Public Toilet Finder – Kiel Project Report

Student: Furkan Yilmaz
Student Number: 953661
Course: Geographical Web Applications
University: HAW Kiel
Semester: Winter Semester 2025/26
Lecturer: Hendrik Oenings
Submission Date: 08 December 2025

1. Introduction

Public facilities are an essential part of urban infrastructure. Among these facilities, public toilets play a particularly important role for elderly people, tourists, families with children, and individuals with disabilities. Despite their importance, reliable and easy-to-access information about public toilets is often missing or fragmented. Many people do not know whether a toilet is free or paid, whether it is wheelchair accessible, or during which hours it is open.

The motivation behind this project is to solve this problem by developing a modern web-based geographical information system that provides detailed and accurate information about public toilets in the city of Kiel. The application is based on freely available OpenStreetMap (OSM) data and aims to improve accessibility and urban orientation for both residents and visitors.

The main objective of this project is to design and implement a standards-compliant, accessible, and interactive web mapping application using Vue.js, OpenLayers, GeoServer, WMS, WFS, and TypeScript. The application fulfills the technical and design requirements of the Geographical Web Applications course.

2. Data Source and Data Processing

The primary data source for this project is OpenStreetMap (OSM). OpenStreetMap is a collaborative and community-driven project that provides a free and openly accessible geographic database of the world. Millions of contributors continuously update and maintain spatial information such as roads, buildings, public facilities, and points of interest. Due to its openness and high level of detail, OSM is an ideal data source for web-based geographic applications.

For this project, all spatial features tagged with the attribute amenity = toilets were extracted from the OpenStreetMap dataset. These features represent public toilet facilities distributed across the city of Kiel. The extraction ensures that only relevant and meaningful data is used for the application.

The following attributes were selected and used inside the application:

- wheelchair – indicates whether the toilet is accessible for wheelchair users.
- fee – specifies whether the toilet is free or requires payment
- charge – provides detailed price information, if available
- opening_hours – describes the operating times
- male, female, unisex – represent gender availability
- changing_table – indicates whether a baby changing table is available
- access – defines access restrictions such as public or customers only

After extraction, the data was converted into GeoJSON format. GeoJSON is a lightweight and web-friendly data format that is fully supported by modern web GIS frameworks such as OpenLayers. This conversion enables efficient client-server communication via standardized web services.

The resulting GeoJSON file was then uploaded to GeoServer, where it was published as a vector layer. GeoServer provides this dataset through a Web Feature Service (WFS), which allows the application to dynamically load, filter, and display individual toilet features based on the current map view and user interaction.

Data Processing Screenshots

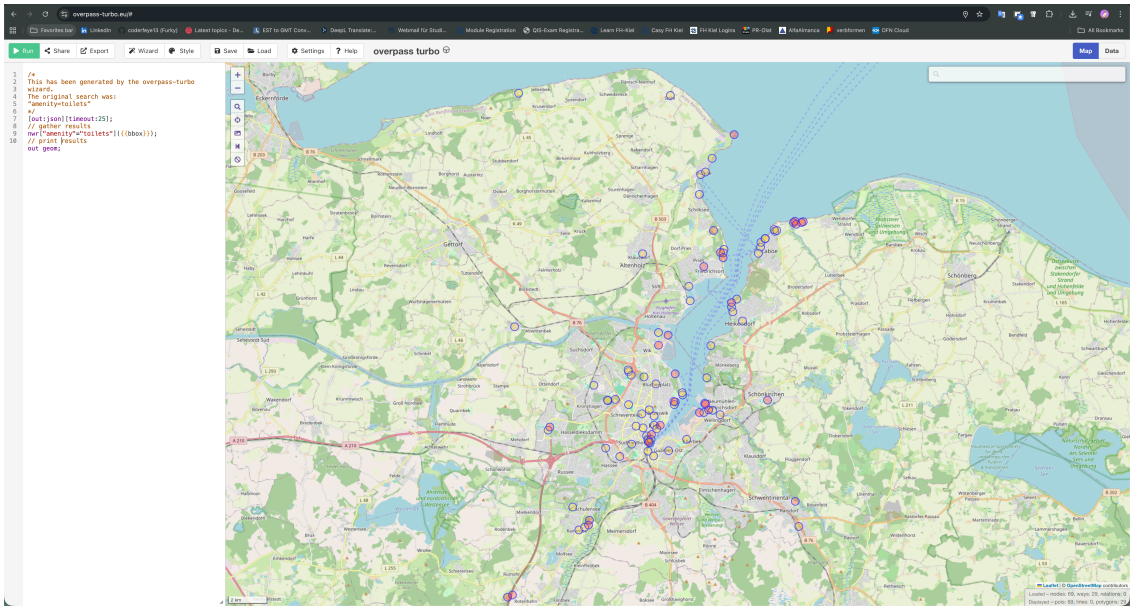

Figure 1: Screenshot of public toilet features extracted from OpenStreetMap using Overpass Turbo.

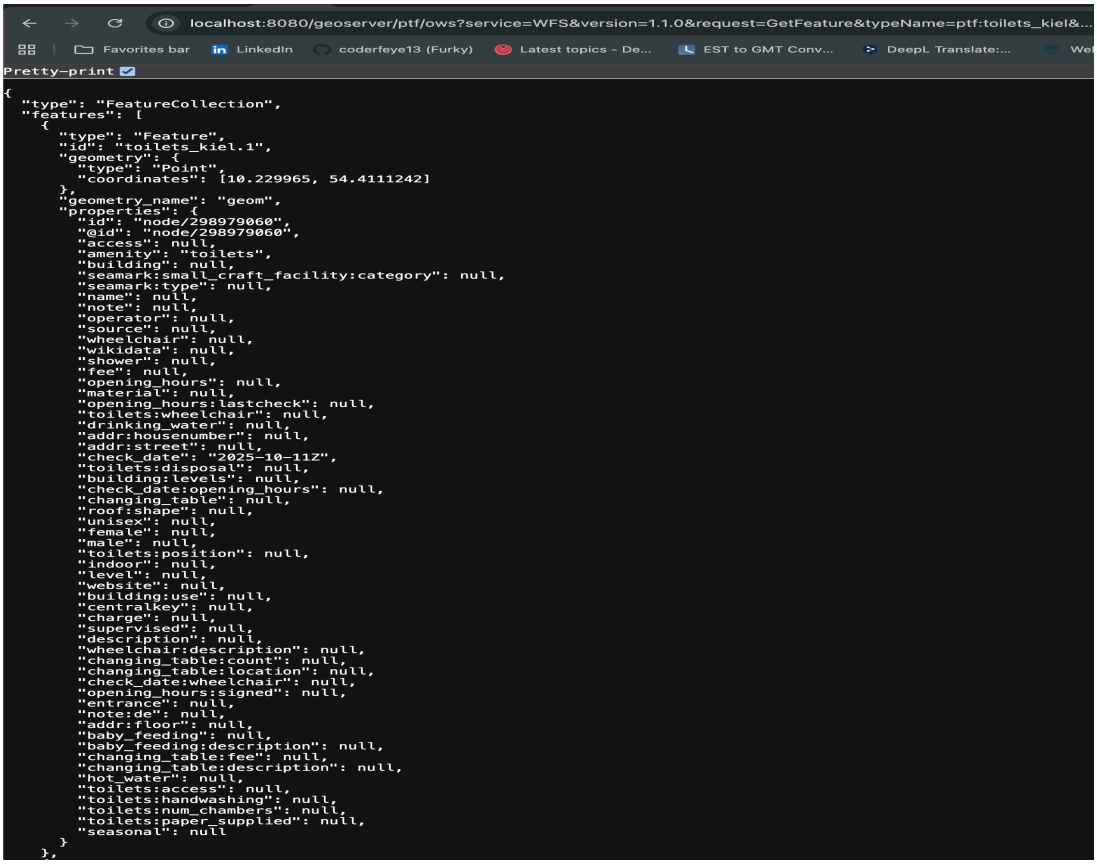

Figure 2: Screenshot of the GeoServer WFS response in GeoJSON format showing public toilet features and attributes.

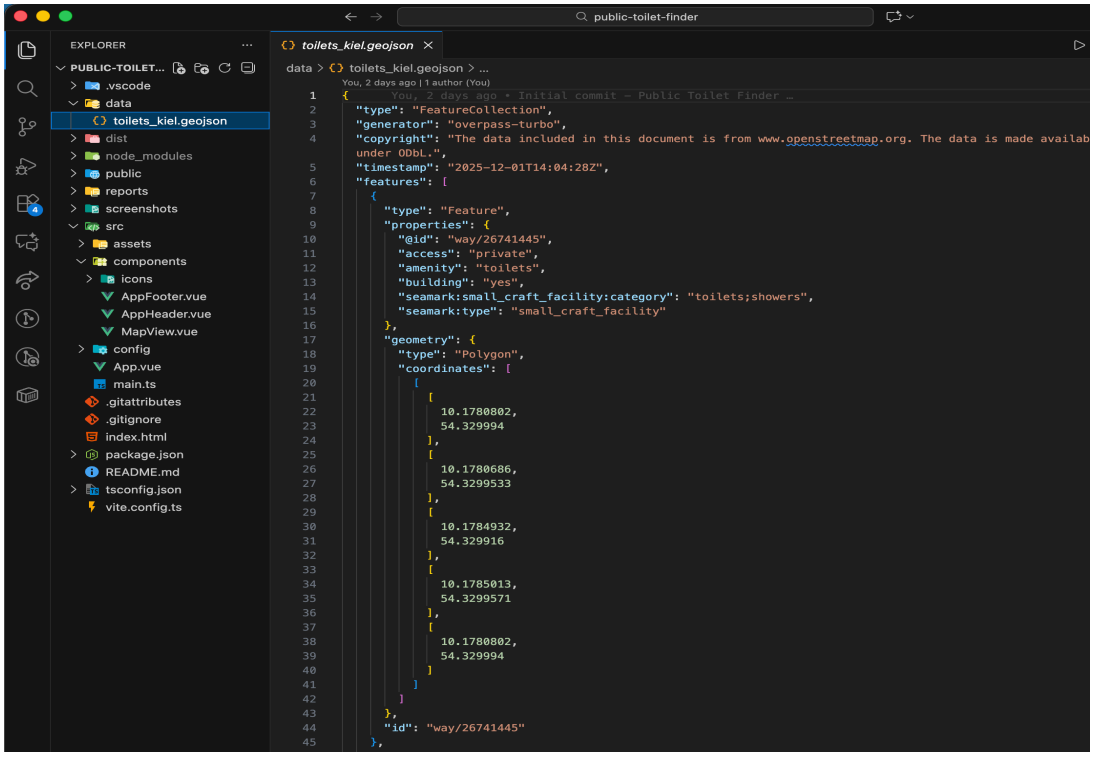

Figure 3: Screenshot showing the structure of the GeoJSON file containing extracted toilet features and attributes.

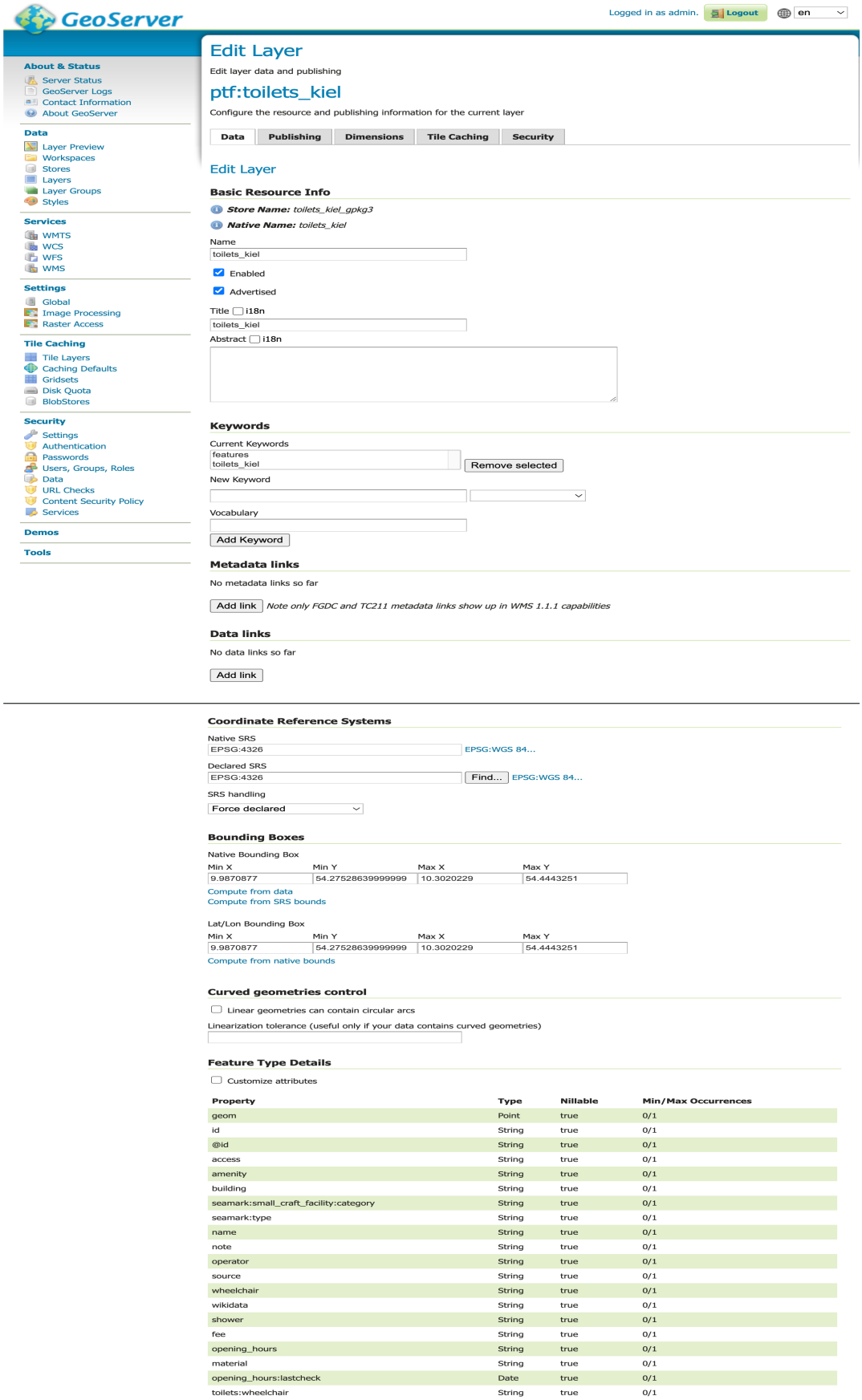

Figure 4: Screenshot showing the GeoServer layer configuration for the public toilet dataset (ptf:toilets_kiel).

3. System Architecture

The application follows a client–server architecture, where spatial data processing and map services are handled on the server side, while visualization and user interaction take place on the client side. This separation ensures better performance, modularity, and maintainability.

Frontend

The frontend is implemented as a Single Page Application (SPA) using:

- Vue 3
- TypeScript
- HTML5 & CSS3
- Vite
- OpenLayers

HTML is used for the semantic page structure, CSS for responsive layout and visual design, and TypeScript for application logic and map interaction. OpenLayers handles map rendering and communication with map services.

Backend / Data Services

The backend is provided by GeoServer, which publishes the dataset through standard OGC services:

- WMS (Web Map Service) for raster visualization
- WFS (Web Feature Service) for vector-based features and interaction

This ensures full compliance with international OGC standards.

Data Flow

The overall data flow of the system is as follows:

OpenStreetMap → GeoJSON → GeoServer → WMS / WFS → OpenLayers → Vue Application

1. Public toilet data are extracted from OpenStreetMap using amenity = toilets.
2. The data are converted into GeoJSON format.
3. The GeoJSON dataset is published as a vector layer in GeoServer.
4. The layer is made available through WMS and WFS.
5. OpenLayers loads and visualizes the services.
6. Vue manages all user interaction and UI logic.

This architecture provides a scalable and standards-compliant solution for web-based GIS applications.

4. Application Features

The application provides several core functionalities for interactive exploration and accessibility-focused usage.

Interactive Map Display

The web map is implemented using OpenLayers. Users can navigate the map through panning and zooming. The map dynamically updates its content based on the visible area.

Visualization with WMS and WFS

The dataset is visualized using both OGC services:

- WMS is used for raster-based visualization.
- WFS provides vector features in GeoJSON format for interaction.

This hybrid approach enables efficient visualization and advanced feature interaction.

Click-Based Information Popups

Each toilet feature is clickable and displays a popup with detailed information such as:

- Price (free or paid)
- Wheelchair accessibility
- Opening hours
- Gender availability
- Baby changing table availability
- Public access status

Wheelchair Accessibility Filter

A filter allows users to display only wheelchair-accessible toilets (wheelchair = yes). All other features are hidden dynamically without reloading the page.

Custom Map Control Buttons

Custom floating map buttons are implemented using HTML and CSS:

- Zoom In
- Zoom Out
- Recenter Map

All buttons are fully accessible via keyboard and include ARIA labels.

5. Accessibility Implementation

Accessibility is a central requirement of this project. The application was evaluated using the Google Lighthouse audit tool in order to measure performance, accessibility, best practices, and SEO compliance. The test results demonstrate that the application fully complies with modern web standards and accessibility principles.

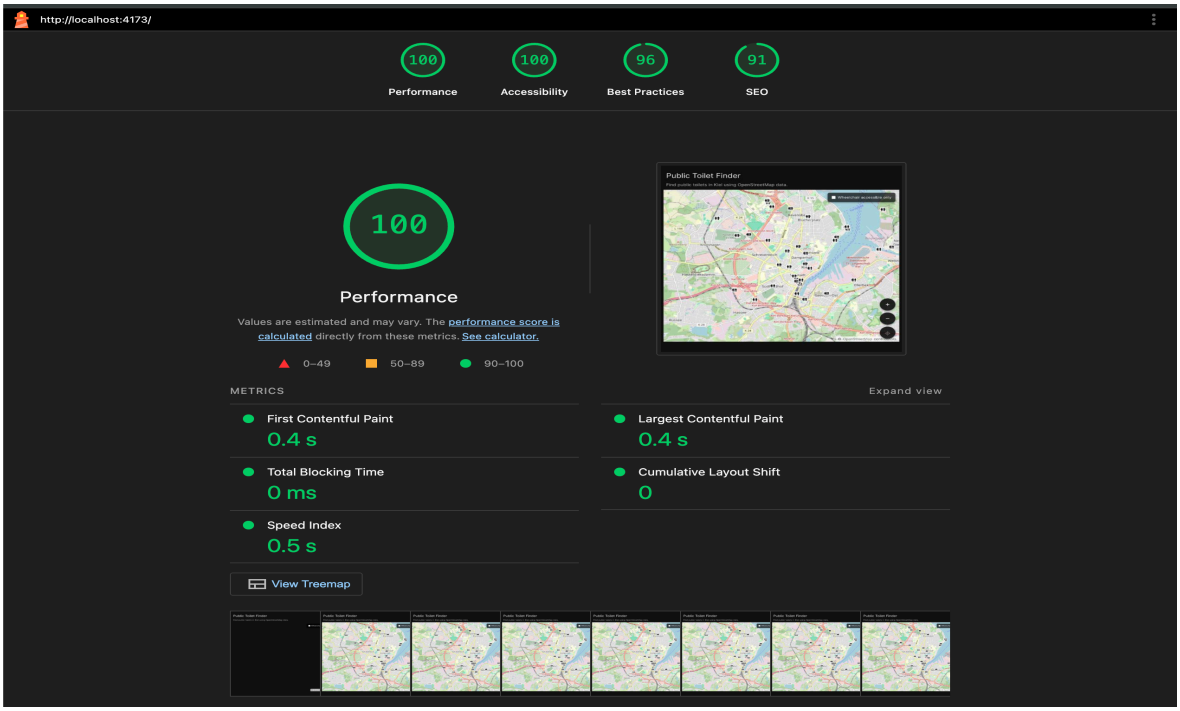

Figure 5: Google Lighthouse audit results showing performance, accessibility, best practices, and SEO scores for the desktop version of the application.

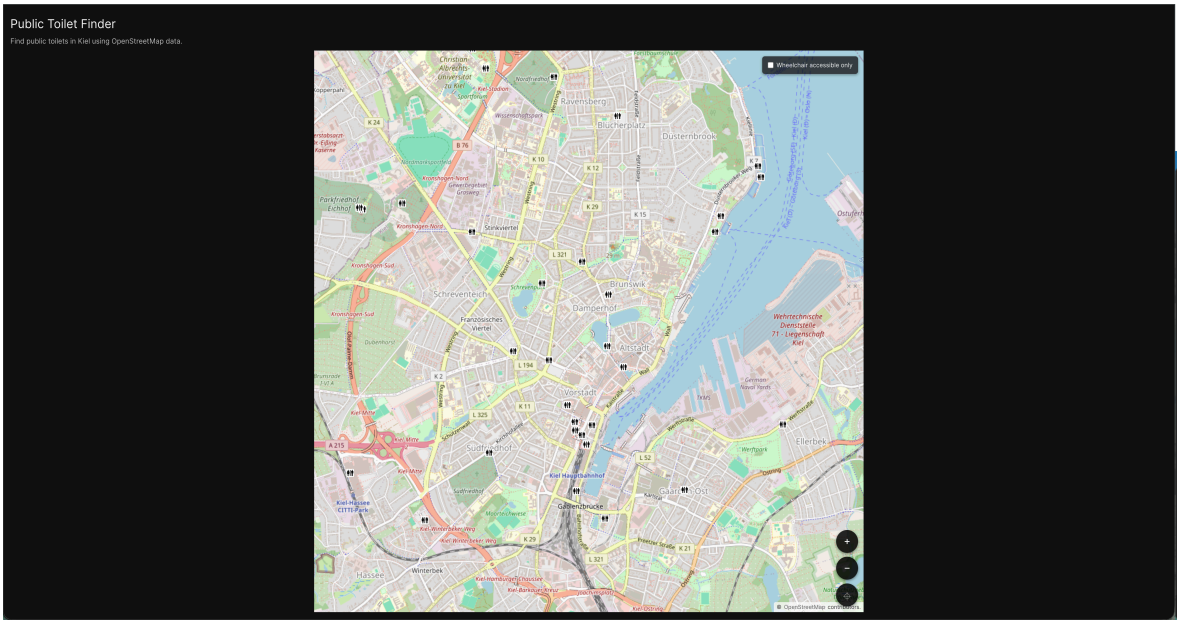

Figure 6: Desktop version of the application tested with Lighthouse showing optimized performance and full feature availability.

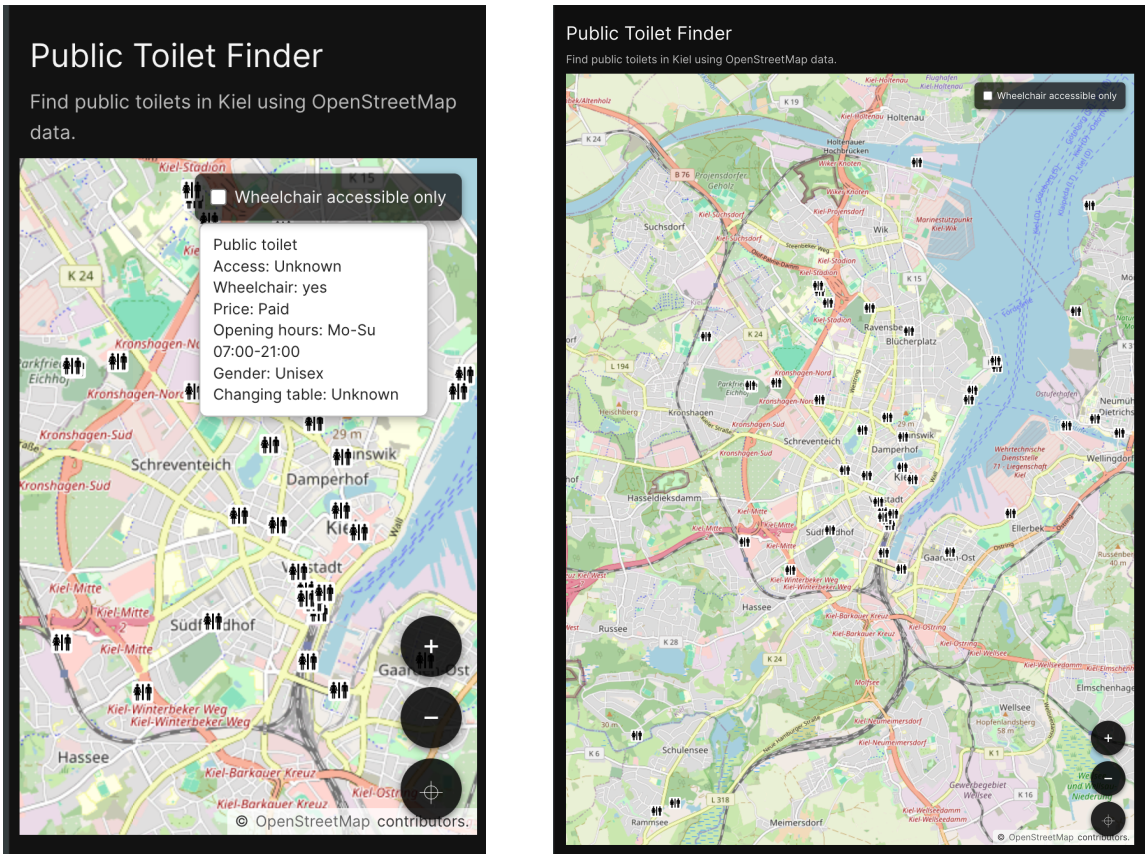

Figure 7: Mobile version of the Public Toilet Finder application tested with Lighthouse showing responsive layout and accessible UI elements.

6. Code Quality and ESLint

To ensure consistent coding standards and high code quality, the project uses ESLint with the shared configuration **@dataport/eslint-config-geodev**. All source files were successfully checked using the command npm run lint without any errors. This guarantees proper TypeScript usage, consistent formatting, and compliance with the course coding standards.

7. Version Control and GitHub

The project is fully managed using Git as the version control system. Repository: GitHub

8. Conclusion and Future Work

This project successfully demonstrates the development of a web-based GIS application for visualizing public toilet locations in the city of Kiel by integrating OpenStreetMap data, GeoServer services, and an OpenLayers-based frontend within a Vue 3 application to create a fully functional and standards-compliant system. The application offers interactive map visualization, detailed feature information, accessibility filtering, and a responsive user interface for both desktop and mobile devices, while the high Lighthouse performance and accessibility scores confirm its technical quality. Future improvements may include additional attribute filters, routing to the nearest toilet, clustering techniques for dense areas, and user-driven data updates through WFS-T.