

# Project Summary Report: Hydrant Distribution Use Case Scenario (Buffered Reach)

## Introduction

This project aims to optimize the distribution of fire hydrants across a city by using spatial data and buffer zones to represent the effective reach of each hydrant. The goal is to assess if hydrants are placed in a way that provides adequate coverage for firefighting operations. The solution will integrate both external and local web services to visualize the data and answer the following critical question:

"Are fire hydrants optimally distributed to ensure all areas of the city are within the effective reach of a hydrant during a fire?"

The data will be visualized using the Leaflet web mapping library, combining external city infrastructure data (roads, buildings, and city boundary) with local hydrating data (hydrant locations stored in a GeoPackage).

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## Use Case Scenario

Scenario: The fire department wants to ensure that the fire hydrants across the city are adequately distributed so that all critical infrastructure, such as buildings and roads, are within the effective reach of a hydrant during a fire emergency. In this case, the effective reach is represented as a buffer around each hydrant indicating the area that can be served by that hydrant.

The system will answer the following question:

"Are the fire hydrants distributed optimally, and are there areas with insufficient coverage?"

To achieve this, the following steps will be taken:

- Visualize hydrants with their buffered reach (e.g., 50 meters around each hydrant).
  - Assess whether the current hydrant distribution covers all areas of the city, based on infrastructure data and the city boundary.
  - Identify gaps in coverage where additional hydrants may be needed.
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## Data Requirements

1. External Spatial Data from Web Services:
  - City Infrastructure (Roads, Buildings, and City Boundary): This data will be accessed from an external WMS or WFS service provided by the city's municipal GIS server. The road, building, and city boundary data will help determine the proximity of hydrants to critical infrastructure and define the area under consideration.
2. Local Dataset (GeoPackage):

- Fire Hydrant Locations: A dataset containing the locations of fire hydrants across the city. This dataset will be stored in a GeoPackage (GPKG) format, which is ideal for storing spatial data in a single file. The dataset will include attributes such as:
    - Hydrant\_ID: Unique identifier for each hydrant.
    - Position: The precise coordinates of every hydrant.
  - Buffer Zones: For each hydrant, a buffer (polygon) will be created to represent its effective coverage area (e.g., a 50-meter radius buffer).
3. Data Storage and Management:
- The GeoPackage will be stored locally, and the data will be served using GeoServer to make it accessible via WMS or WFS services.
  - GeoServer Setup: The GeoServer instance will be set up locally or on a server to serve the fire hydrant data stored in GeoPackage format. The buffer zones will be dynamically generated using GeoPandas spatial functions (e.g. geometry.buffer).
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## Data Model and Structure

1. Fire Hydrant Dataset (GeoPackage):
- Data Model:
    - Hydrant\_Locations: A Point dataset representing the location of fire hydrants.
    - Attributes:
      - Hydrant\_ID: Unique ID for each hydrant.
  - Buffer Zones:
    - A buffer will be created for each hydrant to represent its effective reach. The buffer will be a polygon representing a certain distance around the hydrant (e.g., 50 meters).
2. City Infrastructure Dataset:
- Data Model:
    - Roads: A Line dataset for the city's road network.
    - Buildings: A Polygon dataset for the building footprints in the city.
  - These datasets will be accessed via WMS or WFS services from the city's municipal server and displayed as layers in the client application.
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## Web Service Setup

1. GeoServer Instance:

- The GeoServer will be set up to serve the fire hydrant data and the buffered zones as WMS layers.
  - The hydrant data stored in GeoPackage will be served via WMS already with the added buffers
  - The external city infrastructure data (roads, buildings, and city boundary) will also be served via WMS for spatial context.
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## Client Application: Leaflet Integration

The Leaflet-based client application will connect to the GeoServer WMS service to visualize the hydrants and their buffered reach as well as external city infrastructure data. This interactive map will allow the fire department to analyze the distribution of hydrants and assess whether all urban areas are adequately covered.

### 1. Leaflet Map Setup:

- Base Map: OpenStreetMap to show the city's geographical context.
  - City Roads, Buildings, and Boundary: The road network, building footprints, and city boundary will be displayed as WMS layers from the external service, giving spatial context to the hydrant distribution.
  - Fire Hydrants: Display fire hydrants as Point features. Each hydrant's buffered reach will be visualized as a Polygon around the point, representing the effective coverage area (e.g., a 50-meter radius).
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## Conclusion

This project uses spatial data and buffer analysis to evaluate the distribution of fire hydrants and their effective coverage area within a city. The GeoPackage format is used to store fire hydrant locations and their associated buffer zones, while the infrastructure data (roads, buildings, and city boundary) is accessed from external WMS services. The data is visualized in a Leaflet-based web application, allowing the fire department to interactively assess hydrant distribution and coverage.

By using buffer zones to represent the reach of each hydrant, the system helps identify areas that are underserved and in need of additional hydrants. The system enables informed decision-making by visualizing gaps in coverage and facilitating distance analysis for effective firefighting resource allocation.

The project fulfills the interoperability requirements by using GeoServer to serve the local dataset and external data services (via WMS) for city infrastructure. The Leaflet web application integrates these services to provide an intuitive, interactive interface for decision-makers in the fire department.