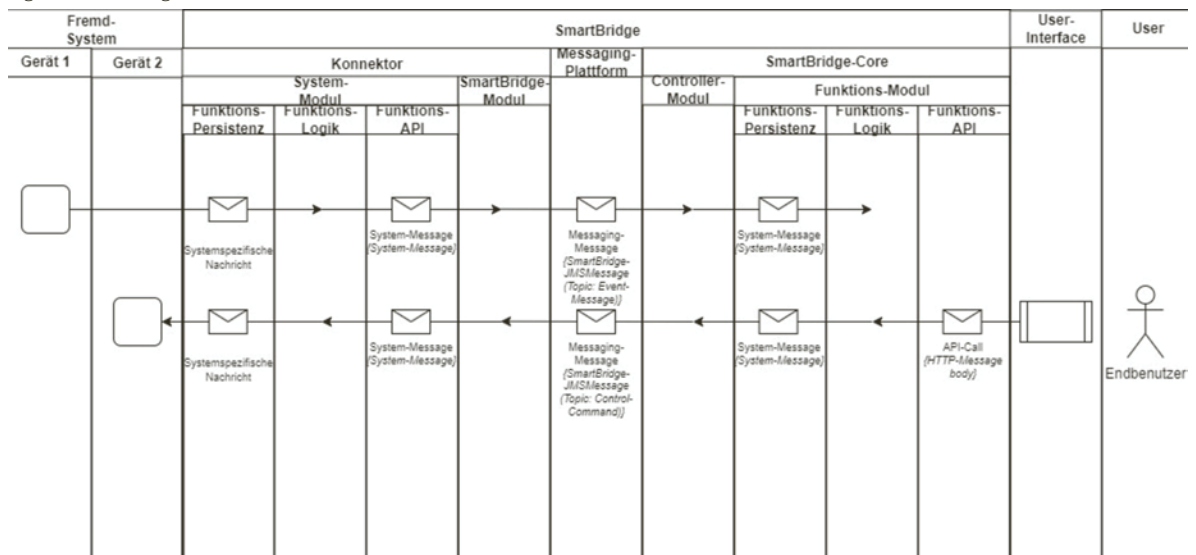
Kontextveranschaulichung der Middleware
Eigene Darstellung



Testaufbau
Eigene Darstellung



Fluss der Nachrichten zwischen Fremd-System und User-Interface
Eigene Darstellung



Referent
Prof. Dr. Olaf Zimmermann

Korreferent
Dr. Gerald Reif, Innovation Process Technology, Zug, ZG

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

Development of a Gamifiable Application for Programming Education

Creation & Implementation of Codable

Graduate Candidates



Mathias Fischler



Lukas Messmer



Svenja Sutter

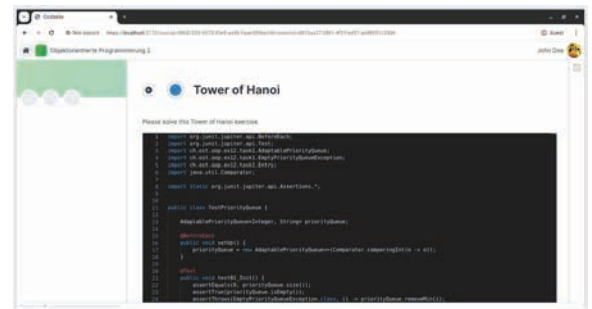
Introduction: In this Bachelor's thesis, we were tasked with the creation and implementation of Codable. Codable is a new user-centered application for creating, managing and solving exercises in an academic environment. Its main goal is to improve the organizational and qualitative problems of exercises at the Department of Computer Science, which were identified in the preceding semester thesis written by Lukas Messmer and Mathias Fischler.

Result: In its current state, Codable allows the creation and management of exercises by lecturers and assistants. Exercises are structured into courses and can be granularly configured both in terms of their content (i.e. what the exercise should contain) as well as their logic (i.e. how the exercise should be evaluated). At the same time, the application provides a uniform interface for students to solve and submit exercises either locally with Git or via the browser. The main strength of Codable comes from its modular plugin system which allows lecturers to extend the functionalities of the application with regard to the exercise contents by implementing a dedicated C# interface. In addition, the application enables modeling exercise logics using a flow-engine-like system, which means that sophisticated workflows can be created that automatically run when students submit their exercises. Both of these features facilitate the streamlining of exercises across different courses, making it easier for students to solve and submit exercises even when complex tools or evaluation processes are required in the background.

Conclusion: Codable is intended to be used productively in the coming semesters at the Eastern Swit-

zerland University of Applied Sciences. If the application is well received, further development might take place to improve upon its current features. We are confident that Codable can considerably increase both interest and engagement in exercises if adequate resources are provided to ensure the sustainable growth of the system.

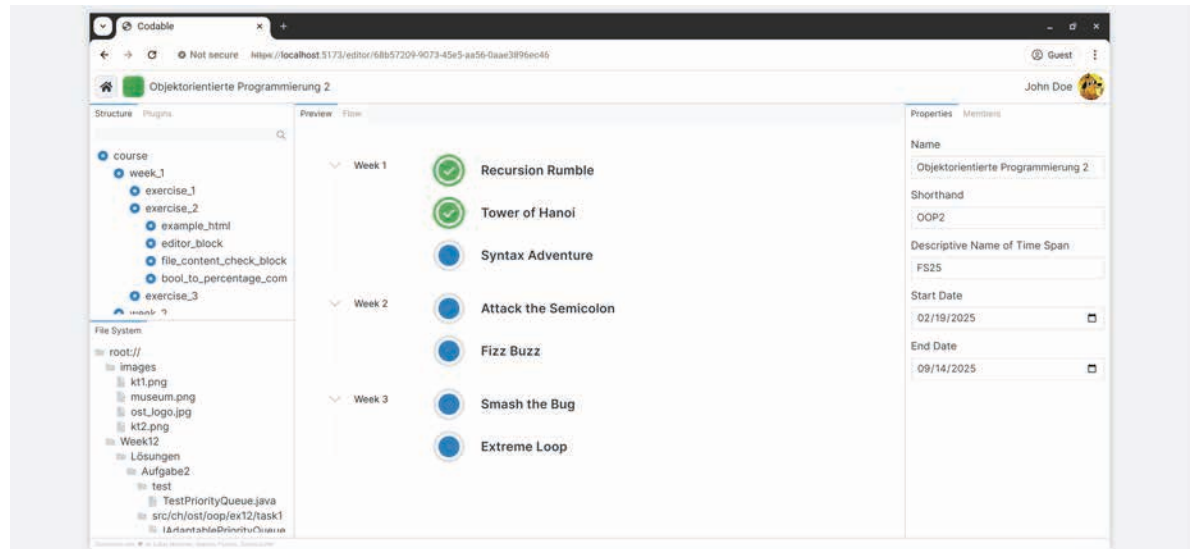
All exercises can be solved in the browser or locally using Git.
Own presentation



Sophisticated exercise workflows can be modeled directly in the application using a flow-engine-like system.
Own presentation



Exercises can be extensively customized in terms of their content and logic.
Own presentation



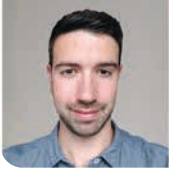
Advisor
Prof. Dr. Frieder Loch

Co-Examiner
Dr. Juliane Fischer,
Audi Planung GmbH,
Gaimersheim, BY

Subject Area
Application Design,
Software, Internet
Technologies and
Applications

Design of a locomotive UI for system testing

Graduate Candidate



Arnaud Kenzler

Objective: Testing new components on a real locomotive is expensive. That is why there are simulations for locomotives. The aim of this project is to design and develop a prototype of a GUI for system testing which can interact with a new simulation system that is still under construction. The new Application should have improved usability and structure, limited on a locomotive driver's cab for the time being. The design approach should be inspired by a real locomotive. Expandability, variability and modularization are particularly important. The new application should serve as a foundation for future expansion, accommodating additional views, variants, and functionalities.

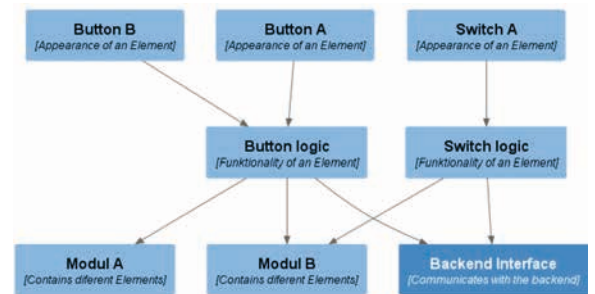
Approach: A component-based stateless user interface using web technologies is implemented that can be integrated into the new simulation system. This prototype aims to provide an intuitive user experience by aligning the structure with the real locomotive. This is achieved with usability tests, official documentation and a test scenario for putting the locomotive into operation. The application should also be easily configurable to support different variants. Although the system is a prototype, it provides insight into how a new and improved user interface can be achieved and it serves as a starting point for future developments. To simulate the prospective interface connection, a mock backend was created as the actual backend implementation is pending.

Conclusion: A component-based UI prototype for a locomotive testing system with focus on the cab was developed. The system is designed to be expandable so that other modules and overviews can be added in the future. A key feature is the customization capability

through a configuration file in CSV format, allowing flexible configuration of modules and variants. The prototype also includes a collection of components and modules available in Figma and React. This project provides a solid foundation for further development and demonstrates the possibilities of extending the application with additional views and functionality, serving as a valuable platform for ongoing work in this area.

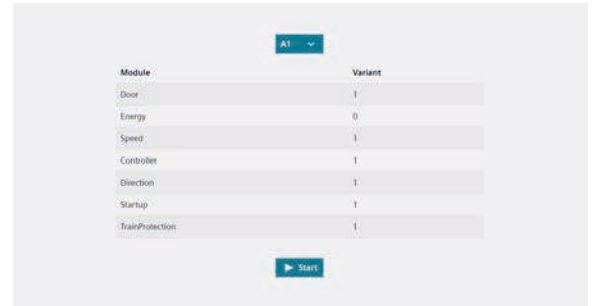
Component structure

Own presentation



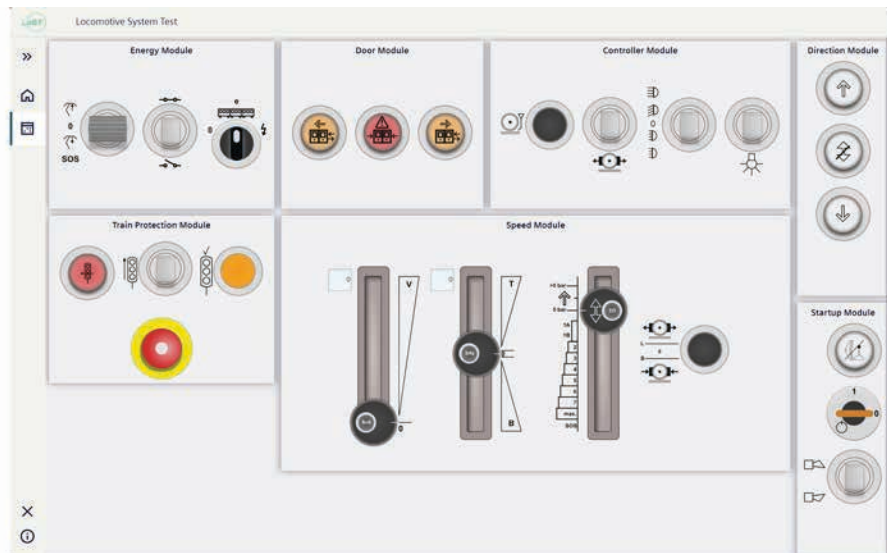
Configuration screen

Own presentation



UI of driver's compartment

Own presentation



Advisor
Prof. Dr. Frieder Loch

Co-Examiner
Dr. Felix Ocker, Honda
Research Institute
Europe GmbH,
Frankfurt am Main, HE

Subject Area
Application Design,
Software, Software
Engineering – Core
Systems

AI as a Teacher's Assistant

Graduate Candidates



Dominik Castelberg



Linus Flury

Introduction: The digital transformation of higher education has led to a significant shift in teaching methods, with blended learning emerging as a favored approach. In this paradigm, traditional face-to-face teaching is combined with online learning, resulting in the well-known inverted classrooms. In this setting, students begin with self-study, supported by multimedia materials, followed by interactive face-to-face sessions.

However, experience shows that students may struggle with self-study, highlighting the need for AI-supported learning assistants. These assistants should provide students with personalized guidance, feedback, and assessment, adapting to their individual needs and learning styles. By leveraging AI, primarily large language models (LLMs), these assistants can help students progress towards competency in an efficient and effective manner.

Approach: Three state-of-the-art LLMs (GPT-3.5, GPT-4 and Mixtral-8x7B) are evaluated on three sub-tasks based on lecture notes about political rights in Switzerland:

- Generating questions
- Evaluating answers
- Providing feedback on the current study level

The models were fine-tuned and the quality of their outputs were compared to their non-fine-tuned equivalents.

A prototype application for a chat bot that supports multiple languages, model selection from a graphical user interface and an approach that combines chat history and RAG is built. Model access is wrapped under an abstracted class, allowing extensibility and enabling rapid integration of new models. Administrators assign documents and system prompts to individual chat bots, giving them granular control over their behavior and available information. The documents get embedded with a locally hosted Multilingual-E5-base instance.

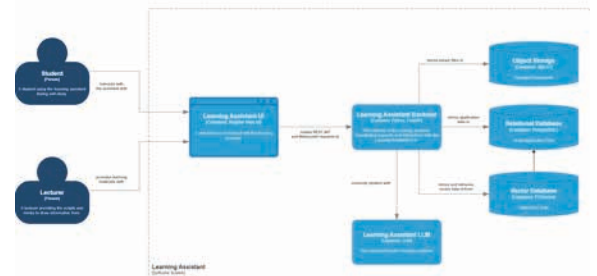
Result: Our work has shown that while there is potential in using LLMs as assistants for pre-study. It was shown that existing chat models can work well on text-based lecture scripts out of the box. However, they could not interpret lecture scripts using images and text. The vast range of possible user inputs in this case makes finetuning challenging as it would require an enormous amount of specific training data. Given that the non-finetuned versions already performed well, finetuning with few data points actually worsened the overall quality of the output.

The prototype serves as a blueprint for history-aware and RAG-enabled chat bot applications. When provided with a locally hosted Mixtral-8x7B instance, the entire RAG process can be done locally. This gives its users control over the use of their data and ensures that classified information can be used to enhance the chat bots.

In its current form, the prototype is primarily limited by its resource consumption and therefore scalability concerns.

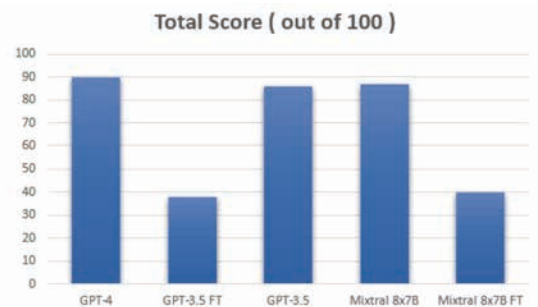
Container diagram of the prototype

Own presentation



Score of each model in our evaluation (FT = fine tuned)

Own presentation



The prototype application, showcasing a user-AI interaction

Own presentation



Advisor
Prof. Dr. Mitra Purandare

Co-Examiner
Dr. Lars-Jochen Thoms, Pädagogische Hochschule Thurgau, Kreuzlingen 1, TG

Subject Area
Artificial Intelligence

PanPal: A chef's chatbot

A chat assistant for the SmartEating platform

Graduate Candidate



Andri Joos

Introduction: PanPal is a chef's chatbot to enable interactive and intelligent user experience of the SmartEating platform at OST. The primary focus of PanPal is to provide an integrated chatbot that responds to user queries via text or audio and intelligently assist with various recipe-related tasks.

Approach / Technology: The project employs several innovative approaches and technologies to enable PanPal support in the SmartEating platform. First, a chatbot interface (CI) has been developed and embedded into the SmartEating platform. This CI facilitates user interactions, making the cooking guidance accessible and user-friendly. A key feature of this CI is the model selection which allows users to choose from a variety of interaction models based on their preferences. The project integrates both a GPT-3.5 based OpenAI assistant and Mixtral, a free large language model (LLM) hosted at OST. These models facilitate a comparison between a free LLM and an enterprise LLM.

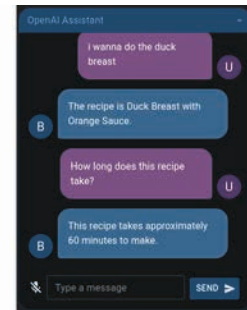
Significant technical challenges are the integration of the Mixtral LLM using the framework LangChain as well as the associated prompt engineering and LLM memory management. This is essential for managing context and memory during interactions, ensuring that the chatbot can maintain a coherent and relevant conversation over extended interactions.

Result: The PanPal project is a robust and functional integration of a chatbot into the SmartEating platform. The chatbot provides interactive assistance in cooking related tasks, significantly enhancing the cooking experience. The successful implementation

of both the GPT-3-based OpenAI assistant and the Mixtral assistant, which are capable of processing both audio and text input, demonstrates the project's ability to leverage advanced AI technologies to meet user needs. These assistants have been compared to evaluate their performance and effectiveness. The project's outcomes indicate that with further refinements and scaling, the PanPal chatbot has the potential to become an indispensable tool for users seeking interactive cooking assistance.

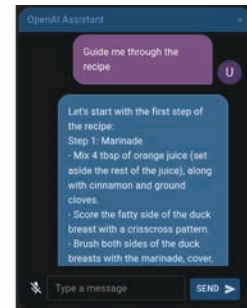
Chatbot interaction

Own presentation



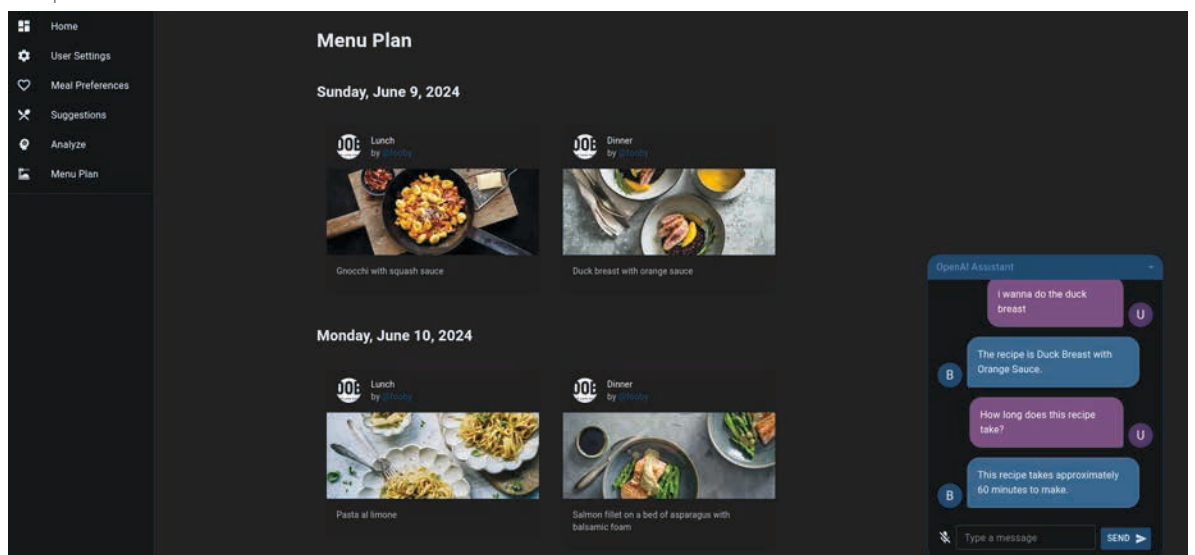
Chatbot recipe guidance

Own presentation



Chatbot in the SmartEating platform

Own presentation



Advisor

Prof. Dr. Mitra Purandare

Co-Examiner

Dr. Raphael Polig, IBM Research GmbH, Rüschlikon, ZH

Subject Area

Artificial Intelligence, Software

AI-Pipeline Integration for Historic Plan Digitisation

Custom desktop app for digitising landscaping plans using deep learning models

Graduate Candidate



Kevin Löffler

Initial Situation: The Swiss Archive for Landscape Architecture at OST in Rapperswil houses over 100,000 historic plans. This collection includes works from prominent Swiss and European architects of the 20th century. The archive serves as a vital reference for contemporary architects, in addition to supporting teaching at OST. Currently, the archive manually digitises its documents, a process that is highly time-consuming. This thesis automates the digitisation process. The solution involves two main components: a transformer-based deep learning and image processing pipeline to locate and extract text, identify relevant entities such as client, date, or scale of a plan, and a desktop app to manually edit and refine the AI-generated output.

Approach / Technology: The desktop app is developed using Tauri, a cross-platform framework that integrates SvelteKit for the GUI and Rust for the backend. This setup allows computationally intensive tasks like image white balance adjustments to be handled asynchronously by the efficient Rust backend. Users can manage estates (projects), upload images, and visually inspect and override AI predictions. A global environment file holds all configuration settings, enabling simultaneous work by different employees.

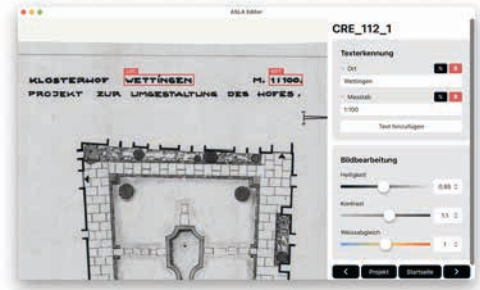
The AI pipeline is dockerized and exposed via a FastAPI web server. Upon image upload, the plan's size and position are determined, followed by preprocessing steps such as contrast normalization, noise reduction, adaptive thresholding, and morphological operations. Three deep-learning models are then applied: a pretrained layout model (LayoutLMv3) to detect all text occurrences, K-means clustering to group text boxes into logical blocks, and a transformer-based OCR model (TrOCR) to extract text. Relevant entities are then identified using a custom-trained German BERT model. The output undergoes post-processing for formatting and normalization, with project-specific keywords like the architect's name filtered out. The predicted metadata is sent back to the client app, which saves it into the corresponding working directory. Metadata files track all changes to the image, ensuring non-destructive editing. Only when a project is uploaded to the archive website a copy is exported, keeping the original image as well as all changes available.

Every weekend, images with manually corrected predictions are automatically uploaded to the server, and the models are retrained on the corrected data and evaluated on a test set. If a model's performance improves, it is automatically updated. The thesis focuses more on implementing a robust pipeline and

continuous retraining than on improving the models because the continuous retraining is expected to enhance the AI pipeline's performance over time. Result: The app significantly speeds up the digitisation process for the archive and is an improvement over the old Excel-based workflow. The AI pipeline's prediction accuracy varies by model. Marker detection is 100% reliable, and the OCR model reaches 98% accuracy after retraining on only 77 images. The NER model, currently at 46% accuracy, is about 10% better than the model from the SA project. If the accuracy continues to increase with additional training data, an F1-score of over 80% can be foreseen within 600 images. Thanks to the new app, these images can be collected in less than a month of archival work.

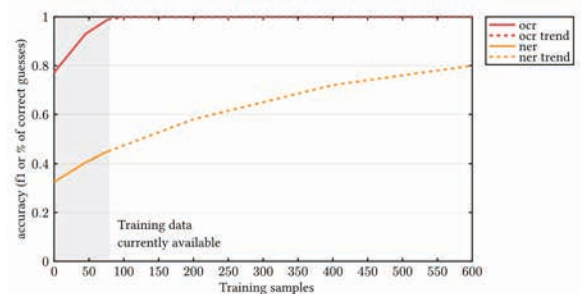
ASLA-Editor: The desktop app

Own presentation



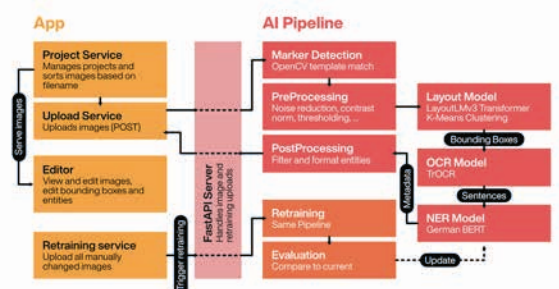
Evolution of model accuracy with more training data

Own presentation



Architecture Diagram

Own presentation



Advisor
Prof. Dr. Mitra Purandare

Co-Examiner
Dr. Marc Röösl, Mettler-Toledo International Inc., Greifensee, ZH

Subject Area
Artificial Intelligence, Software, Application Design

Development of a Scalable and Distributed Streaming Platform

Building a resilient platform for the open future of adaptive bit rate streaming.

Graduate Candidates



Manuel Metzler



Sascha Häring

Introduction: The increasing demand for video streaming services highlights a gap in the availability of free and open-source tools that support scalable and distributed streaming with video conversion capabilities. Existing platforms like YouTube and Vimeo offer scalability and conversion but are neither open source nor self-hostable. Conversely, open-source solutions such as Jellyfin and PhotoPrism lack the ability to convert videos upon upload and do not scale efficiently. This thesis aims to develop a backend server that facilitates scalable and distributed video streaming with integrated conversion capabilities. The objective is to create a free and open-source solution that addresses the limitations of current offerings in the market (<https://gitlab.com/goreeltime/goreeltime>).

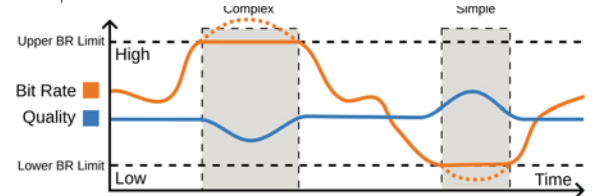
Approach / Technology: The development process began with an evaluation of streaming technologies, focusing on factors such as client support, openness of the standard, and streaming requirements. Dynamic Adaptive Streaming over HTTP (DASH) was selected due to its open standard, extensive client support, and compatibility with royalty-free formats such as WebM-DASH. To achieve scalability, the server was designed to be stateless. Video files are automatically converted and published post-upload utilizing a message queue system for signaling, ensuring scalable and atomic conversion tasks.

Result: Using DASH as the underlying streaming technology allowed the use of modern video formats, reducing storage requirements. The stateless design enabled horizontal scaling, while the message queue ensured efficient handling of video conversion tasks.

Each conversion task is processed exactly once and in the order received, ensuring reliability and temporal decoupling. The developed streaming platform successfully meets the needs for a scalable, distributed, and open-source video streaming service with integrated conversion capabilities. It fills the existing gap by providing a self-hostable solution that leverages modern streaming standards and scalable architecture, making it a valuable tool for communities and organizations seeking an alternative to proprietary platforms.

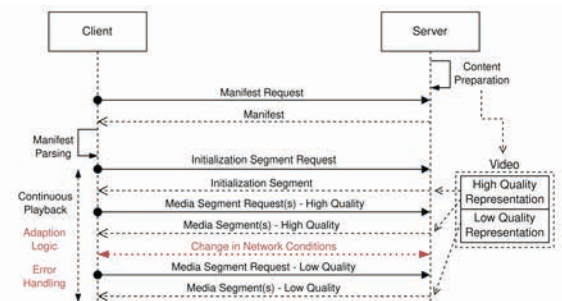
By using constrained bit rate encoding, video files with predictable streaming performance are generated.

Own presentation



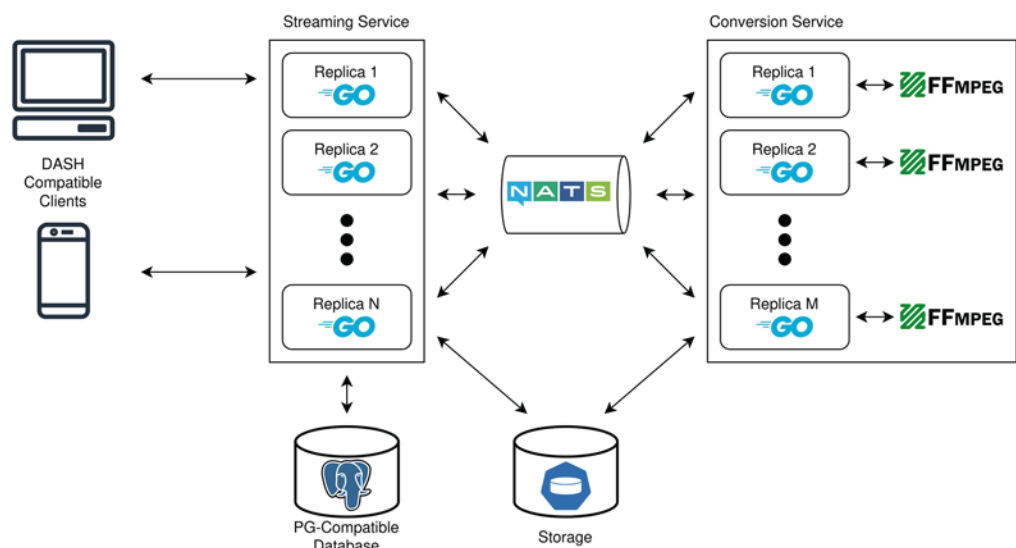
Using client side logic, DASH can adapt to changes in network conditions and ensure smooth video playback.

Own presentation



An overview of the operational model of the software developed during this project, showing the service relationships

Own presentation



Advisor
Dr. Thomas Bocek

Co-Examiner
Sven Marc Stucki,
Procivis AG, Zürich, ZH

Subject Area
Internet Technologies
and Applications

What's up in RJ

Graduate Candidates



Michael Enzler



Fabio Stocker

Initial Situation: Rapperswil-Jona is full of activities and events that are taking place all year round. Organizers are promoting them through various channels, such as social media, posters, newspapers, and websites. With the platform «What's Up in RJ», a central place is created, where events can be published and viewed by the public. A previously developed prototype in the context of a «Studienarbeit» is to be further developed and improved. The existing web application provides the basic functionality to create and manage user and organizer accounts. The organizers were allowed to create, edit and delete events. All viewers were then able to view, search and filter the events. Additionally, registered users can subscribe to a newsletter. The goal is to add needed features to the platform before going live.

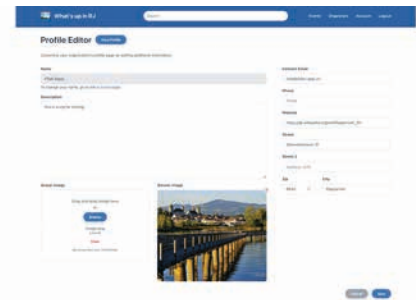
Approach: The existing three tier web application is to be refactored in a first step to create a clean code base. Then, the PostgreSQL based database is updated with new tables and single fields in existing tables. The backend is extended with new API endpoints and remains the sole layer to implement business logic and communicate with the database. Furthermore, it communicates with the external DigitalOcean Spaces object storage and the SendGrid API, to store images and send emails respectively. The Angular frontend is to be extended to incorporate all new features.

Result: The result is a web application with various new features. Organizers can create their own profile page, where they can present themselves with a description and contact information. They are also able to upload images to their profile page and

events. The newly added administrator can log in to access the admin panel that contains user and category management panels, giving them the ability to verify and unverify organizers, and view all organizers, users and administrators. Furthermore, email verification has been implemented to prevent spam accounts. A new onboarding process for all users is also shown after signing up. Finally, all users, logged in or not, can use the platform on different screen sizes and mobile devices due to the new responsive design.

Profile Editor including Image Upload Fields

Own presentation



User Management on the Admin Panel displaying a List of Organizers

Own presentation

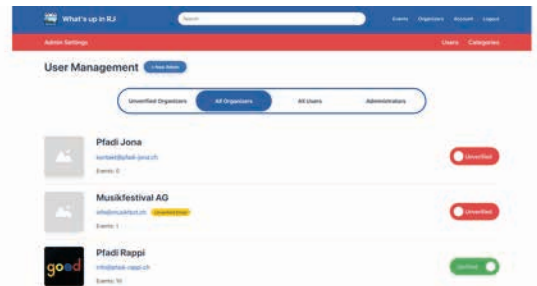
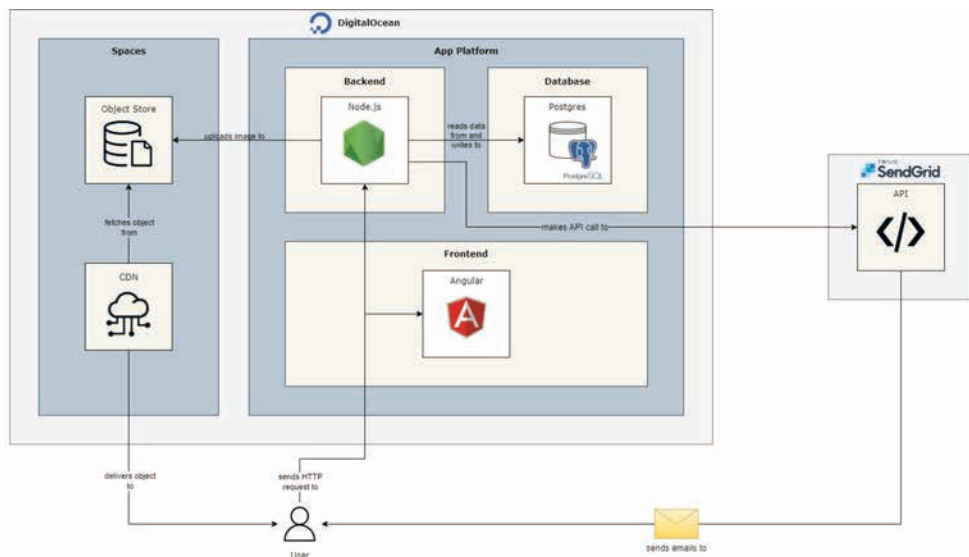


Diagram showing an Overview of the Architecture

Own presentation



Advisor
Prof. Frank Koch

Co-Examiner
Prof. Hansjörg Huser,
Menzingen, ZG

Subject Area
Internet Technologies
and Applications

Project Partner
AdaptIT, Jona, SG

Green Networking

Visibility, a first step towards sustainable networking

Graduate Candidates



Ramon Bister



Reto Furrer

Introduction: This thesis is a follow-up project to our term paper that proposed green networking metrics aimed at enhancing the energy efficiency of networking infrastructures. The initial study highlighted the lack of visibility in network energy efficiency, which hampers efforts to optimize sustainability. The primary objective of this thesis is to demonstrate a comprehensive use case in a virtualized environment where the energy efficiency indicators, developed in the earlier study, are exported and visualized. This aims to provide network operators with the tools necessary to improve network efficiency.

Approach / Technology: The research involves setting up a proof of concept (PoC) within a simulated network environment. This includes implementing an IPFIX exporter on network switches to gather efficiency data, establishing collecting servers for persistent storage of information, and creating dashboards to visualize the network's current state. Additionally, an automation solution is implemented to dynamically configure and update the simulation network. The project successfully developed a virtualized demo application that simulates an energy efficiency-enabled network, as proposed in the term paper. The demonstration shows that exporting flow efficiency information using IPFIX is straightforward and feasible. BMv2 models are used as software switches, and P4 is used as the data plane programming language in the PoC. The IPFIX extension is written in C++, and the automation solution is written in Python and utilizes Nornir.

Result: The study concludes that while the export and visualization of efficiency data are straightfor-

ward, the collection of such data and the implementation of additional data plane functionalities (such as the IOAM protocol) require support from vendors and must be advocated at the IETF. The research demonstrates that significant information can be extracted from the network with a manageable processing overhead, paving the way for more sustainable networking practices.

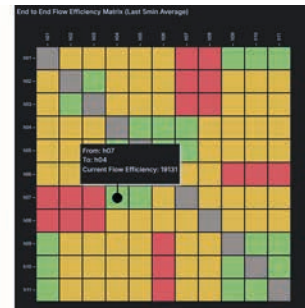
The average network flow efficiency over time is shown in the Network Flow Efficiency statistics.

Own presentation



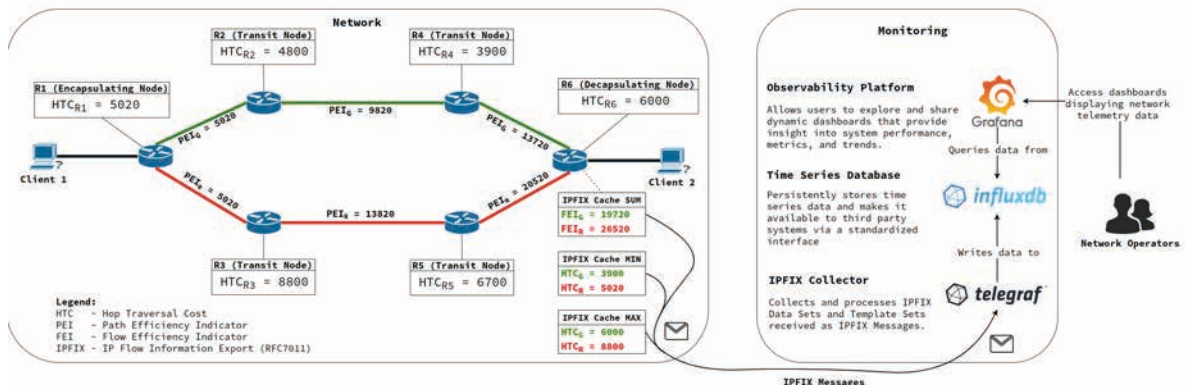
The end-to-end flow efficiency matrix shows the average flow efficiency between hosts over the last 5 minutes.

Own presentation



PoC on BMv2 programmable software switches with IOAM Aggregation Option, IPFIX export and an external monitoring system

Own presentation



Advisor
Prof. Laurent Metzger

Co-Examiner
Dr. Alexander Clemm,
Los Gatos

Subject Area
Internet Technologies
and Applications,
Networks, Security &
Cloud Infrastructure,
System Software

Integration of Computer Vision Models for Document Interpretation and Anonymisation

Graduate Candidate

Marc Havrilla

Introduction: Visual Document Understanding (VDU) models, combined with Optical Character Recognition (OCR) or OCR-free, offer businesses and institutions a great opportunity to digitalise their processes and improve workflows. The digitalisation is progressing. However, challenges like gaining sufficient know-how to integrate VDU models and compliance with data protection regulations as well as identifying processes where VDU models offer the most significant benefit, have to be resolved.

The main goal of the work is to analyse and evaluate the practicality and appropriateness of available VDU models for processing of documents (e.g. PDF of scanned documents) and to demonstrate these in a Proof-of-Concept application. Even though some regulatory aspects, especially regarding anonymisation, are discussed in the work, the developed application does not aspire to be regulatory compliant.

During this work, two areas have been identified where a tool to extract text from an image, identify relevant entities of personal information and anonymise these, is beneficial. First, the anonymisation of medical documents makes more data available for research and educational purposes. A second application is data leakage prevention, since detecting client data from screenshots would lower the risk of data breaches.

Approach / Technology: Various tools exist to extract text from an image. In the scope of this project, three tools have been integrated i.e., Tesseract, Amazon Textract and OpenAI GPT-4V(ision). The application extracts the text of uploaded documents or images and provides the user with the resulting text from all three tools. The user will be able to select the text with the best quality. Afterwards, a Named Entity Recognition (NER) Transformer model is used to identify the names of persons in the extracted text. The last step is the pseudonymisation of the entities: a randomly generated unique string replaces the entities in the text, so that a person cannot be identified based on the name in the text.

Another feature of the application is the evaluation of the OCR accuracy. The user is able to upload an additional ground truth file, which will then be compared with the output of the uploaded images. The OCR accuracy is implemented with string comparison algorithms. Furthermore, the NER model can also be tested by uploading the expected entities of the document in a separate file.

Conclusion: It is impressive how powerful today's text extraction and NER models have become. However,

during the work, it was recognised that they are not yet off-the-shelf and ready to use. Neither works each tool perfectly, so errors are propagated to subsequent processes, nor are the outputs of each tool standardised. To overcome such limitations, the process of text extraction and entity recognition should be executed by one model, which is also fine-tuned on the specific document types.

Example of an anonymised text

Own presentation

Welcome to the Anonymiser!

Upload an image. The text will be extracted and the names will be anonymised. You can also upload an already anonymised text in order to revert the anonymisation.

Back to Start

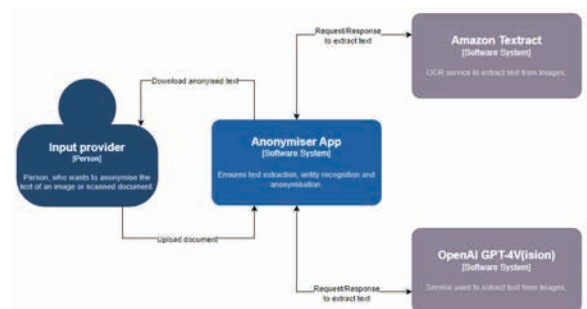
afeda4c2-e084-4734-8c31-6c3ec2521fbc 123 Main Street Cityville, State 56789
 ABC Company 456 Business Avenue Townsville, State 67890 Cityville, 15.10.2023
 Termination Mobilephone Contract Dear Sir or Madam Please terminate my
 mobilephone contract for 077 300 00 00 as soon as possible. May I kindly ask you
 to confirm the receipt of this letter. Many thank and kind regards afeda4c2-e084-
 4734-8c31-6c3ec2521fbc

Download Text

Deanonimise

C4 Context diagram of the Anonymiser App

Own presentation



The screenshot shows the OCR accuracy of the three text extraction tool for a simple test case

Own presentation

OpenAI	Tesseract	Textract
Max Mustermann Musterstrasse 123 12345 Musterstadt Sabine Schmidt Schmidt GmbH Musterweg 456 67890 Beispielstadt 15.10.2023 Termination Mobilephone Contract Dear Sir or Madam Please terminate my mobilephone contract for 077 300 00 00 as soon as possible. May I kindly ask you to confirm the receipt of this letter. Many thank and kind regards Max Mustermann	Max Mustermann Musterstrasse 123 12345 Musterstadt Sabine Schmidt Schmidt GmbH Musterweg 456 67890 Beispielstadt Musterstadt, 15.10.2023 Termination Mobilephone Contract Dear Sir or Madam Please terminate my mobilephone contract for 077 300 00 00 as soon as possible. May I kindly ask you to confirm the receipt of this letter. Many thank and kind regards Max Mustermann	Max Mustermann Musterstrasse 123 12345 Musterstadt Sabine Schmidt Schmidt GmbH Musterweg 456 67890 Beispielstadt Musterstadt, 15.10.2023 Termination Mobilephone Contract Dear Sir or Madam Please terminate my mobilephone contract for 077 300 00 00 as soon as possible. May I kindly ask you to confirm the receipt of this letter. Many thank and kind regards Max Mustermann
1	0.9981981981981982	1

Advisor
 Prof. Dr. Marco
 Lehmann

Co-Examiner
 Dr. Johanni Brea, EPFL,
 Lausanne, VD

Subject Area
 Miscellaneous,
 Software

Digitally Connecting Devices on Mettler Toledo Shopfloor

Graduate Candidate

Florian Falkner

Introduction: In the rapidly evolving landscape of industrial production, the connectivity of devices on a shopfloor has emerged as a critical factor in optimizing operational efficiency and ensuring seamless production processes. This thesis focuses on the development of a scalable architecture and communication protocol for device connectivity at Mettler Toledo's shopfloor, specifically within the framework of the Lean Manufacturing Execution System (LMES). The initial problem centered around the lack of a standardized approach for device connectivity, leading to operational inefficiencies, security vulnerabilities, and challenges in data management.

Objective: The primary objective of this thesis was to develop a solution that could be seamlessly integrated into LMES, allowing it to function as a centralized hub for data transmission and analysis. This involved identifying and establishing a scalable architecture that supports efficient and manageable data flow across different sectors of the production environment. The selection of appropriate communication protocols, with a focus on MQTT for its lightweight and efficient messaging capabilities, was crucial. The development of a proof-of-concept using the MQTT protocol to connect devices, specifically the AUBO Cobot i7, was undertaken to demonstrate the practical application of the proposed architecture and protocol in a real-world setting.

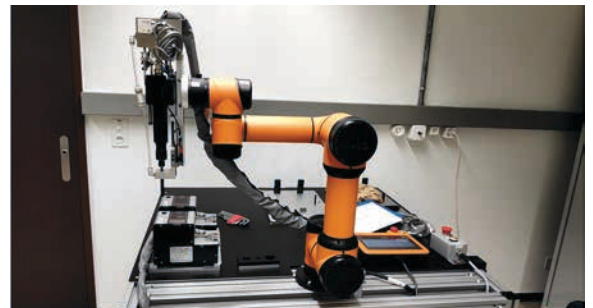
Result: The result was a functional prototype MQTT client integrated into LMES, adaptable for future use with various devices, demonstrating the potential for scalable and efficient device connectivity in industrial settings. The prototype showed the feasibility of

employing the MQTT protocol for real-time data communication. The outlook involves expanding cobot functionalities, integrating additional devices, and adapting the client for OPC UA compatibility. The successful integration of the MQTT client into LMES and its adaptability for various devices signifies a significant advancement in smart manufacturing, highlighting the potential for further development and contributions to industrial automation.

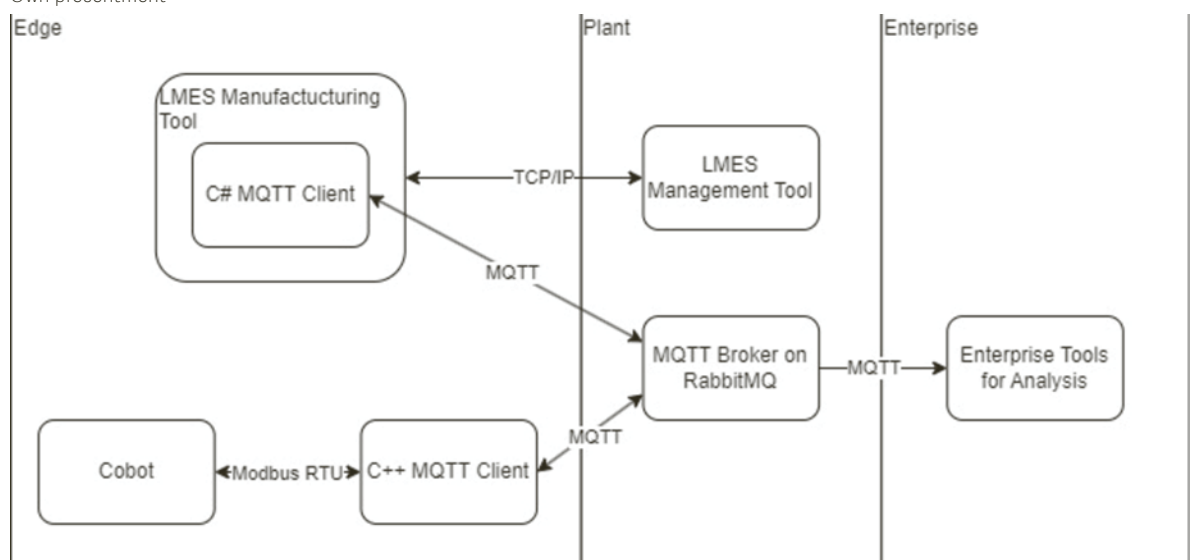
Mettler Toledo Shopfloor with Automated Guided Vehicle (AGV)
Own presentation



AUBO Cobot i7
Own presentation



Solution Architecture using MQTT
Own presentation



Advisor
Dr. Alexandru Caracas

Co-Examiner
Dr. Thorsten Kramp

Subject Area
Networks, Security & Cloud Infrastructure

Project Partner
Mettler Toledo AG

Network insights in OpenTelemetry

Graduate Candidates



Leandro Ceriani



Michael Brändli

Initial Situation: Distributed applications are increasingly becoming state-of-the-art in software development in the age of containers and various cloud providers. This naturally offers excellent flexibility for application developers. However, distributing applications has some downsides. The more systems are involved in a distributed application, the more challenging it becomes to troubleshoot in case of an error or slow application behavior. OpenTelemetry, a vendor-neutral observability framework, excels at capturing application-level insights. In OpenTelemetry, an essential component is still missing. Specifically, there is currently no information about the network devices between the different tiers of an application. Telemetry of Network components is especially useful when the application is hosted across different data centers or clouds.

Approach: The aim was to evaluate different variants and test how telemetry data can be collected from network devices. Four different variants were considered and evaluated. The next step was to collect this data in a central location and integrate it into a trace in OpenTelemetry.

OpenTelemetry is an open-source observability framework. It helps developers gain insights into the performance and behavior of their systems. It is not designed out of the box to integrate with telemetry data from network devices. In order to integrate network telemetry data, the code base of an OpenTelemetry collector must be extended.

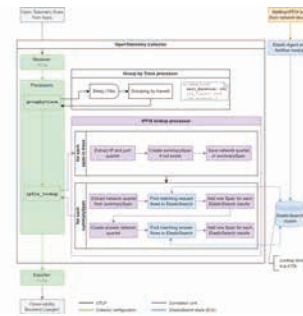
Result: Network components like routers and firewalls sent Netflow/IPFIX data to a central ElasticSearch cluster. A newly developed processor in the OpenTelemetry collector was created. This `ipfix_lookup` processor searches the ElasticSearch cluster for network telemetry data as soon as the application telemetry data arrives. This processor then integrates the network data into existing application traces.

The developed solution successfully provides a comprehensive view of latency and performance across the distributed system by integrating network component data into the existing traces. Latency at the network layer could be analyzed and correlated with application-level requests, enabling more effective troubleshooting and optimization. This advantage minimizes the effort required for troubleshooting, which indirectly leads to a reduction in resources and costs. The enhanced visibility provided by the `ipfix_lookup` processor will invariably contribute to an extended mean time between failures.

While the developed solution achieved the desired objectives, there are opportunities for further improvement. Future work could focus on enhancing the analysis capabilities by including information about the reason for a delay. This could be achieved by incorporating additional data from the network components, such as the device status and error information. Additionally, the solution could be extended to support other observability backends and protocols for collecting network component data.

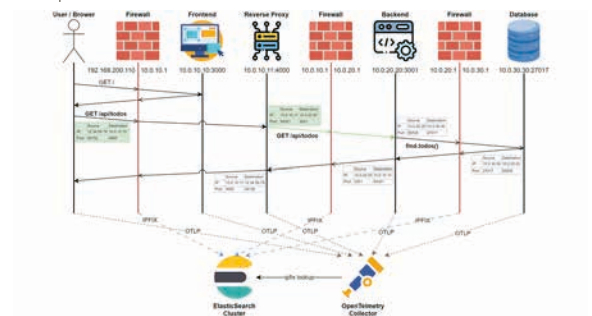
Custom collector/correlation unit

Own presentation



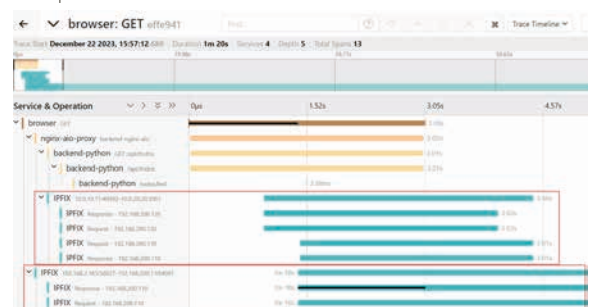
3-tier-app traffic flow example

Own presentation



Network telemetry data span – final implementation

Own presentation



Advisors

Urs Baumann, Yannick Zwicker

Co-Examiner

Philip Schmid, Isovalent GmbH, Zürich, ZH

Subject Area

Networks, Security & Cloud Infrastructure

API Security Lab

Understanding and defending against attacks on APIs

Graduate Candidates



Corsin Salutt



Thajakan Thirunavukkarasu

Initial Situation: APIs play a crucial role in software development and digital business transactions. However, with the increasing spread and importance of APIs, there is also a growing threat landscape.

This bachelor thesis aims to develop an API Security Lab curriculum for future students of the OST using the Hacking-Lab platform. This curriculum will provide practical exercises that allow students to apply theoretical concepts in a hands-on environment, simulating real-world scenarios and challenges.

Approach: The initial phase involves a comprehensive literature review, historical API usage as well as analysis of existing API security threats and standards. The awareness document on OWASP Top 10 API Security vulnerabilities from 2023 forms the basis for this work. It describes the most critical vulnerabilities that organizations should address to secure their API's. In the next phase, lab ideas are developed based on the OWASP Top 10 API Security risks to provide participants with various aspects of API Security. The challenge ideas are fitted into a generic framework to enable comparison, even though they differ in context. The final part involves going through a selection based on meaningful criteria and evaluating labs to determine the final candidates.

Result: As a result of this project, six challenges were created on the Hacking-Lab platform. Each lab covers separate vulnerabilities from the OWASP Top 10 API Security awareness document. The labs can be divided into three categories: tool-based labs in which existing tools such as Burp Suite or Coraza WAF must be learned and used in a ready-made

setup, implementation-based labs in which JavaScript applications must be secured, or where students have to exploit a vulnerable authentication flow.

OWASP Top 10 API Security Risks 2023

<https://owasp.org/API-Security/editions/2023/en/ox11-t10/>

OWASP Top 10 API Security Risks – 2023	
API1	Broken Object Level Authorization
API2	Broken Authentication
API3	Broken Object Property Level Authorization
API4	Unrestricted Resource Consumption
API5	Broken Function Level Authorization
API6	Unrestricted Access to Sensitive Business Flows
API7	Server-Side Request Forgery (SSRF)
API8	Security Misconfiguration
API9	Improper Inventory Management
API10	Unsafe Consumption of APIs

Rate limiting lab: Test report

Own presentation



Hacking-Lab: Labs overview

Own presentation

#	Name	Categories	Level	Mode	Grading
1	API Security: Implementing logging c577a441-ca8e-47cc-9e15-791d1fbcc21f1	🔍️ 🛡️ 🌐	easy	🔄	📋
2	API Security: Enumeration and reconnaissance 8f0e97cc-9d8e-4da3-6796-5d0219e074c1	🔍️ 🛡️ 🌐	medium	🔄	📋
3	API Security: OAuth2 Vulnerabilities 8db957ee-1313-46c9-85a8-c667a998c8f1	🔍️ 🛡️ 🌐	easy	🔄	📋
4	API Security: OWASP Coraza WAF 1c6f6d9ac-3d9e-4d35-a33c-059c1970a7f9	🛡️ 🛡️ 🌐	medium	🔄	📋
5	API Security: Rate limiting 4b590bda-c5e2-48d5-6119-02b302c1a6d1	🛡️ 🛡️ 🌐	medium	🔄	📋
6	API Security: Input validation and sanitization 66694e25-675c-42d6-9d70-10d991eeba04	🔍️ 🛡️ 🌐	easy	🔄	📋

Advisor
Ivan Bütler

Co-Examiner
Dr. Benjamin Fehrensen, Berner Fachhochschule, Bern, BE

Subject Area
Networks, Security & Cloud Infrastructure, Security

Enhancing Cybersecurity with Machine Learning: Beaconing Detection in PCAP Data

Graduate Candidate



Anastasiia Graftceva

Definition of Task: The objective of this study is to develop a model capable of detecting beaconing activity within network traffic capture (PCAP) files. Although not designed for real-time detection, this model is intended for integration into existing Network Detection and Response (NDR) or Security Orchestration, Automation and Response (SOAR) systems for analyzing post-capture files. It combines machine learning (ML) algorithms and neural networks (NN) to address the challenge of detecting beaconing, which involves repetitive, periodic communication often used by malicious actors to maintain connections with compromised systems. The model includes a Histogram Gradient Booster Classifier (HGBC) for binary classification of PCAP data features and a Long Short-Term Memory (LSTM) neural network for analysis of temporal dependencies in the communication patterns. This combination aims to achieve higher detection accuracy and demonstrates resilience against ever-evolving tactics of cyber threats.

Approach / Technology: The approach applies advanced ML algorithms and NN, along with the collection of network traffic data from various sources for model training and evaluation. Malicious data, primarily from botnet traffic involving DNS and HTTP protocols, highlights repetitive beaconing patterns. For benign activity, data from IoT-enabled environments, both open-source and private, was used to develop a dataset of regular and semi-automated non-malicious communication. Initially, raw PCAP data is processed to extract unique packet flows and structured into a format where relevant metrics indicative of beaconing are computed. The HGBC then analyzes this data to identify potential malicious patterns, and these results are processed by the LSTM to examine temporal relationships. During testing, the model was challenged with both benign and malicious files from a simulated cyber attack environment, ensuring it was tested against realistic scenarios. This approach led to the development of a highly accurate beaconing detection framework, achieving a 99.37% accuracy rate on a modestly sized training set, and demonstrating advanced cybersecurity threat detection capabilities.

Conclusion: Integrating this sequenced ML and NN model with existing cybersecurity systems such as SIEM, IDS, NDR, SOAR and firewalls can significantly increase their ability to identify and mitigate network threats. The model's modularity allows for application across different network environments. Future enhancements should include expanding the dataset with more diverse data collected over extended periods, to capture a comprehensive view of net-

work activity. Continuous data recording at different times will also enrich the dataset, reflecting a broader range of network behaviors and potential threats. Additionally, the developed framework shows promise for detecting various network traffic patterns, which could extend its use beyond beaconing detection. Adapting the model to recognize different network anomalies could enable NDR systems to identify a wider array of malicious activities, such as unusual data exfiltration as well as command and control communication. Integrating this model could improve incident response times, reduce undetected breaches, and enhance overall network security. Future research should focus on dataset augmentation and extending the framework's capabilities to ensure even greater protection and resilience in network security.

HGBC-LSTM results on unseen data

Own presentation

file2.csv	file3.csv
Statistics:	Statistics:
Total sequences: 362	Total sequences: 47
Malicious sequences: 48	Malicious sequences: 0
Percentage of malicious sequences: 13.26%	Percentage of malicious sequences: 0.00%
Sequence 249: Benign	Sequence 5: Benign
Sequence 250: Malicious	Sequence 6: Benign
Sequence 251: Malicious	Sequence 7: Benign
Sequence 252: Benign	Sequence 8: Benign
Sequence 253: Benign	Sequence 9: Benign
Sequence 254: Benign	Sequence 10: Benign
Sequence 255: Benign	Sequence 11: Benign
Sequence 256: Benign	Sequence 12: Benign
Sequence 257: Benign	Sequence 13: Benign
Sequence 258: Malicious	Sequence 14: Benign

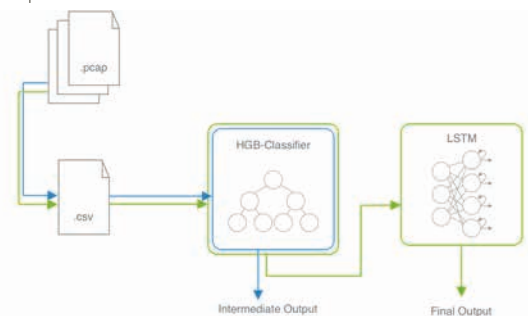
HGBC-LSTM accuracy report

Own presentation

Training Summary:		
Total epochs: 10		
Epoch-wise Loss and Accuracy:		
Epoch	Loss	Accuracy
1	0.5479	0.7475
2	0.2196	0.9939
3	0.0879	0.9939
4	0.0517	0.9935
5	0.0392	0.9933
6	0.0343	0.9939
7	0.0315	0.9935
8	0.0311	0.9935
9	0.0298	0.9935
10	0.0299	0.9937
Final Metrics:		
Loss: 0.0299		
Accuracy: 0.9937		

HGBC-LSTM Pipeline

Own presentation



Advisor
Nikolaus Heners

Co-Examiner
Ludovico Bessi, Zürich,
ZH

Subject Area
Security

React Security Labs

Graduate Candidates

Natalia Gerasimenko

Tim Gamma

Introduction: In the field of web development, ensuring security is crucial.

This project, React Security Labs, led by the School of Computer Science at OST Eastern Switzerland University of Applied Sciences and Compass Security, focuses on enhancing web security education.

The aim is to create practical, hands-on labs on the Hacking Lab platform that simulate common security vulnerabilities within a React application. Those vulnerabilities will be implemented into a Swiss-themed web shop.

Approach: The project began with research, particularly focusing on the most common web vulnerabilities in React, and the selection of relevant vulnerabilities. Afterwards, the requirements were defined, and the React frontend of the web shop was developed. The Flask backend could be reused from a different web shop. The security vulnerabilities were integrated based on the research on the most common React-specific vulnerabilities. Step-by-step solutions were developed to demonstrate how exploits could occur if prevention mechanisms were not used. Docker was used for containerization and delivered as a zip file to Compass Security AG, which maintains labs on the Hacking Lab platform. This setup allows for starting and stopping of the vulnerable web shop within the labs.

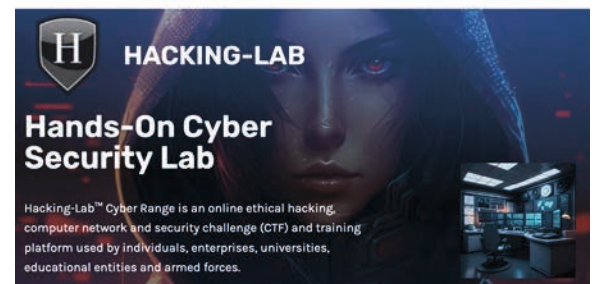
Result: The project successfully developed a functional React-based cheese-themed web shop incorporating various React security labs. These labs cover a range of common vulnerabilities, including three different Cross-Site Scripting (XSS) scenarios and Cross-Site Request Forgery (CSRF). The CSRF lab demonstrates a CSRF attack scenario and what happens if no protection mechanisms are used. Since React does not have built-in CSRF protection (unlike e.g. Angular), a solution was provided on how CSRF protection can be implemented, using React and Flask. Additionally, a vulnerable setup lab was included to demonstrate the risks associated with not regularly updating application dependencies. Also, a comparison was made between security mechanisms in React, Angular, and Vue.

The React Security Labs project achieved its goal of creating challenges that allow users to see and exploit the most common React-specific web vulnerabilities. Additionally, research showed that most websites use reasonably up-to-date versions of React, similar to Angular and Vue websites. While React offers protection against XSS, it does not provide built-in protection against CSRF. Therefore, it is

vital to adhere to security best practices to achieve the most secure React application.

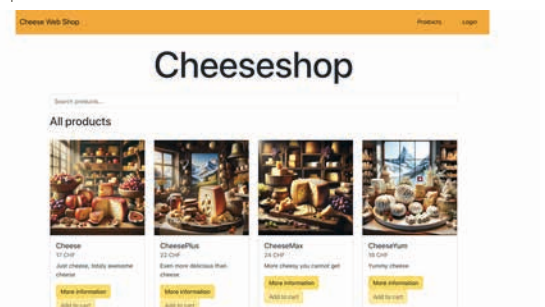
Hacking-Lab platform

<https://www.hacking-lab.com>



Developed «Cheese» web shop based on React

Own presentation



Example of XSS attack – script injection via URL

Own presentation



Advisor
Cyrill Brunschwiler

Co-Examiner
Thomas Risch, Zürich, ZH

Subject Area
Security

Dynamic Pentest Lab Generator

Building a standardized Azure Pentest Deployment Framework

Graduate Candidates



Janosch Bühler



Samuel Maissen



Dante Suwanda

Initial Situation: Hacking-Lab is a platform that provides ethical hacking for educational purposes. The overall goal is to promote awareness in the field of hacking and security. The corresponding challenges are developed in the format of a capture-the-flag scenario. As it stands, Hacking-Lab leverages Terraform deployments to establish pentest labs in Azure. Each lab consists of a static Terraform deployment, which is manually developed to suit a specific use-case. This approach, involves a time-intensive process that necessitates manual interventions and several procedures. It also calls for time dedicated to debugging the Terraform deployment. Additionally, it expects the lab creator to possess knowledge of cloud deployments.

Objective: The objective of this bachelor's thesis is to develop a web application that automates the deployment and configuration of custom pentest lab environments, integrating it into the existing Hacking-Lab infrastructure. The project aims to implement a Visio-like tool that defines the basic infrastructure of a corporate IT network, generating configurations for deployment via Terraform. The solution should simplify the creation of network setups with multiple subnets, deployment of virtual machines and container services. It should include VPN access for students, the possibility to manage communication between resources like a firewall, and DNS resolution for these resources. The tool should offer the ability to use existing Hacking-Lab Docker images and allow virtual machines to be customized. It should also provide options for distributing dynamic flags and setting static or dynamic passwords, enhancing the uniqueness of the labs.

Result: The project successfully established a solid framework for generating pentest labs. This was achieved using Django for backend operations and Angular for the frontend, ensuring a scalable and maintainable solution. For the deployment part Terraform was used, which dynamically configures and deploys the necessary resources based on the configuration applied in the frontend. The framework integrates seamlessly with Hacking-Lab using SSO authentication.

Core Technologies

Microsoft, Angular, Django, HashiCorp, MiniO



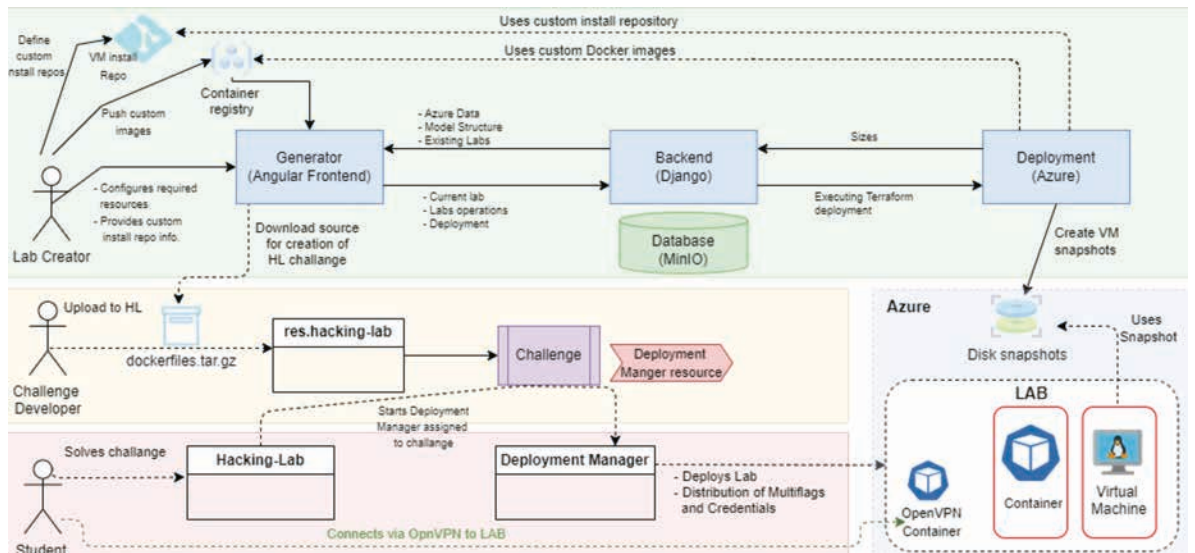
Dynamic Pentest Generator Frontend

Own presentation



Dynamic Pentest Generator System-context

Own presentation



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Co-Examiner
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Subject Area
Security, Networks, Security & Cloud Infrastructure, Software

Project Partner
Hacking-Lab AG, Jona, SG

Systematic Identification of Vulnerabilities in C and C++ Source Code through Fuzzing

Advanced Techniques for Efficient Vulnerability Detection

Graduate Candidate



Miles Strässle

Introduction: As software becomes more complex and security issues in applications grow. This research focuses on the use of high-performance fuzzing techniques and also investigates performance parameters for fuzzing in different contexts. Fuzzing is a method of finding software vulnerabilities by injecting random data into programs to reveal and be able to fix potential security flaws. The goal is to use an advanced fuzzing framework to identify vulnerabilities in real-world open-source C and C++ software, thereby improving its robustness and security.

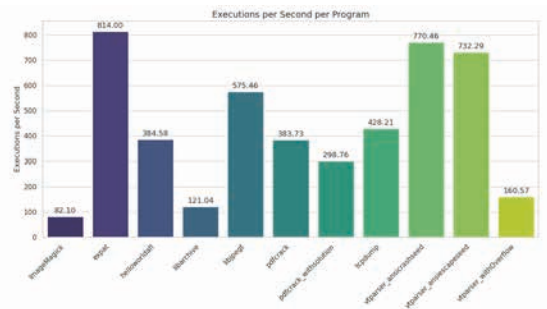
Approach: To find a suitable project for fuzzing, the search targeted software that accepts input from users or external sources, focusing on areas most likely to contain vulnerabilities. A variety of open-source C and C++ projects with significant user interaction components were selected. A fuzzing harness was then created to test these critical areas of the software, utilizing various inputs and seed values. Employing white-box fuzzing, full access to the source code is provided, which allows for more informed tests, simplifying bug identification and avoiding reverse engineering as in black-box fuzzing. Once the tests were executed, the resulting bugs and hangs were analyzed to understand their causes and potential security implications. Metrics such as the number of bugs found, the types of vulnerabilities, and the duration of tests were collected to assess the effectiveness of the fuzzing process.

Conclusion: This project used advanced fuzzing techniques to test real-world C and C++ open-source projects. The fuzzing framework successfully reproduced many known security vulnerabilities, proving its effectiveness and reliability. Although no new vulnerabilities were found, the high performance and the

efficiency of the setup make it suitable for ongoing security testing. The metrics collected – such as the number and types of bugs found and test durations – highlighted areas for improvement. The results demonstrate the robustness of the code in the context of penetration testing and security audits, underscoring the importance of continuous security testing and how fuzzing can enhance software security.

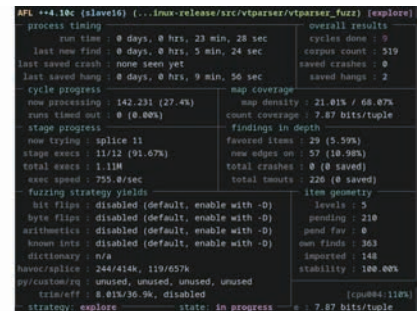
Execution Speed per Fuzzing-Project

Own presentation



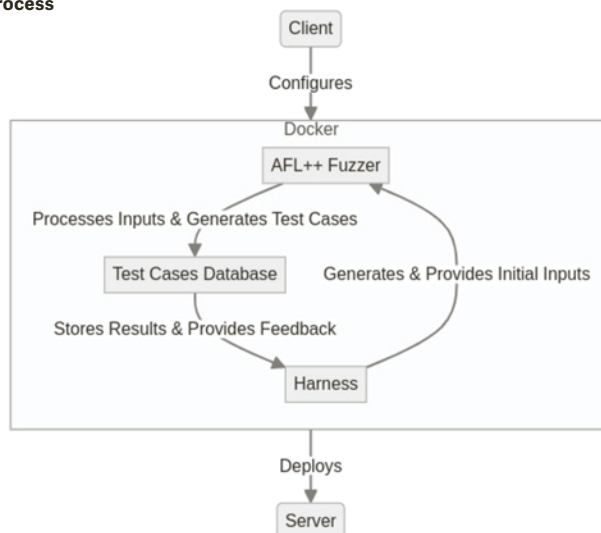
Screenshot of AFL++ running on vt-parser

Own presentation



Overview of the AFL Fuzzing Process

Own presentation



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Nikolaus Heners

Co-Examiner
Thomas Sutter, ZHAW
School of Engineering,
Winterthur, ZH

Subject Area
Security, Software

Barrierelos

Crowdsourced E-Accessibility Dashboard

Graduate Candidates

Michael Hofmann

Pascal Lehmann

Introduction: According to the Swiss Federal Statistical Office (BFS), almost 18% of the population have disabilities as defined under the Disability Discrimination Act (BehiG). In December 2023, the Federal Council of Switzerland announced that they are working on a revision of these regulations, also obligating private companies to make their digital services accessible. Therefore, a far greater number of actors will now have to adhere to these rules. Despite existing regulations, there are clear deficits regarding the accessibility of digital services in Switzerland, especially regarding government services at the cantonal and municipal levels. However, the extent of these deficits cannot currently be determined. For this reason, our project aims to: record accessibility issues on websites, score these websites based on their accessibility and classify them by region and other categories. The collected data is made available to the public to raise awareness of web accessibility and help website maintainers resolve such issues.

Result: The result of this thesis is a software system to automatically determine the accessibility of websites and a web dashboard to highlight these results. Crowdsourcing is employed to collect and categorize websites. The system was developed from scratch but uses the axe-core accessibility engine to search for accessibility issues. The work on this thesis included software engineering, requirements engineering, software architecture, database modeling, wireframing, UX design and the development of a scoring algorithm. The score quantifies the accessibility of websites (from 0 to 100) and was given the name Barrierelos-Score. It is based on the number of accessibility issues found on the website and the severity of these issues.

The frontend is a web application providing an overview of the state of web accessibility in Switzerland and Liechtenstein that also allows collaboration and moderation. It is a React single-page application with client-side rendering written in TypeScript. The backend implements the business logic that commissions website scans, assesses the results and calculates the score. It is a Spring Boot application written in Kotlin that provides a RESTful web API with OAuth 2.0 offered for authorization. A PostgreSQL database and JPA are used to manage persistence. The scanner receives jobs from the backend via a RabbitMQ message broker to temporally decouple the resource-intensive scanning tasks. It searches for accessibility issues and returns the findings to the backend via RabbitMQ. The scanner is implemented in TypeScript and runs on Node.js.

Advisor
Prof. Dr. Markus Stolze

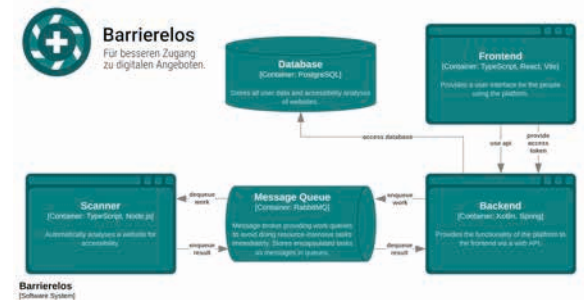
Co-Examiner
Markus Flückiger,
Zühlke Engineering AG,
Schlieren, ZH

Subject Area
Software

Conclusion: Thanks to the containerization and temporal decoupling of resource-intensive tasks, the system is easily scalable. The highly modularized architecture is designed in a way that new requirements can be implemented with little effort. Large suites of automated unit and integration tests were written to improve quality and maintainability of the code. An agile workflow was fully embraced, with an automated pipeline for building, testing and deployment with GitLab CI/CD, and Flyway for automated database migration, enabling both continuous integration and continuous deployment. Writing the documentation with RST and Sphinx allowed making it available online as a web documentation through GitLab Pages.

The software architecture as a C4 container diagram

Own illustration



Screenshot of the website assessment result page

Own illustration



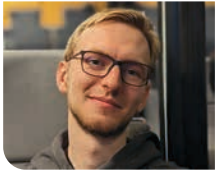
Technologies used for the project

Own illustration



Bluetooth LE Audio Test Infrastructure

Graduate Candidates



Jeremy Stucki



Vina Zahnd

Introduction: The introduction of Bluetooth® 5.2 has paved the way for new audio transmission features like LE Audio and Auracast™, revolutionizing the wireless audio technology landscape. Auracast™ allows users to broadcast audio to multiple devices simultaneously, enhancing shared listening experience in public or private settings. A typical setup includes a transmitter sending a broadcast, receivers listening to the broadcast, and an assistant configuring which broadcast receivers render. Currently, a few end user devices already support this new feature and more will come in the future.

In collaboration with Sonova, we started the development of a test library which facilitates the testing of Auracast™ features in their products. Within the existing .NET test environment, control over broadcast transmitters and assistants is required for defining automated test scenarios.

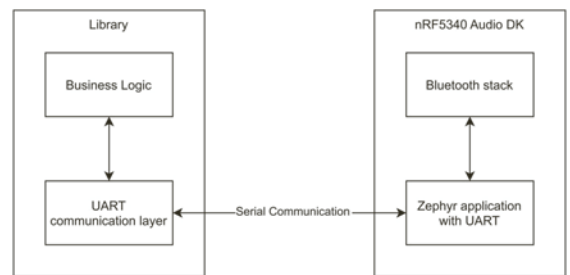
Approach / Technology: The project utilizes Nordic nRF5340 Audio Development Kits for the broadcast transmitter and assistant roles. Several strategies for the communication between the boards and the .NET library were evaluated. Ultimately, a simple yet scalable solution, using serial communication via UART with a custom Protocol Buffers-based layer on top, was chosen.

Existing sample applications for the Nordic boards were translated from C to C++ and customized to meet the project's requirements. Additionally, a small console application was developed to test the setup.

Result: The key functionality has been implemented, however, some of the more advanced features and configuration operations did not fit into the time frame of the project. After the completion of this bachelor thesis, there will be a handover process and the project will be continued by Sonova. They will use it to support their development of Auracast™ capable products.

Chosen Communication Strategy

Own presentment



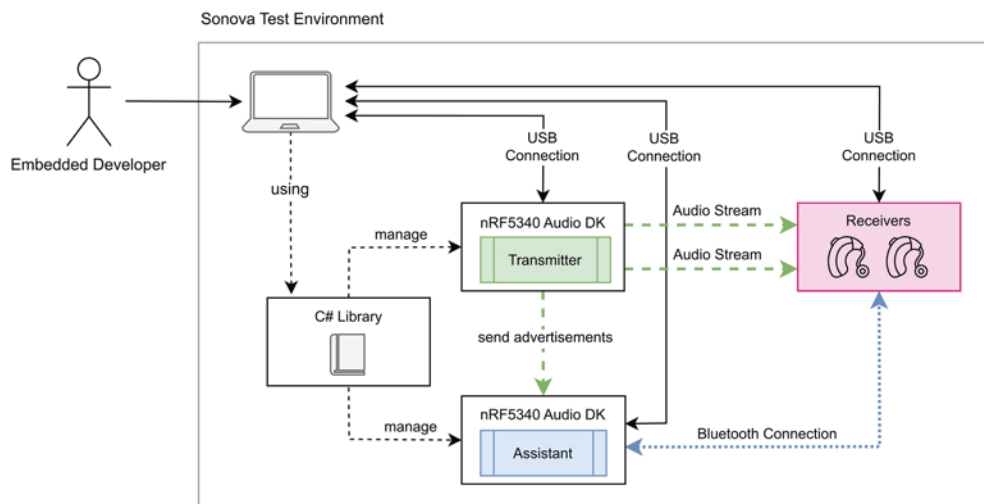
nRF5340 Audio Development Kit

Nordic Semiconductor



Environment Diagram

Own presentment



Advisor
Thomas Corbat

Co-Examiner
Guido Zraggen,
Google Switzerland,
Zürich, ZH

Subject Area
Software

Project Partner
Sonova Holding AG,
Stäfa, ZH

HSL Interpreter Rewrite

Architectural Design and Prototype of an Interpreter for a Scripting-Language used in Robotic Laboratory Automation

Graduate Candidate



Jann Marco Flepp

Introduction: Hamilton Bonaduz utilizes the VENUS software platform with the HSL (Hamilton Standard Language) interpreter to operate advanced pipetting robots. However, the current interpreter, built long ago in C++ with Lex and Yacc tooling and COM interfaces, struggles with maintainability and extensibility, limiting its adaptability to modern practices and new developments on the VENUS platform. This thesis aims to resolve these issues by designing and developing a new HSL interpreter.

Approach / Technology: The new HSL interpreter is developed using modern software engineering practices to address the limitations of the existing system. The chosen technology stack includes C# and ANTLR, a powerful parser generator, to ensure a maintainable and extensible codebase.

The thesis adopts a structured development approach that employs the following methods: The requirements analysis is conducted through interviews and document studies of the existing system. The architectural design utilizes C4 modeling to ensure a clear and structured design. The implementation proves the feasibility of the proposed architecture. The quality assurance includes a comprehensive suite of unit, integration, and manual tests to ensure that the developed system meets a high level of quality.

Result: The main outcome of this thesis is a clean software engineering documentation from requirements to architecture and quality assurance of a new interpreter. It demonstrates how the issues of the current system can be resolved with modern design

and techniques while maintaining compatibility with the current implementation.

The secondary result is a prototype that successfully demonstrates the viability of the proposed architecture. It can parse and interpret a subset of HSL and can send simple commands to instruments. It is seamlessly integrated into the VENUS platform and, in addition, features a command-line interface capable of running on non-Windows platforms.

HSL Code Example

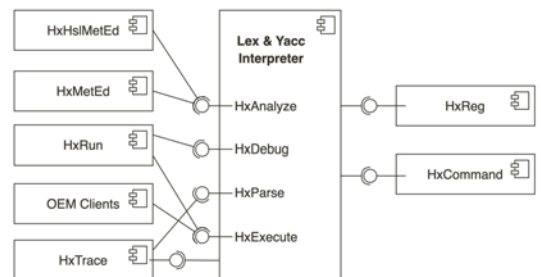
Own presentation

```
#include "sequences.hsl"
device star("MLStar");

method Main()
{
    variable counter;
    for (counter = 0; counter < 10; counter++)
    {
        star.Aspirate(source);
        star.Dispense(target);
    }
}
```

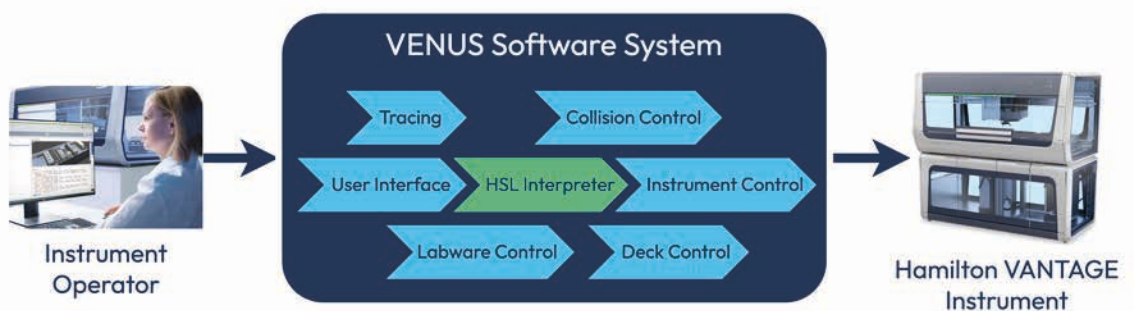
VENUS systems Interacting with the HSL interpreter

Own presentation



Overview of the Hamilton VENUS software platform

Own presentation, Images by Hamilton Bonaduz AG



Advisor
Philipp Kramer

Co-Examiner
Christian Marrocco,
Triamec Motion AG,
Arni AG, AG

Subject Area
Software

Project Partner
Hamilton Bonaduz AG,
Bonaduz, GR

Limbic Chair Anwendung

Diplomanden



Nicolas Gattlen



Kevin Pfister

Einleitung: Der Limbic Chair ist eine innovative Sitzlösung von Limbic Life. Er nutzt Sensortechnologie, um durch Bewegungstracking die Interaktion mit dem Benutzer zu verbessern. Diese Bachelorarbeit untersucht die Entwicklung eines fortschrittlichen Softwaresystems, das die Funktionalitäten des Limbic Chair durch die Nutzung seiner integrierten Sensoren erweitert. Der Stuhl ist mit sechs Sensoren ausgestattet, die verschiedene Beinbewegungen überwachen und aufzeichnen. Insbesondere erfassen die linken und rechten Pitch-Sensoren die vertikalen Bewegungen der Beine, während die linken und rechten Yaw-Sensoren die seitlichen Beinbewegungen verfolgen. Darüber hinaus messen die Roll-Sensoren auf beiden Seiten die Rotationsbewegungen des Stuhls. Ziel dieses Projekts ist es, diese Sensoreingaben in eine Softwareplattform zu integrieren, die ein erweitertes Benutzererlebnis bietet und den Weg für innovative Anwendungen in Bereichen wie Gesundheit und Gaming ebnet. Der Entwicklungsprozess, die Systemarchitektur und die potenziellen Anwendungen des erweiterten Limbic Chair werden in dieser Arbeit aufgezeigt.

Vorgehen / Technologien: In der heutigen Zeit sitzen viele Menschen aufgrund ihrer beruflichen und privaten Aktivitäten zu lange, was nachweislich negative Auswirkungen auf die Gesundheit hat, wie Rückenprobleme und schlechte Körperhaltung. Diese Bachelorarbeit zielt darauf ab, diese Probleme anzugehen und eine Lösung zu entwickeln, die zu mehr Bewegung im Sitzen anregt.

Eine umfassende Recherche und Analysen wurden durchgeführt, um die gesundheitlichen Auswirkungen von übermäßigem Sitzen zu untersuchen und bestehende Lösungen zur Bewegungsförderung am Arbeitsplatz zu analysieren. Basierend darauf wurde der Movement Score entwickelt, der verschiedene Parameter zur Berechnung der Bewegung des Nutzers heranzieht. Ein Algorithmus berechnet den Score kontinuierlich basierend auf den getrackten Bewegungen.

Zur Erhöhung der Attraktivität des intelligenten Stuhls wurden zwei interaktive Bewegungsspiele entwickelt, die den Stuhl als Controller nutzen. Im Raketenspiel steuert der Benutzer eine Rakete, während er im Jump-and-Run-Spiel einen Charakter durch eigene Bewegungen im Stuhl steuert. Diese Spiele sollen zu mehr Bewegung motivieren und gleichzeitig Spass bieten.

Ergebnis: Das Usability-Testing zeigte, dass Benutzer sich deutlich mehr bewegten, sobald sie sich des Movement Score bewusst waren. Der Score stieg

schnell an, da Benutzer motiviert waren, ihren Punktestand zu verbessern. Die Nutzung der Bewegungsspiele führte zu gemischten Ergebnissen: Einige spielten bis zu 15 Minuten, andere nur kurz.

Ein weiterer positiver Effekt war das gesteigerte Bewusstsein der Benutzer für ihre täglichen Aktivitäten. Viele versuchten, sich auch im Sitzen mehr zu bewegen. Bei Aufgaben mit hoher Konzentration wurde der Movement Score jedoch häufig ignoriert, während bei leichteren Tätigkeiten wie Meetings eher passive Bewegungen in den Alltag integriert wurden.

Bild des Limbic Chair

sitz.ch/wp-content/uploads/Limbic-Chair_Totale_01_AM.jpg



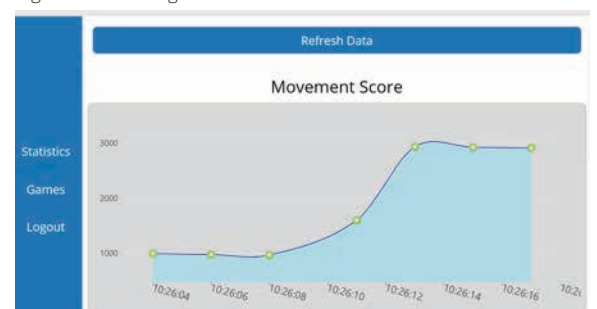
Bild des Spiels Rocket Escape.

Eigene Darstellung



Bild der ActiveSit Software

Eigene Darstellung



Referent

Prof. Dr. Markus Stolze

Korreferent

Markus Flückiger,
Zühlke Engineering AG,
Schlieren, ZH

Themengebiet Software

Projektpartner

Limbic Life AG, Zürich,
ZH

a decentralized STI tracing approach

Graduate Candidate



Laurin Zubler

Introduction: Sexually Transmitted Infections (STIs) are a significant global public health challenge. While in Switzerland the incidence of Human Immunodeficiency Virus (HIV) has been declining since the 1980s pandemic, other STIs such as Chlamydia, Gonorrhea, and Syphilis exhibit an upward trend. Effective partner notification is essential to mitigate the spread of STIs. However, it is not practiced sufficiently, and no dedicated technical solution currently addresses this challenge.

During the COVID-19 pandemic, proximity-tracing mobile apps were successfully deployed to combat the spread of SARS-CoV-2. Various system architectures were employed, utilizing different approaches concerning privacy and data sovereignty.

The primary objective of this thesis is to design and develop upsi, a mobile application for STI partner notification. Inspired by the COVID-19 proximity tracing apps, upsi aims to enhance partner notification, thereby mitigating the spread of STIs. Experts in the field of STIs will be consulted to evaluate the feasibility and importance of upsi.

Approach: Research was conducted to understand the current STI situation and existing solutions for STI partner notification and COVID-19 proximity contact tracing. A concept for upsi was developed based on insights gained from the research and presented to leading STI experts. The expert feedback was integrated into the solution design. A minimum viable product (MVP) was developed using the most feasible technologies evaluated.

Result: upsi, a partner notification application for STI rapid tests, was developed with a focus on privacy and decentralization. The solution consists of a Flutter mobile app for users, which provides contact exchange and partner notification, and a second mobile app for test center employees to ensure trustworthy notifications. A .NET Core server application deployed to Azure handles the publication of positive test results onto the Optimism blockchain and simplifies wallet handling for the test center employees.

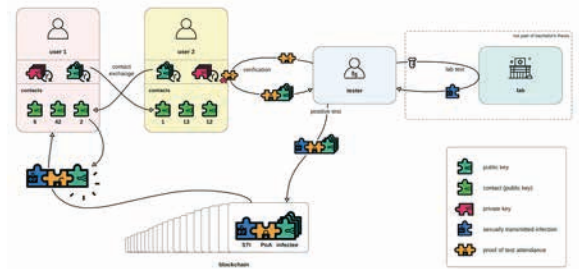
STI experts responded positively to the proposed concept and provided helpful inputs and insights that were integrated into upsi. While technical solutions for partner notification are discussed among experts, integration into existing IT systems remains challenging due to the large number of test centers, each using its own IT solution.

Further development of upsi is suggested, including the extension to iOS mobile devices and additional

features to enhance user experience and functionality. Integration into existing STI test center IT systems should be carried out to also handle laboratory tests. Additionally, a study to evaluate the effectiveness and acceptance of upsi among users should be conducted.

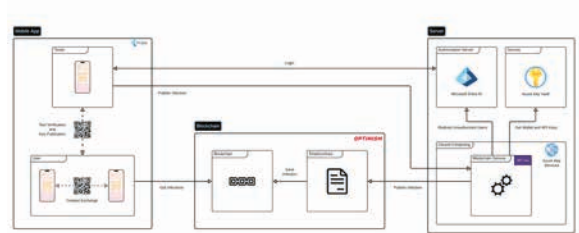
upsi system overview

Own presentation



upsi architecture diagram

Own presentation



upsi app design prototype

Own presentation



Advisor
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Subject Area
Software

Konzeption und Prototyp eines Storefrontsystems mit Plugin- und Theme-Architektur

Ablösung des Abacus E-Commerce-Systems AbaShop

Diplomanden



Ramon Ebnetter



Gian-Luca Vogel

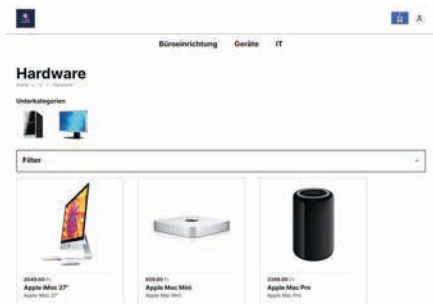
Ausgangslage: Die Abacus Research AG hat im Rahmen ihrer ERP-Lösung «Abacus» die E-Commerce-Applikation «AbaShop» entwickelt, deren Wartung Ende 2025 eingestellt wird. Aus diesem Grund muss die Customize AG, ein Vertriebspartner von Abacus, eine Nachfolgelösung für ihre Shop-Kunden finden. In einer vorangegangenen Studienarbeit wurde das E-Commerce-System «nopCommerce» evaluiert und über das entwickelte Plugin «Abacus Connector» an das ERP angebunden. Um die individuellen Anforderungen der breiten Kundschaft mit einem System bedienen zu können, soll ein Storefront-System entwickelt werden, das die Services von nopCommerce nutzt und den Consultants von Customize vielfältige Möglichkeiten zur Konfiguration des Webshop-Frontend bietet.

Vorgehen: In dieser Bachelorarbeit wurden gemeinsam mit den Consultants die Anforderungen an die Konfigurationsmöglichkeiten des Storefront-Systems anhand von Kunden-Use-Cases erfasst. Die Implementierung eines Prototyps zeigt, wie individuelle Anforderungen durch die erhobenen Use Cases abgedeckt werden können. Durch einen Benutzertest wurde sichergestellt, dass die Consultants die Kundenanforderungen über die Konfigurationsmöglichkeiten erfüllen können. Die Entwicklung eines Migrationspfades zeigt auf, wie Kunden von AbaShop auf das neue Storefront-System migrieren können.

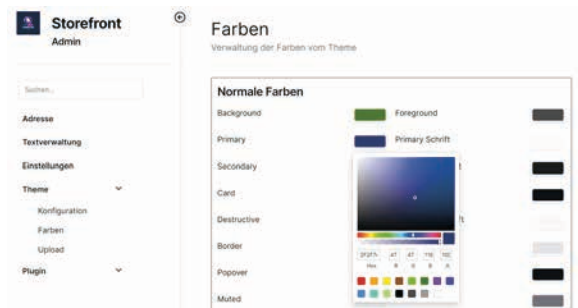
Ergebnis: Die Implementierung einer RESTful HTTP Schnittstelle als Plugin für nopCommerce ermöglicht einen «headless»-Zugriff auf dessen Services. Der entwickelte Storefront-Prototyp bietet ein Kernsystem mit Standard-Webshop-Funktionalitäten für alle Kunden. Die Integration einer Plugin- und Theme-

Architektur ermöglicht umfangreiche kundenspezifische Anpassungen des Kernsystems. Themes können das visuelle Erscheinungsbild des Storefront komplett verändern, während Plugins eigene Seiten und Logik hinzufügen. Die Entwicklung von zwei Themes und mehreren Beispiel-Plugins zeigt, wie Consultants das Storefront-System individualisieren können. Darüber hinaus ermöglicht ein Admin-Bereich umfassende Konfigurationen, um einfache Kundenanforderungen schnell umzusetzen, ohne ein Theme oder Plugin entwickeln zu müssen.

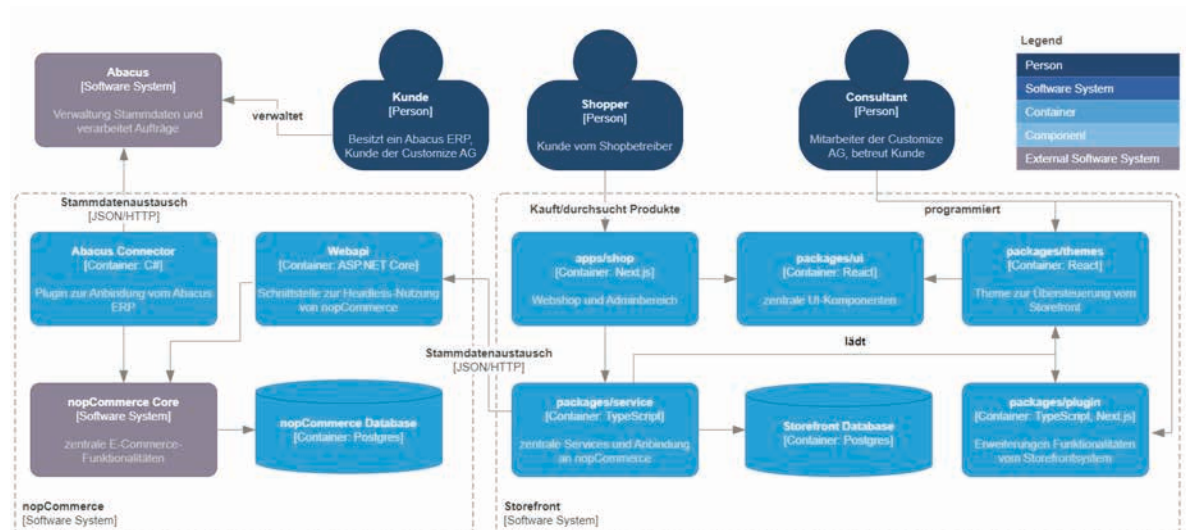
Webshop-Frontend des Standard-Theme
Eigene Darstellung



Ausschnitt aus dem Adminbereich des Storefront-Systems
Eigene Darstellung



Übersicht Container Gesamtsystem (C4 Containerdiagramm)
Eigene Darstellung



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Software, Application Design

Projektpartner
Customize, Winterthur, ZH

Integration von Abonnement-Modellen in einer React-Webanwendung

mit Java Spring Boot Microservices

Diplomanden



Nick Götti



Joshua Beny Hürzeler

Einleitung: Die Bachelorarbeit widmet sich dem Projekt «Vanlife Travel», welches darauf abzielt, die Planung von Campingtrips zu vereinfachen und den Buchungsprozess für Campingplätze zu optimieren. Diese Anwendung umfasst ein Frontend in React und ein Backend, das in Microservices mit Java Spring Boot unterteilt ist. Unser Team hat sich bereits in der Studienarbeit mit diesem Projekt befasst. In der Bachelorarbeit liegt nun der Fokus auf der Integration von Abonnement-Modellen, um die Anwendung zu monetarisieren.

Vorgehen: Zur Umsetzung wurde die bestehende CI/CD-Pipeline weiterentwickelt, um ein automatisiertes Deployment auf Entwicklungs- und Produktionsservern zu ermöglichen. Verschiedene Zahlungsanbieter wurden mittels Nutzwertanalyse evaluiert und Chargebee als geeignetster Anbieter ausgewählt. In einem Workshop mit den Stakeholdern wurden Abonnement-Modelle definiert, die anschliessend in Epics und User Stories unterteilt wurden. Die Implementierung erfolgte in einem iterativen Prozess. Wöchentliche Meetings mit dem Betreuer und den Stakeholdern dienten dazu, den Fortschritt zu präsentieren und Feedbacks einzuholen.

Ergebnis: Dank der neuen CI/CD-Pipeline können durch Merge-Requests nun Test- und Produktionsumgebungen automatisiert aktualisiert werden. Die Integration von Chargebee ermöglicht es den Benutzern, Abonnements abzuschliessen und zu verwalten. Dabei wurden Entitlements, eine Funktion von Chargebee, genutzt, um die Berechtigungen und Funktionen je nach Abonnement in der Anwendung zu steuern. Die implementierte Travel-Agent-Über-

sicht ermöglicht es den Betreibern, alle User einzusehen, die sich auf der Plattform registriert haben. Die Anwendung wurde somit erfolgreich monetarisiert und ist nun bereit für den Produktivbetrieb.

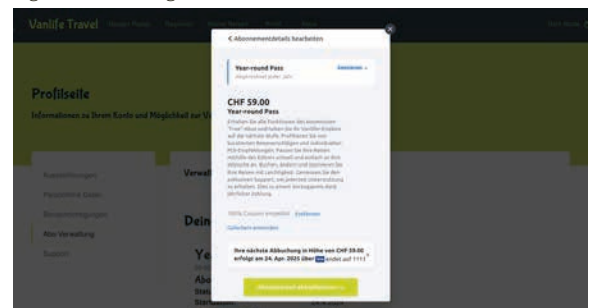
Vanlifer Abo-Modelle aus dem Stakeholder-Workshop

Vanlife Travel GmbH



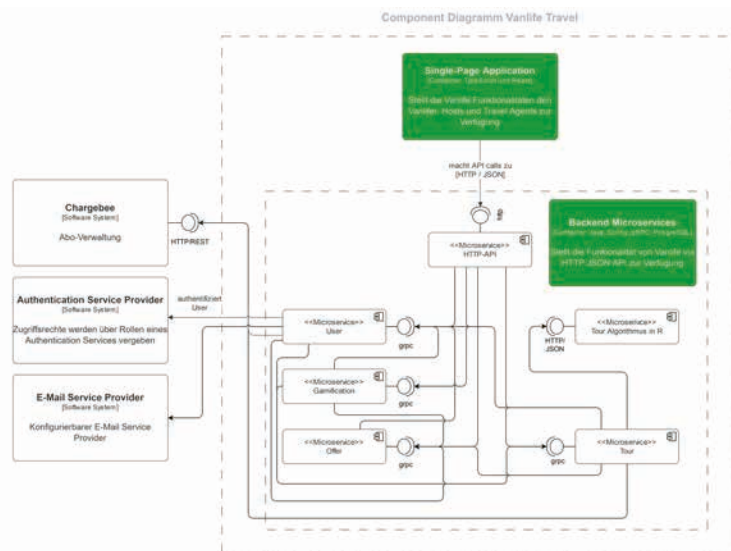
Abo-Verwaltung über unsere Webapp mittels Hosted-Page von Chargebee, eingebunden als iFrame

Eigene Darstellung



Architektur des Backend anhand eines C4-Komponentendiagramms

Eigene Darstellung



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Korreferent
Ramon Schildknecht

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

Projektpartner
Vanlife Travel GmbH

Open GIS-to-BIM-Converter (LKMap 2025 Data to IFC 4.3 Data)

Graduate Candidate



Jamie Maier

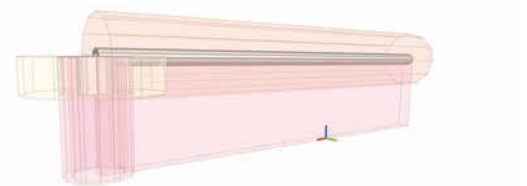
Initial Situation: Underground networks and cadastral data are managed in Geographic Information Systems (GIS), which mostly contain 2D data. For the exchange and publication of this information in Switzerland, the standard SIA 405 (LKMap) exists, which is a minimalistic approach that allows the coordination of the parties involved mainly through geometries. LKMap is currently under revision to support some 3D geometries, as there is a high demand for this information to be available in 3D. Therefore, the focus of this thesis is on the latest version of the model, LKMap 2025. Further, 3D geometries would be of great benefit in Building Information Modeling (BIM). The cadastral data would allow BIM operators to visualize, plan, model and design the exact locations where utility infrastructures intersect with building elements of their model.

Objective: This thesis aims to provide a Command Line Interface (CLI) prototype that lets users convert INTERLIS LKMap 2025 data (.xtf) to valid 3D IFC 4.3 data (.ifc). The generated data should provide users with visualizations of uncertainty geometries. The prototype should be standalone and Open-Source.

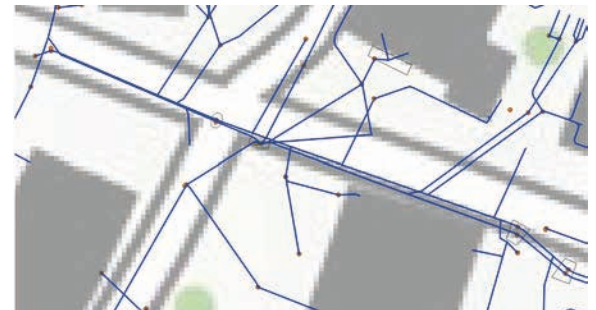
Result: The solution strategy and software architecture has been divided into three main logical containers. The first is the CLI, the entry point for users, which requires them to pass at least two arguments, the LKMap 2025 INTERLIS data file and a reference null point defining the origin position used to generate the 3D elements. The second container focuses on extracting and preparing the given INTERLIS data, ensuring that the elements passed to the IFC generation logic container contain valid 3D coordinates. The

technologies used here are ilizgpkg (Java) to write a GeoPackage file from the INTERLIS data file, and pyogrio (Python library) to extract data from the generated GeoPackage file. The processed data is then passed to the third container containing the IFC creation logic, which is achieved using the Python library IfcOpenShell. This container constructs IFC elements with their geometric representations, including uncertainty representations when geometries are marked as imprecise.

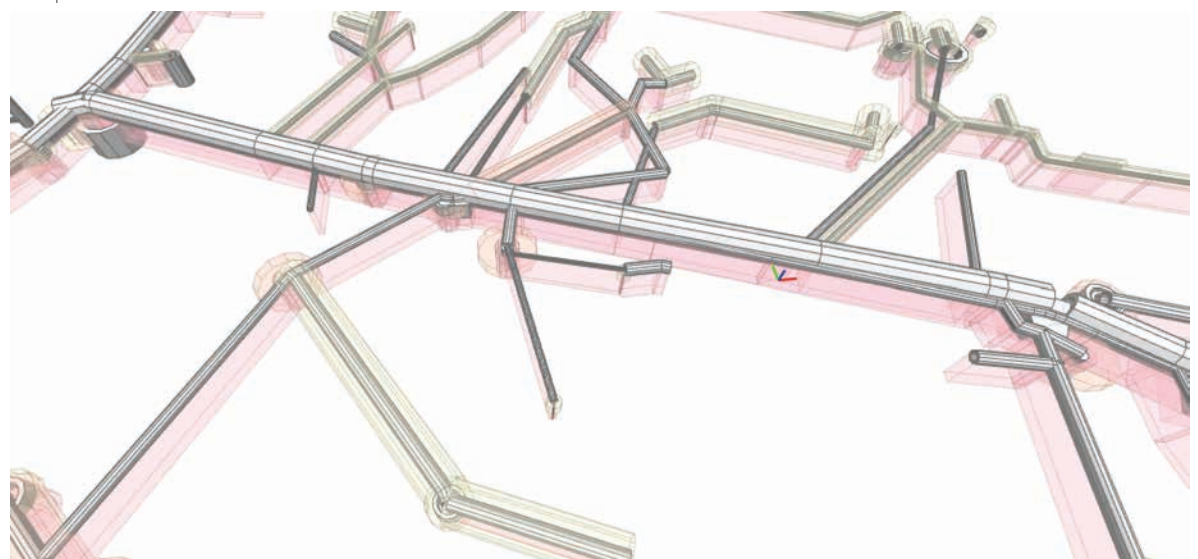
Uncertainty geometries of a generic duct and pipe. Pink = height uncertainty, Orange/Yellow = position uncertainty
Own presentation



2D view of Dorfstrasse/Kirchgasse junction in Meilen ZH. Blue = pipes, Red = ducts, Black polygons = special structures
Own presentation



3D view of Dorfstrasse/Kirchgasse junction in Meilen ZH including uncertainty geometries
Own presentation



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Subject Area

Software, Application
Design, Miscellaneous

Project Partner

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/ Prof. Martin Beth,
Bauingenieurwesen,
Rapperswil, St. Gallen

Settingsapplikation mit integriertem Plugin System

ReSet

Graduate Candidates



Fabio Lenherr



Felix Tran

Introduction: This paper expands on ReSet, a settings application developed with Rust for Linux-based systems to be compatible with different graphical desktop interfaces. Its core functionalities of WiFi, Bluetooth and Audio were completed successfully, but additional functionalities require desktop-specific implementation with their own set of rules that need to be adhered to. Therefore, A flexible system is needed where these differences can be handled.

Objective: The main objective is to create a plug-in system that allows users to add plug-ins to extend ReSet's functionalities and enable other developers to create their own or expand an existing plug-in to support more systems. Additionally, a testing framework will be implemented to allow developers to write integration tests for their plug-ins. To demonstrate that this system works, two exemplary plug-ins will be developed:

- Monitor plug-in: The monitor plug-in should allow users to manage display settings such as placement, resolution, orientation, etc.
- Keyboard plug-in: The keyboard plug-in should allow users to add/remove keyboard layouts and change their order

As a side objective, the code base from ReSet was improved to accommodate the plug-in system.

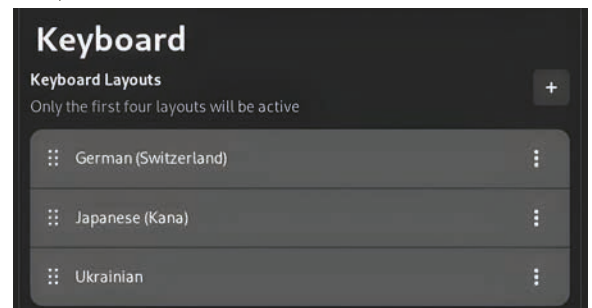
Result: The plug-in system was successfully implemented and both the monitor plug-in and keyboard plug-in work as intended. The keyboard plug-in is compatible with GNOME, KDE and Hyprland while the monitor plug-in is compatible with GNOME, KDE,

Hyprland, Sway and more. These plug-ins demonstrate the effectiveness of the plug-in system, showcasing its potential to handle diverse environment-specific settings. The testing framework was also implemented with some example tests for the plug-ins. The repository can be found via the QR code.

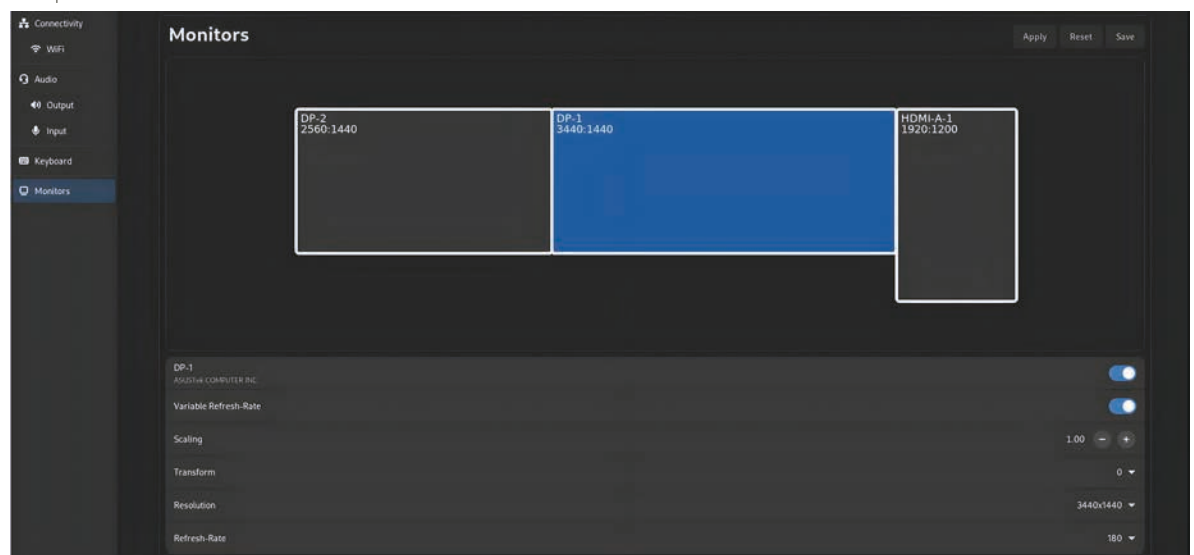
ReSet Logo
Own presentation



ReSet Keyboard Plug-in
Own presentation



ReSet Monitor Plug-in
Own presentation



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Subject Area
Software, Application
Design, System
Software

Natural Language to GraphQL

Leveraging the power of LLMs to build a natural language interface for GraphQL schemas

Graduate Candidates



Florian Rohrer



Lucien Zimmermann

Introduction: In-context learning enables large language models (LLMs) to comprehend and respond based on the context of the input, allowing them to adapt to a wide range of domain-specific tasks without additional training. However, they have notable limitations in accessing real-time or domain-specific data because they operate primarily on the knowledge they were trained on. Natural language-to-SQL (NL-to-SQL) systems offer a practical solution, enabling LLMs to transform natural language into SQL commands. This makes data accessible to people without technical expertise. GraphQL, having emerged as a flexible alternative to REST, enables software clients to specify the precise data they require from an API based on a schema. Based on this research, the project aimed to evaluate the best practices for building a natural language interface for GraphQL by adapting the concepts of NL-to-SQL to the GraphQL domain. By understanding the concepts and evaluating a few optimal strategies, a strong foundation was laid for future development.

Approach: Upon starting the project, in-depth research was conducted to understand the current state of the art, focusing on NL-to-SQL due to its similarities and substantial literature available. Key findings were documented and possible strategies were defined. After a proof of concept, two strategies with few subvariants were established for implementation. The first strategy solely relies on the capabilities of LLMs to directly follow instructions and, using in-context learning, enhance the prompt with relevant samples. The second strategy focuses on using entity extraction to identify entities in the user's question, match them to the schema, and then build the operation based on an abstract syntax tree (Fig 1). During implementation, a third strategy combining the benefits of both previous approaches evolved that overcomes the context size limitation of LLMs. In order to measure the strategies' performance in various metrics, an evaluator was built to efficiently test different implementations against a test set (Fig 3). The latter was inspired by the Spider dataset, a widely used benchmark for NL-to-SQL solutions.

Result: The evaluation has seen 7 different LLMs tested against the 4 most mature variants. The results were analyzed to determine the best-performing combinations. While the first strategy showed promising results for simple test cases, it demonstrated limitations in terms of quality and consistency for more complex ones. The best-performing combination uses entity extraction and algorithmic query generation, which is capable of correcting intermediate errors and always produces valid output, making it reliable enough to be used in experi-

mental environments. In general, OpenAI models (GPT-4) are reliable in following instructions, while open source models (Llama3, Mistral) have trouble consistently generating valid structures such as JSON. Hallucinations, though occurring on both OpenAI and open source models, can be drastically reduced with prompt engineering, making the output more consistent. However, both strategies are limited by the context size of the LLM used, making them cost-inefficient or even non-processable for large schemas. To overcome this limitation, future research should focus on an iterative entity extraction approach, enabling large schemas to be processed. Additionally, the shot sampling process can be optimized to further benefit from the LLM's in-context learning capabilities.

Fig 1: A demonstration of how a user prompt is transformed into a valid GraphQL operation
Own presentation

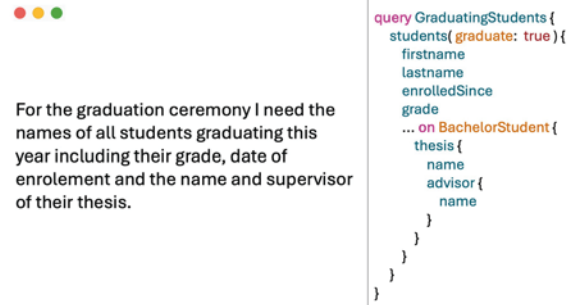


Fig 2: Entity Extraction-based solution strategy, using few-shot in-context learning, creating an Abstract Syntax Tree
Own presentation

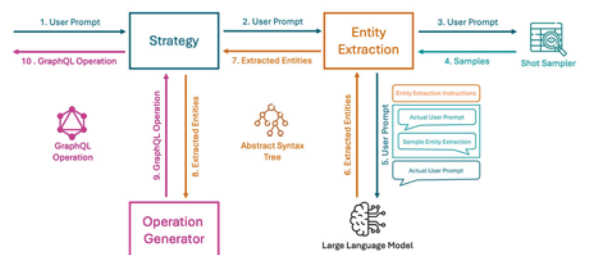


Fig 3: Evaluation results of the Entity Extraction-based strategy on a selection of test cases (lower numbers = better)
Own presentation

Metric	TestCase Results			
	Simple 1	Medium 1	Medium 2	Complex 1
Valid Syntax	✓	✓	✗	✓
Valid on Schema	✓	✓	✗	✓
Equivalent	✓	✓	✗	✗
Overfetched Fields	0	0	-	1
Underfetched Fields	0	0	-	1
Argument Mismatch	0	0	-	2
LLM Roundtrips	1	1	1	1
Tokens Used	4100 / 222	5621 / 157	4638 / 287	5644 / 489

Advisor
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Burgdorf, BE

Subject Area
Software, Artificial
Intelligence

Project Partner
ChilliCream, Zürich

3D-Visualization of Utility Lines in the Browser using Augmented Reality on Tablets

Graduate Candidates



Lukas Domeisen



Kaj Habegger

Introduction: Locating underground utility lines, such as water pipes, is challenging because they are typically hidden and only illustrated on 2D plans. This project aims to further develop the existing application from the preceding term thesis. The existing solution provides basic 3D visualization of utility lines in the real-world environment using augmented reality (AR). Alternative solutions for this purpose are native applications and require specialized, expensive hardware. In contrast, this project's application is web-based, works with off-the-shelf tablets and a low-cost, high-accuracy GNSS (GPS) device such as ArduSimple's RTK Handheld Surveyor Kit. These utility lines are defined using Industry Foundation Classes (IFC) data, a standard for Building Information Modeling (BIM).

Approach: Key requirements derived from the term thesis include user authentication, IFC data upload, and various enhancements in the AR viewer. Keycloak was used for user authentication. Authenticated users can upload their IFC files. To handle the IFC data, the backend was adjusted to convert IFC files to a web-optimized 3D format (glTF) using the BlenderBIM add-on. Furthermore, the backend extracts relevant information from IFC files, such as type and reference coordinates. The frontend was extended by correction controls for the models' placement and convenience features. Main technologies used for the project are shown in the figure at the bottom.

Result: The resulting application tubAR allows users to log in with Google or GitHub accounts and upload IFC files. After a successful upload, the utility lines

are saved in the database and can be visualized in the AR viewer. Utility line models can be loaded manually or dynamically based on the user's position, with the option to filter by type. Models are colorized based on their type. Users can click on models for details and manually adjust the position and rotation of the model to increase accuracy. In addition, a guided compass correction feature helps with alignment. The screenshot from the outdoor test in Stäfa demonstrates the utility lines correctly aligned and colorized by type.

Example screenshot showcasing another augmented reality solution by vGIS using a native app

<https://www.vgis.io/>

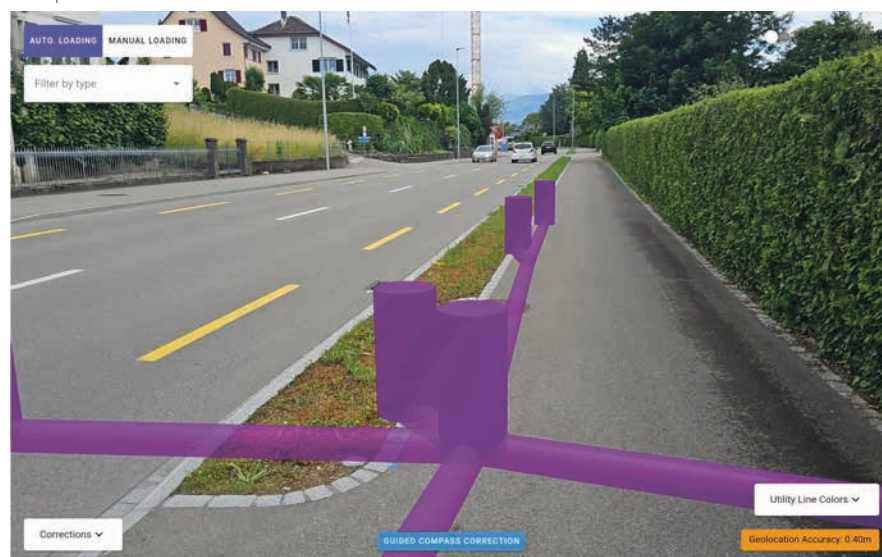


Stäfa Seestrasse without virtual utility lines visualized in the AR space

Own presentation



Stäfa Seestrasse virtual utility lines visualized with control overlay; utilized key technologies on the right



AR tubAR

WebXR

Vue.js three.js

Flask

PostgreSQL BLENDERBIM

KEYCLOAK

IfcOpenShell

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Software, Internet
Technologies and
Applications

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