Situation-Aware Linked heTerogeneous Enriched Data

D4: Situation-aware Application creation for Smart-City and Smart Agriculture

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Abstract	The deliverable for this work package involves the implementation of smart applications within the Smart City and Smart Agriculture domains, utilizing enriched data from Activity 2 and the NGSI-LD API. Further the deliverable aims to contribute to the advancement of Smart City and Smart Agriculture domains by creating practical

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	applications, involving the creation of open-source services, aligning with the concepts of reusability and collaboration within the development of applications.
Keywords	Smart City, Smart Agriculture, Smart Services, NGSI-LD API

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1 INTRODUCTION

1.1 SCOPE OF DOCUMENT

The WP4 handles the development of applications leveraging the SALTED architecture developed and implemented within the previous work packages. The development of applications can hereby follow either a bottom-up or top-down approach. Depending on the approach used, WP4 tasks include e.g. the selection of data sources, the derivation of requirements for the SALTED Data Injection Toolchain (DIT) / Data Enrichment Toolchain (DET) and the implementation of the applications themselves.

The applications developed within SALTED try not only to act as examples of the added-value that arises through the usage of the SALTED architecture, but also intend to fit into the framework of the European data strategy[1] promoting the goals formulated within the framework of this strategy. In particular the overarching goal of strengthening the data economy is a key goal set. Therefore, the creation of added value – through the use of data – but also through the collection, harmonization and analysis of data is the main focus of this WP.

This document captures all developments and insights created and obtained during working on the WP4, which results mainly in the description of the applications. For details regarding the leveraged SALTED architecture the document refers to the D2.1 [1]. Similarly for details on data sources and data injection and enrichment services the document refers to D1.1 [2], D2.2 [3] and D2.3 [4].

Furthermore, the term “applications” in this document, is based on the broader term to ensure that no potentials for the extraction, enrichment and use of data are excluded. In doing so, the project wants to do justice to SALTED's overarching goal of promoting data economy at all levels and in all facets.

Finally, the KPIs defined within the WP5 formulate important goals, which can be used to evaluate the applications regarding the data integration and dissemination reached. The goal is to cover all these as best as possible with the applications described within this document, keeping in mind, that the D5 focusses on the description of those points in more detail.

1.2 TARGET AUDIENCE

This document is publicly available and meant to raise awareness of the SALTED project, its relationship with the FIWARE ecosystem and especially the possibilities for application development using the SALTED infrastructure (the added value through the Data Injection and Enrichment Toolchains is showcased due to their integration into the application setup and the e. g. query possibilities of the Scorpio Broker are presented).

[1] https://data.europa.eu/en/news/discover-dataeuropaeu-strategy-mapping-report

In addition, the document is the reference for the technical teams of all project partners who have cooperated in work packages 1, 2, 3, 4 on the applications implemented as part of the project. It especially serves as a summary of the situation-aware applications developed in work package 4. The document also describes the approach developed to track applications and application ideas, which was used during working on the WP within the team.

1.3 Structure of the Document

Within the first substantive chapter, Section 2, general aspects of the WP4 are explained. This involves the big picture of the applications being developed within SALTED, but also the documentation approach chosen during the project, which enables a common approach of progress tracking. Section 3 focuses on the applications that were developed within the project. Each application is described using the same fact sheet, that refers to e.g. value added, user frontend and code implementations which can be found in the project's GitHub[2]. Section 4, in comparison, describes applications within the backlog of the project. Those are application ideas that were developed, but not implemented fully. Section 5 gives a short summary on the goals reached within WP4.

[2] https://github.com/SALTED-Project

2 OVERVIEW & APPLICATION DESCRIPTION APPROACH

2.1 OVERVIEW/BIG PICTURE

This section presents a comprehensive overview of the implementations within the Smart City and Smart Agriculture domains as part of the SALTED application development. The smart applications are utilizing linked and enriched data, generated through services outlined in Work Package 2. These applications finally leverage the NGSI-LD API and are designed to offer valuable services within urban development and agricultural/environmental management.

The SALTED project focused on two fields of application for the developed platform:

- The Smart City Domain and
- the Smart Agriculture Domain.

2.1.1 Smart City Domain

In the applications implemented in the Smart City Domain our objective is to facilitate decision-making in the transformation processes of urban spaces by harnessing enriched data from diverse sources linked to urban objects and urban actors. The developed applications serve as dynamic tools, providing context- and location-related information to key stakeholders involved in urban development, including cities, companies, and the wider civil society.

2.1.2 Smart Agriculture Domain

The developed application in the Smart Agriculture Domain is rooted in the goal of enhancing crop management in large agricultural expanses. This application delivers context- and location-specific insights, coupled with situational awareness, to optimize the land use regarding the carbon footprint, thereby contributing to sustainable agricultural practices and evolving of the carbon certificate market.

2.2 STRUCTURED DESCRIPTION OF "APPLICATIONS" IN THE CONTEXT OF SALTED

In the context of our initiative, it is imperative to delineate infrastructure components, services, and applications, drawing inspiration from established frameworks for the description of IT architectures. This separation allows for a nuanced understanding of the various layers and functionalities within the system.

In the pursuit of developing a comprehensive understanding of the applications within the SALTED initiative, the establishment of a common **fact sheet** emerges as a strategic imperative. A unified fact sheet serves as a standardized repository of essential information, ensuring clarity, consistency, and efficiency in the documentation of each application. One especially critical facet of our application description is the focus onto specific scenarios where the application will be employed, providing a comprehensive view of its practical utility and functionality. Further the exploration of potential business models associated with these applications is done as far as possible, assessing their economic viability and sustainability. Those fact sheets were

used not only for the final documentation of the applications, but also within the project team to update the other team members regarding not only the status, but also regarding new breakthroughs or goals met. The overarching goal, when describing applications, is that proposed or implemented applications can be quickly captured in terms of their environment and benefits.

3 APPLICATIONS DEVELOPED

3.1 AGENDA ANALYTICS

Application Title:

AGENDA ANALYTICS - compliance with strategic goals and regulations

Application Description:

Agenda Analytics has the matching of given agendas to the activities / communication of companies and public administration as its content. The obtained matching scores can be used for detailed reporting and visualization.

Agendas of interest could not only be the sustainable development goals (SDGs) or environmental social governance risks in banks (ESGs) but also e.g. the public governance codex, addressing the emerging interest on governance topics in public organizations, or the strategies regarding the integration of artificial intelligence (AI). Additionally, any interested party could develop their own agenda, summarizing key aspects to them, under which they intend to analyze organizations of interest.

Activities and communication of interest could be obtained in any way, but keeping the demand for automatization in mind, at the moment, the keyword-driven crawling approach of websites was evaluated as the most efficient one.

Value Proposition:

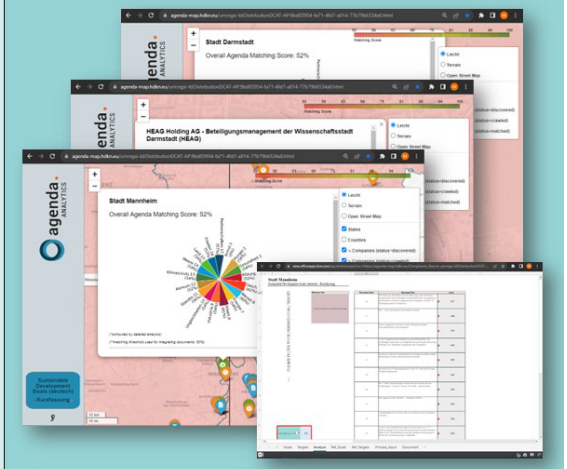
This application leverages public data to generate value for the public, by extracting information needed for an automatic assessment of the given agenda. Therefore, the public gains access to knowledge, which wasn't available before. Additionally, the application shows the added value that can be generated by crawling available web documents, leading the way for other applications that could leverage the same data with a different use case in mind.

The following case study descriptions give insight into the added value by the analysis of each example agenda that SALTED has used to validate the approach:

CASE STUDY	
AGENDA	Sustainable Development Goals
TARGET GROUP	Public Sector Companies in the Rhine-Neckar Metropolitan Region

Analyzing the compliance of public sector companies in the Rhine-Neckar Metropolitan region regarding the Sustainable Development Goals (SDGs) is crucial for several reasons:

Accountability and Transparency: This analysis ensures that these companies are accountable for their sustainable development commitments, promoting transparency and trust.
Local Impact on Global Goals: It helps align local actions with global SDGs, enabling targeted investments in areas where progress is needed most.
Resource Allocation: By identifying compliance gaps, policymakers can allocate resources effectively, ensuring they address critical sustainability challenges.
Innovation and Best Practices: Successful companies' experiences can serve as models for others, accelerating progress toward the SDGs.
Economic Growth: Compliance fosters a conductive business environment, attracting investments and driving economic growth.
Social Inclusivity: It helps reduce disparities in education, healthcare, and social well-being, promoting a more equitable society.
Environmental Stewardship: Identifying leaders in environmental sustainability aids in preserving natural resources and mitigating climate change impacts.
International Reputation: A commitment to the SDGs enhances the region's global image, attracting international collaboration and investments.



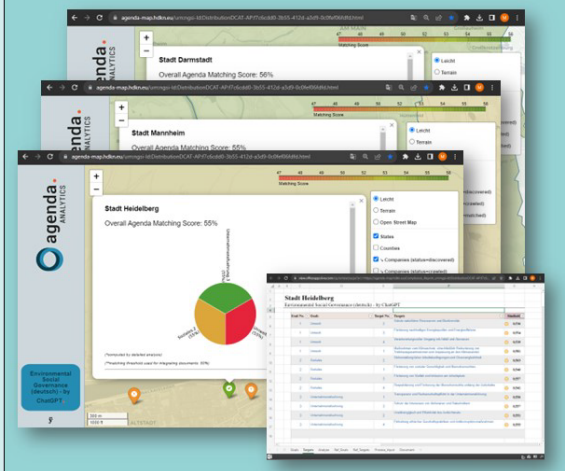
agenda. ANALYTICS

Figure 1: AgendaAnalytics Case Study 1

CASE STUDY	
AGENDA	Environmental Social Governance
TARGET GROUP	Public Sector Companies

Analyzing the compliance of public sector companies regarding the Environmental Social Governance guidelines (ESGs) is crucial for several reasons:

Accountability and Transparency: It ensures public sector companies remain transparent and accountable in their operations, which is essential for maintaining public trust.
Risk Mitigation: ESG analysis helps identify and mitigate legal, financial, and reputational risks associated with non-compliance.
Long-Term Sustainability: Encourages a focus on sustainable practices that benefit future generations and safeguard resources.
Attracting Investment: Positive ESG performance attracts more investment, benefiting public infrastructure and services.
Enhancing Efficiency: Promotes resource efficiency and good governance, leading to cost savings and improved productivity.
Stakeholder Engagement: Promotes constructive engagement with citizens, organizations, and businesses, fostering informed decision-making.
International Commitments: Ensures compliance with global sustainability agreements and maintains international reputation.
Adaptation to Changing Norms: Helps public sector companies stay aligned with evolving societal expectations and environmental standards.



agenda. ANALYTICS

Figure 2: AgendaAnalytics Case Study 2

CASE STUDY	
AGENDA	Artificial Intelligence Strategy of the Federal Government of Germany
TARGET GROUP	AI Companies within the city of Heidelberg

Analyzing the compliance of AI related Companies within the city of Heidelberg regarding the AI strategy of the Federal Government Germany is crucial for several reasons:

Innovative Catalyst: Assessing companies' alignment acts as a catalyst for innovation, driving economic growth and solidifying the country's reputation as a hub for cutting-edge technology.
Global Competitiveness: Ensuring that companies adhere to Germany's AI strategy is essential for maintaining a competitive edge in the AI-driven global landscape, attracting talent, investment, and partnerships.
Championing Ethical AI: The analysis enforces ethical AI principles, building public trust and reducing legal and reputational risks, setting a positive example for the global AI community.
Data Privacy and Security: Upholding stringent data privacy and security measures safeguards trust among consumers and partners, aligning with Germany's robust data protection regulations.
Workforce Development: Highlighting companies' investments in AI-related skills development equips the workforce for an AI-driven future, facilitating a smooth transition into the digital era.
Facilitating Collaboration: Identifying partnership opportunities between government, businesses, academia, and civil society streamlines AI technology deployment for societal benefit, amplifying its positive impact.
Global Influence: Encouraging companies' active participation in international AI discussions strengthens Germany's position as a thought leader, influencing global AI standards and practices.
Societal Impact: Ensuring AI technologies benefit society by addressing challenges and improving public services enhances the well-being and quality of life for German citizens.

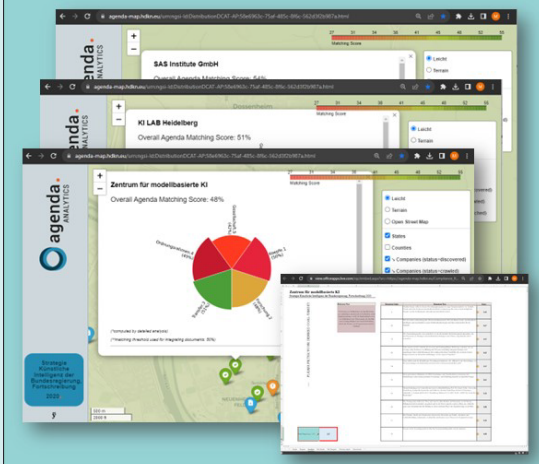


Figure 3: AgendaAnalytics Case Study 3

CASE STUDY	
AGENDA	European Molecular Biology Laboratory Programme 2022-2026
TARGET GROUP	Life Science Companies

Analyzing the compliance of life science companies regarding the EMBL program is crucial for several reasons:

Scientific Advancement: Compliance promotes scientific progress and innovation in areas such as genomics, proteomics, and structural biology.
Public Health Impact: Ensuring alignment helps address pressing health challenges, improve healthcare outcomes, and enhance public health globally.
Research Collaboration: Compliance analysis encourages Life Science companies to engage in collaborative research efforts, fostering a more interconnected and effective research community.
Data Sharing and Open Science: Compliance ensures that companies contribute to the free flow of scientific knowledge and data, accelerating research discoveries and advancing the collective understanding of life sciences.
Ethical Research: Compliance analysis ensures that companies adhere to ethical guidelines in their research and development, maintaining public trust and avoiding ethical controversies.
Education and Training: Compliance ensures that Life Science companies actively participate in educational initiatives, helping train the next generation of scientists and researchers.
Societal Benefit: By aligning with EMBL's goals, Life Science companies contribute to the broader societal benefit by addressing pressing scientific questions, improving healthcare, and advancing our understanding of life on Earth.

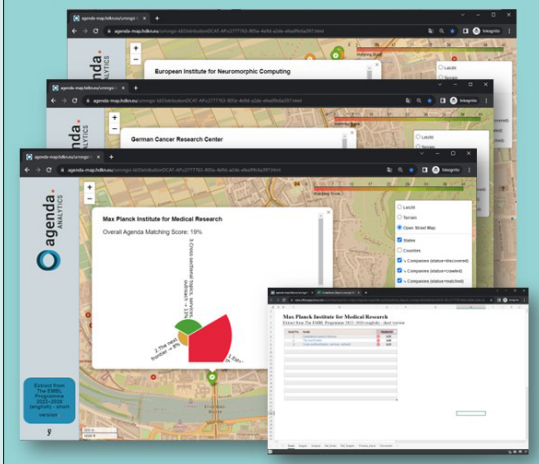


Figure 4: AgendaAnalytics Case Study 4

SALTED reference:

Within the application development, several services, that form the data injection and data enrichment chains used for this application, were developed. Since those services were

implemented in an atomic way, they are stand alone and can be either used directly within another use case or can be adapted to comply with specific needs that may arise. Additionally, the frontend services show an exemplary way how the data within the Scorpio broker can be used to directly implement an end-user application.

All implementations can be found in the projects GitHub repository:
https://github.com/SALTED-Project/AgendaAnalytics

Visualization of the end user frontend:

At the moment there are 4 case studies implemented. That means 4 agendas were used to analyze certain companies regarding their compliance with them. As it is shown in Figure 1-Figure 4, for each agenda a map gets automatically created every night, that is displayed under its public address *(agenda-map.hdln.eu/<agenda-id>.html*):

Current links are:

- AI Map: https://agenda-map.hdkn.eu/urn:ngsi-ld:DistributionDCAT-AP:58e6963c-75af-485c-8f6c-562d3f2b987a.html
- ESG Map: https://agenda-map.hdkn.eu/urn:ngsi-ld:DistributionDCAT-AP:f7c6cdd0-3b55-412d-a3d9-0c0fef06fdfd.html
- SDG Map (default): https://agenda-map.hdkn.eu/urn:ngsi-ld:DistributionDCAT-AP:9bd03954-fa71-4fd7-a014-77b79b6534a0.html / https://agenda-map.hdkn.eu
- Life Science Map: https://agenda-map.hdkn.eu//urn:ngsi-ld:DistributionDCAT-AP:c2777763-805e-4e9d-a2de-efea99c6a397.html

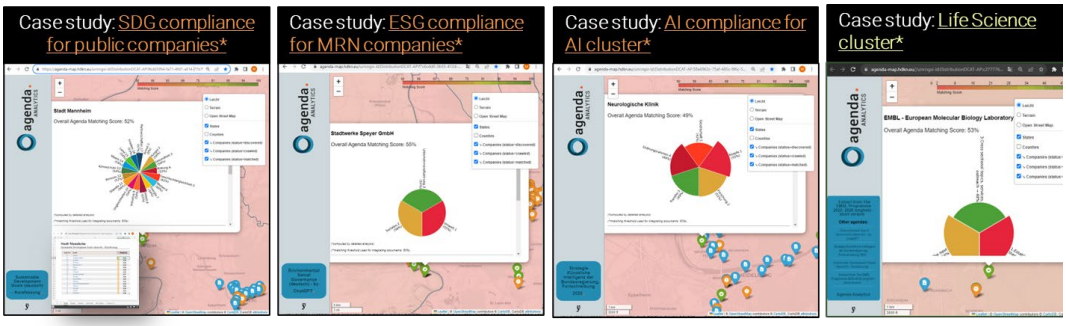


Figure 5: Agenda examples

Each map displays information, that is persistent / can be found in the Scorpio broker, accessible by anyone interested.

Agendas are represented within the *DistributionDCAT-AP* model, organizations within the Organization model, results from the crawling and matching service are represented within the *DataServiceRun* model, while the services themselves are represented by the *DataServiceDCAT-AP* model. The *KeyPerformanceIndicator* model is used to represent the matching results in a more structured / easier to analyze format, than the *DataServiceRun* from the Matching service offers with the raw results.

The frontend tries to enable the user to understand the data representation within the broker, to fully outline the gains that come from an architecture setup like the one done by the SALTED project. Therefor the map shows / offers detailed links to all underlying calculation bases. For example, the popup shown in Figure 6 shows links to the Scorpio entity of the Organization for which the analysis took place and the other relevant entities that together form the result. This allows the user to see exactly which crawling configuration was used and what results were obtained, that later on act as an information basis on which the organization will be evaluated against a given agenda. Figure 7 shows these possibilities exemplary for the referenced crawling entity in Figure 6, which can be looked up using the public Scorpio broker access.

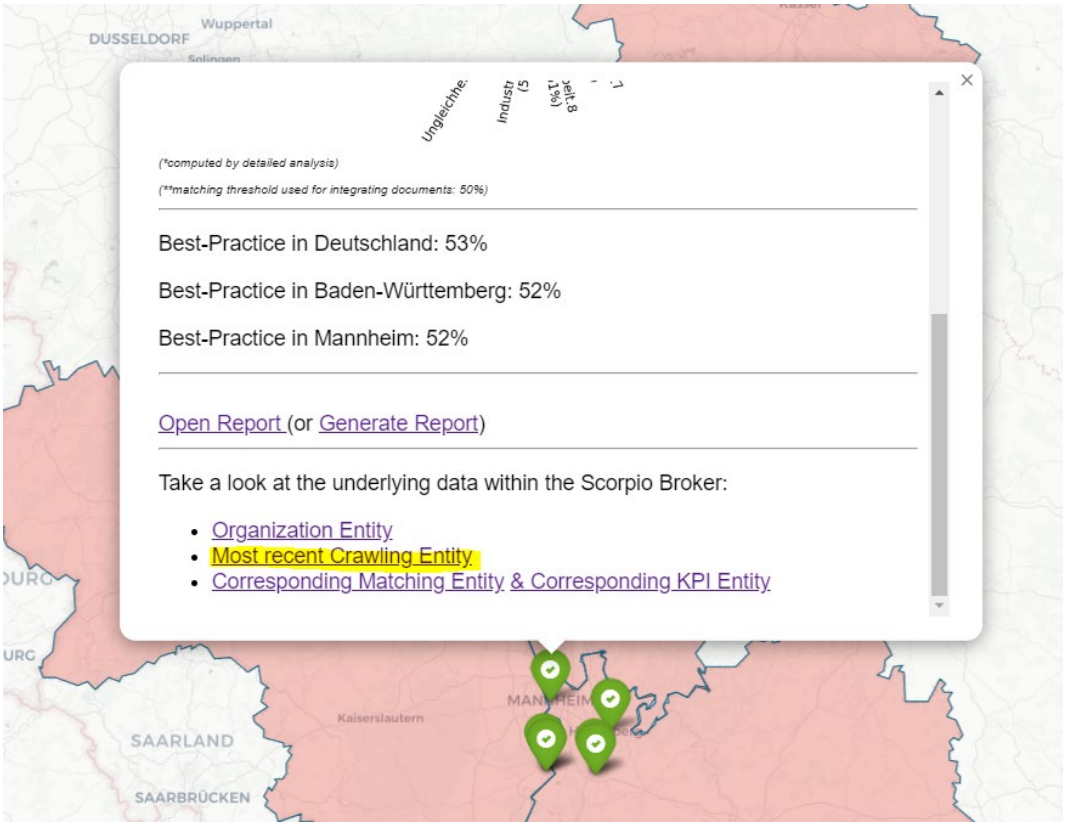


Figure 6: Frontend Agenda Analytics Pop-Up

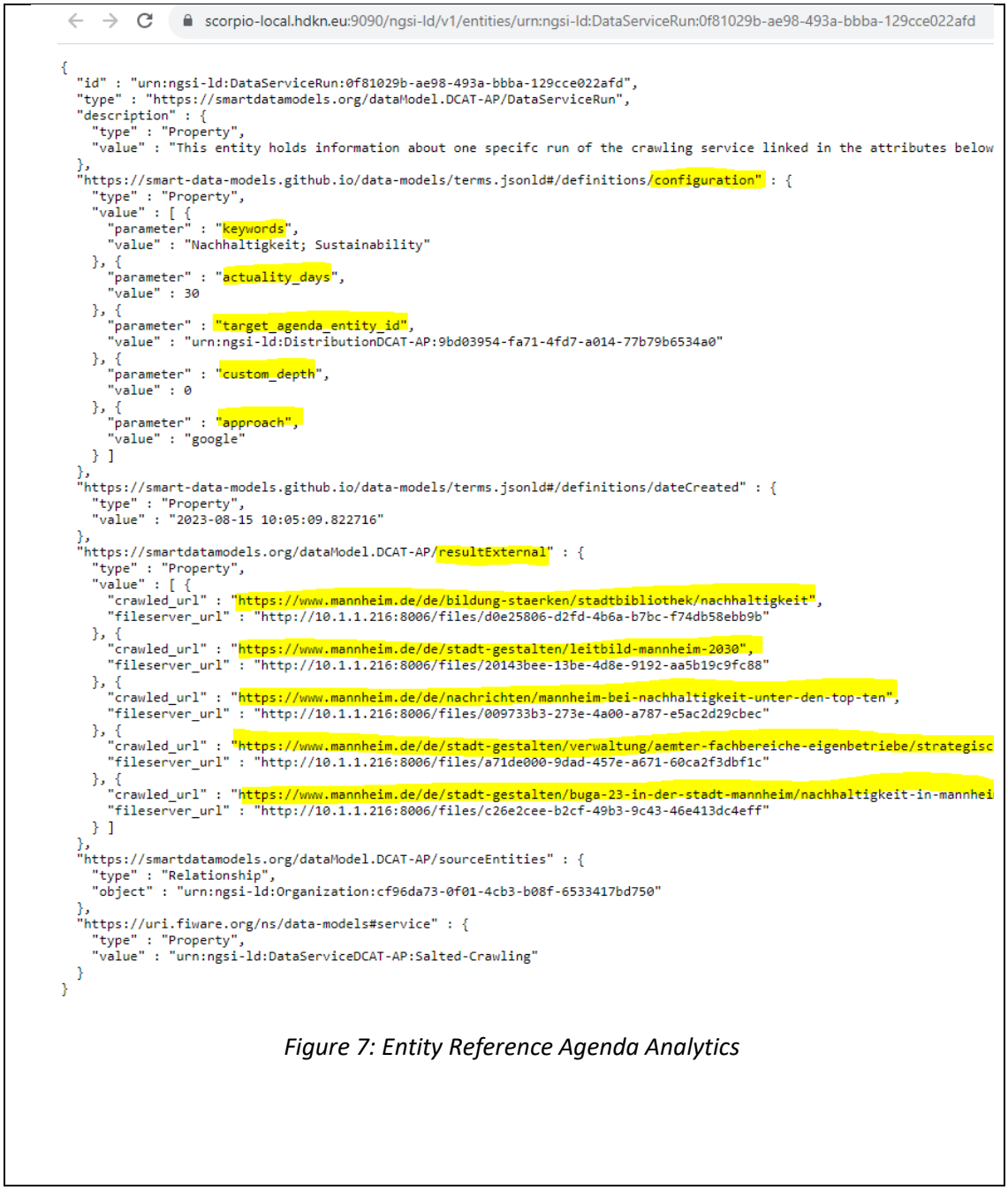


Figure 7: Entity Reference Agenda Analytics

Visualization of Data processed by the application:

For a detailed explanation of the Data Injection and Enrichment Chains used see the D2.2 [3] and the D2.3 [4]. Figures 7 and 8 provide a simple overview:

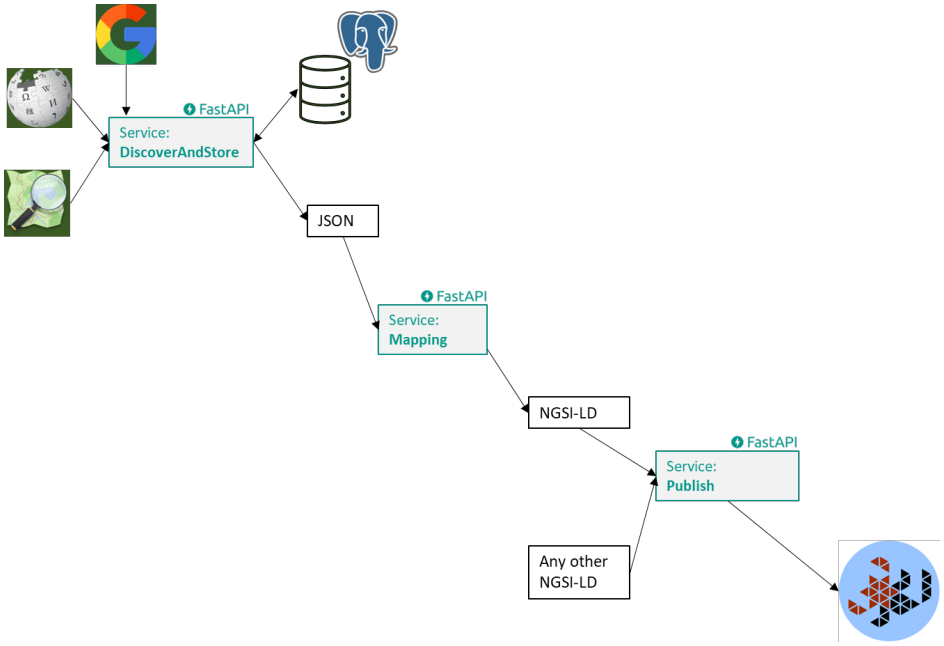


Figure 8: Data Injection Chain Agenda Analytics

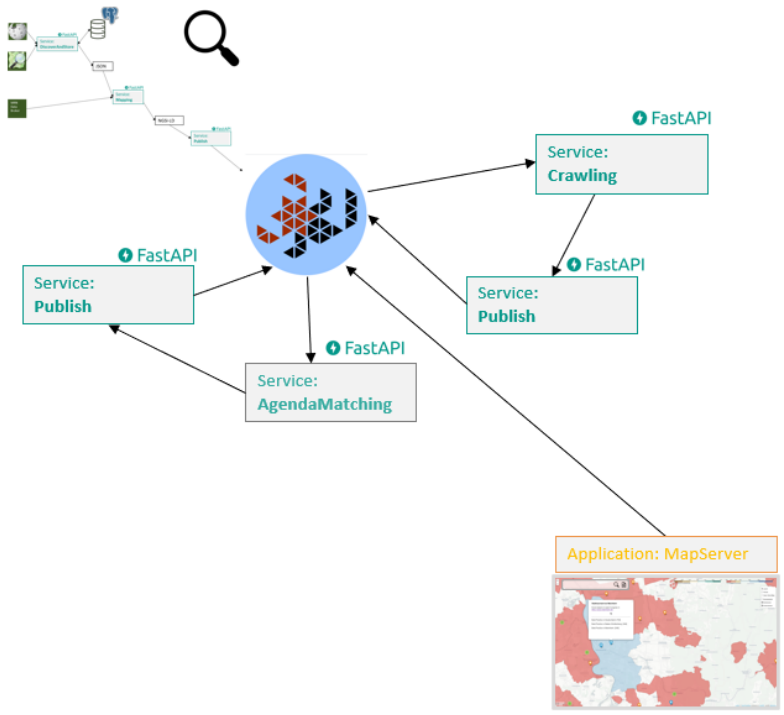


Figure 9: Data Enrichment Chain Agenda Analytics

Acceptance criteria:

- Companies with interest to use
- High value of calculated information
- Availability / transparency of calculation basis for users (crawled documents, matching results, metadata)

3.2 CROPS AND CO2 FOOTPRINT DATA RELATIONSHIP

Application Title:

LAND CROPS AND CARBON FOOTPRINT (LCCF)

Application Description:

SALTED Land Crops and Carbon Footprint (LCCF) application represents two primary and heterogeneous data sources:

- Data from SIGPAC – Spanish platform for Geographic Information System for Agricultural Plots. Those data represent geographical plots information on that site and the soil uses for them.
- Data from PNOA – Spanish platform for National Aerial Orthophotography Plan, obtaining the CO2 fixed in the ground from samples obtained with LIDAR technology carried out with flights. These data are processed to obtain georeferenced samples of CO2 in soil with a resolution of 200x200 meters.

Both data sets are located in the surroundings of the city of Lorca (Murcia), there being a large amount of data for the study.

The application provides a technical solution for mapping these data to NGSI-LD models and serves them to SALTED platform.

SALTED LCCF application is a map-based web application that allows joint visualization of agricultural parcels (crops) and air quality metrics (CO2) in a given location. Furthermore, it automatically generates several graphs that address the statistical results obtained when correlating metric obtaining information about their relationship.

The publication of the information as open data is also an offer to the creative industries in the region to develop attractive solutions to address end customers.

Value Proposition:

SALTED Land Crops and Carbon Footprint (LCCF) application target is to relate available data on carbon footprint with existing crops in a region and display it on a map. The result is a large-scale study that allows obtaining added value information from plots with different types of crops and a real value of CO2 fixed in the soil.

Currently, carbon emissions' markets such as the Spanish one allows companies to plant forests to obtain permits for CO2 emissions of equivalent magnitude. At SALTED, we have considered the possibility of adding crop plantations to the equation, rather than relying solely on forests. This application aims to provide a large-scale study that proves CO2 emissions compensated by forests are of the same order as those compensated by several kinds of crops.

Land Crops and Carbon Footprint (LCCF) application target is to relate available data on carbon footprint with existing crops in a region and display it on a map. So, predictions can be made about which is the most convenient area to grow some kind of crops based on

carbon pollution.

SALTED reference:

The SALTED project is the key to carrying out the large-scale study for different reasons:

- allows the modeling of information in Smart Data Models concepts following the NGSI-LD standard.
- demonstrates that it is possible to obtain valuable information from heterogeneous sources using linking and enrichment mechanisms.
- it allows the extraction of information through a web service on which to develop applications to show the user the synthesis of the value of the data.

Within the application development several services were developed, that form the data injection and data enrichment chains used for this application.

All implementations can be found in the projects GitHub repository:

https://github.com/SALTED-Project/Crop-CO2_Correlator

https://github.com/SALTED-Project/DET_Amper

Visualization of end user frontend:

The LCFF demonstrator web application shows the information graphically georeferenced on a map. This information is obtained from the data source server.

The application can be accessed by the URL: https://salted.grupoamper.com/

The user can interact with the application in several ways. Aside from a login page that the application provider may choose to activate, there is a main screen where all the controls are located, as shown in Figure 10. Most of it is covered by an interactive map, where the user can zoom in and out, pan, and hover over the represented polygons to read tooltips. On the left-hand side, there are four buttons that allow the user to hide or display certain information (CO2, all crops, or individual crops) on the map or have a look at the interactive graphs.

In this case, the data are georeferenced polygons with information of the type of crop, CO2 footprint level and their relationship between them.

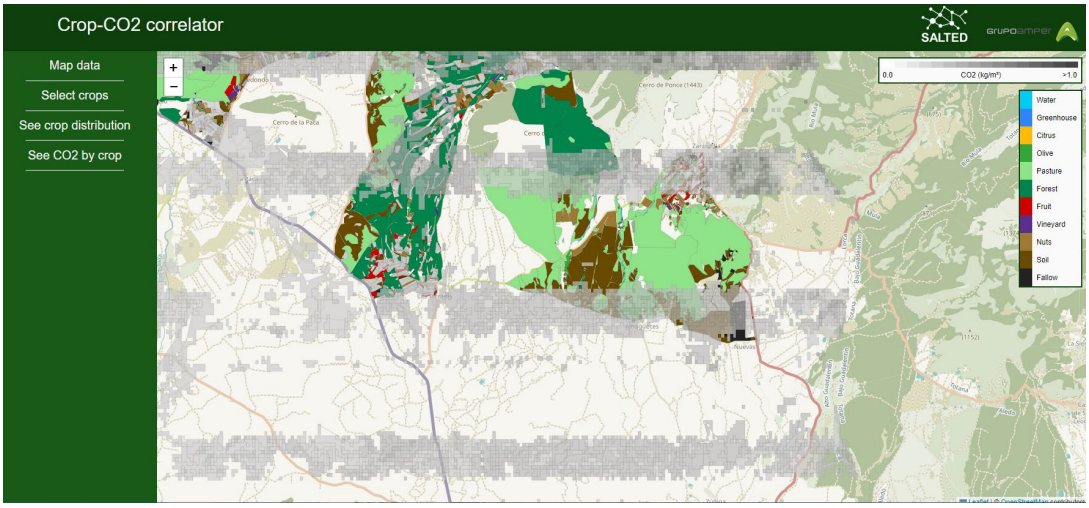


Figure 10: Land Crops and Carbon Footprint Frontend

The user is able to navigate freely on the map and, with the proper zoom level, the application shows using different color and shapes to show the type of crop and CO2 footprint level. The user is able to select a parcel to see in a tooltip the type of crop and associated CO2 level, being possible to select a type of crop to see the pop up shown in Figure 11.

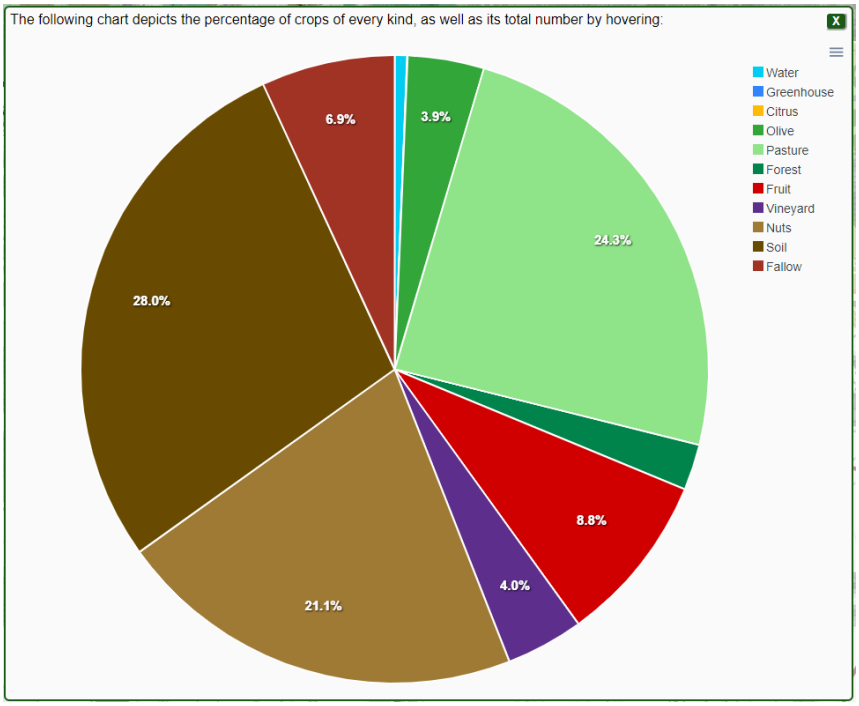


Figure 11: Land Crops and Carbon Footprint Pop-Up

The application allows accessing to a menu box with a crop selector, which gives access to a graph showing the minimum, average, maximum and variance of CO2 values.

Finally, the application allows accessing a CO2 variance graph by a crop type, shown in Figure 12.

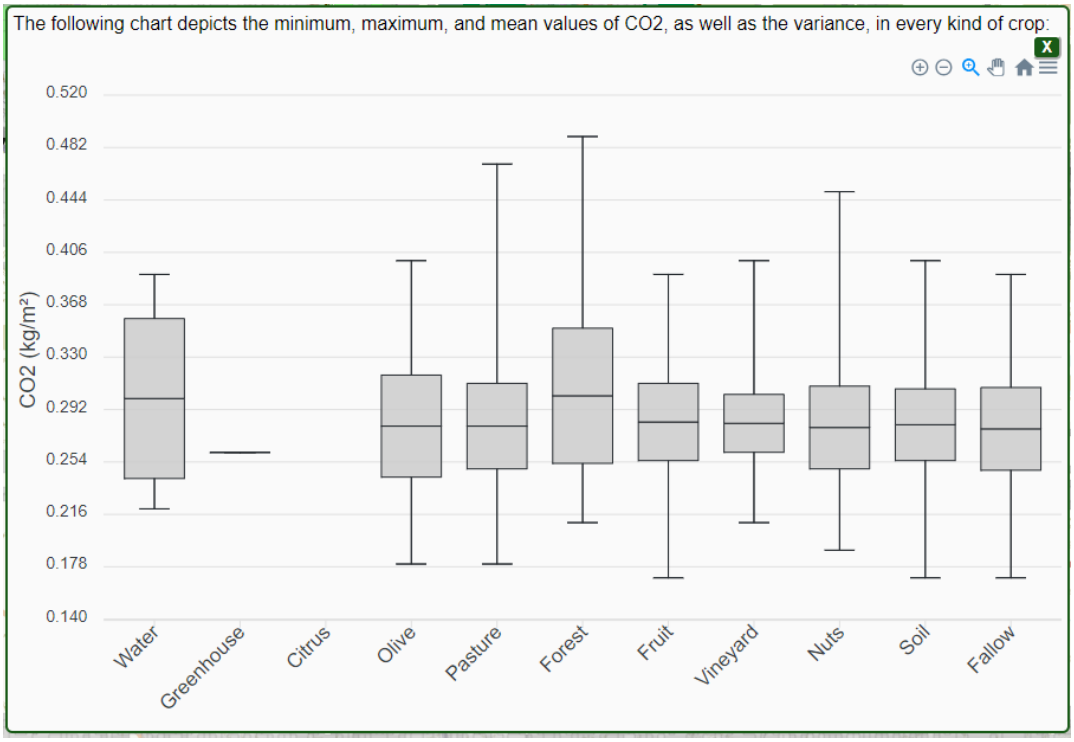


Figure 12: Land Crops and Carbon Footprint Details

Visualization of Data processed by the application:

For a detailed explanation of the Data Injection and Enrichment Chains used see the D2.3 [4].

Acceptance criteria:

- usable web frontend
- data accessible
- goal: show linked data (crops and carbon footprint)

3.3 MESSENGER AS A DATA PORTAL FRONTEND

Application Title:

MATRIX / ELEMENT – Chatbot - Topic: General query

Application Description:

Maubot[3] is a plugin-based *Matrix* bot system written in Python. It provides users the possibility of interacting with an automated bot on a communication platform. This enables the user to leverage services in the background, without having to understand the "inner working". One example would be the provision of information contained in the Scorpio broker on demand or the proactive information sharing of the bot for certain time sensitive information.

The SALTED project implemented a bot, based on the open-source Maubot framework, that can be integrated in any platform that uses the Matrix framework as communication protocol. The communication platform supported by Matrix, which was used here, is the Element platform, since it offers the flexible scaling of the setup by implementing bridges to more common messenger services like Telegram and WhatsApp.

Value Proposition:

A considerable challenge in disseminating innovations in the field of urban data and IoT is motivating potential users who are unfamiliar with the subject and have little or usually no prior knowledge in this area. Bots are widely used on websites of service providers or online-retail-companies and are therefore already known by most people. Therefore, they can be used as a tool to give access to more complicated services by wrapping them into a familiar frontend.

SALTED reference:

The SALTED project wants to support the developers of applications / software with the open-source components of the DET by contributing to the digital service infrastructure defined by the Connecting Europe Facility (CEF). But it also wants to reach the people, since it's an EU-funded project working on the democratization of added value generated from public data. Therefore, its essential to find ways to reach the public in ways they accept and value. This is why this application as a frontend alternative was developed.

All implementations can be found in the projects GitHub repository:
https://github.com/SALTED-Project/MaubotGeoPlugin

Visualization of end user Frontend:

The frontend and its basic functionality are provided by the communication platform itself:

[3] Homepage: https://docs.mau.fi/maubot/index.html, Github: https://github.com/maubot/maubot

e.g. Element platform. The following shows an example interaction with the SALTED GeoBot:

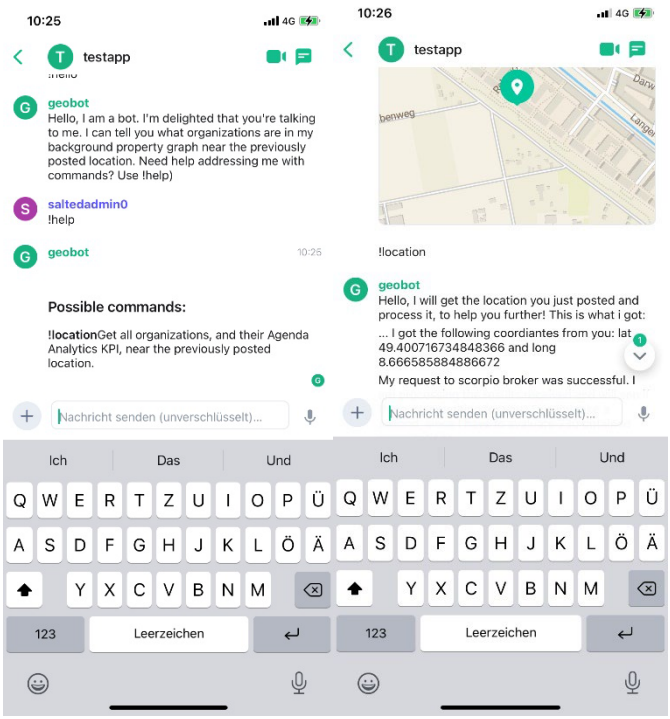


Figure 13: MaubotGeoPlugin Frontend

Visualization of Data processed by the application:

Since this application is a simple frontend to the data that can be queried by the broker, the data processing aspect is kept really simple. The user shared location is simply used to query for NGSI-LD entities near the current position. Of course, any other more comprehensive data processing can be used to provide the user with even more details or linked aspects.

Acceptance criteria:

- Concept for testing user interaction with bot / building up awareness to public regarding added value and possibilities.

3.4 LD-XPLORER

Application Title:

LD-XPLORER - AS A WINDOW INTO WHAT LINKED DATA MEANS

Application Description:

The efficiency of data hinges on its strategic linkage with other data, transcending mere data points to yield practical information in the real world. The NGSI-type data, rife with explicit (e.g., references to other entities) and implicit (e.g., temporal or spatial proximity) links, facilitates systematic exploration.

Our objective is to operationalize this concept through the development of a web application. This application, consisting of both frontend and a basic backend, will leverage Scorpio for efficient data querying and display. Users, including European taxpayers, potential project partners, and data suppliers, will navigate the linked data graph by initiating queries from a single entity.

This interactive process involves tracing explicit and implicit links, offering users a deep dive into data relationships. The overarching goal is to present a tangible, experiential understanding of data interconnectivity. This technical framework not only serves end-users but also acts as a catalyst for data suppliers, encouraging them to share their data within this collaborative environment.

Value Proposition:

The added value of our NGSI-LD-based web application lies in its capacity to demystify data interconnectivity. By showcasing explicit and implicit links between entities, the application not only facilitates efficient data exploration but also promotes collaboration. Data suppliers are motivated to contribute to a shared knowledge pool, realizing the practical benefits of their participation. Beyond immediate gains, users are equipped with a solid foundation in understanding linked data concepts, positioning them to adapt to future advancements. In essence, our application adds value by making abstract concepts tangible, fostering collaboration, and future-proofing knowledge in the evolving landscape of data connectivity.

SALTED reference:

SALTED lives from finding, making accessible, and combing data sources. Thus, it is necessary to convince potential data suppliers and use case partners of the added value through NGSI LD.

All implementations will be made available in the projects GitHub repository:

https://github.com/SALTED-Project/LD-Xplorer

Visualization of end user Frontend:

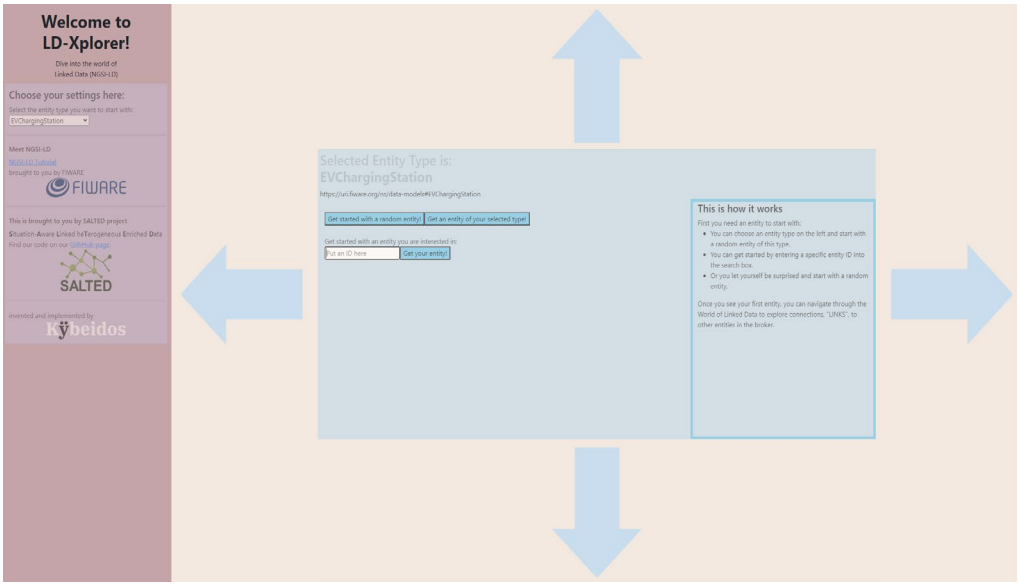


Figure 14: Frontend LD-Xplorer

Visualization of Data processed by the application:

Since this application is a simple frontend to the data that can be queried by the broker no further processing of the obtained entities takes place after the query process.

Acceptance criteria:

- Show the potential of linked data (i.e. users can discover surprising information in – seemingly - unrelated data)

3.5 SENTIMENT ANALYSIS REGARDING TRAFFIC IN MADRID

Application Title:

SENTIMENT ANALYSIS REGARDING TRAFFIC IN MADRID

Application Description:

Initially, we enrich the SALTED social media data through advanced Natural Language Processing (NLP) techniques. This involves extracting sentiment from translated user posts related to traffic in the city of Madrid.

Subsequently, we leverage this NGSI-LD generated sentiment data to construct a sentiment graph that illustrates how people reacted to traffic in Madrid at various times throughout the day. The sentiment graph is designed to portray sentiment scores on a scale ranging from negative to positive.

It was decided to use the sentiment data in the CLIFF dashboard, so the visualizations can be shown there. This integration is an ongoing process.

As an example, the graph might reveal heightened negative sentiment during morning and evening rush hours and a more positive sentiment during mid-day when traffic is comparatively lighter.

Value Proposition:

The value proposition of this idea lies in its ability to provide actionable insights and enhance decision-making processes related to urban traffic management in Madrid (or in the future, any chosen city with available data).

By leveraging advanced NLP techniques to analyze sentiment from social media data, the system generates a sentiment graph. This graph not only captures the flow of public sentiment regarding traffic but also allows for an understanding of how it varies throughout the day.

The value can be summarized as follows:

- Informed Decision-Making: Stakeholders, such as city officials and traffic management authorities, gain valuable insights into public sentiment related to traffic conditions. This information enables them to make informed decisions about potential interventions or improvements.
- Monitoring: The system provides a monitoring mechanism for assessing the sentiment trends. This allows for responsiveness to emerging issues or positive developments, contributing to more agile and adaptive urban planning.
- Predictive Analysis: Over time, the historical sentiment data can be used for predictive analysis, helping anticipate potential traffic-related challenges during specific times or events. This proactive approach enhances overall city planning and resource allocation.
- User-Centric Approach: By tapping into user-generated content on social media, the system adopts a user-centric approach, directly capturing the sentiments and experiences of the city's residents. This makes the insights more relatable and reflective of the community's collective perspective.

In essence, the value proposition revolves around leveraging technology to transform social media data into actionable intelligence, fostering a smarter, more responsive, and user-centric approach to urban traffic management in Madrid.

Stakeholders:

- City Officials and Policymakers:
  Those responsible for urban planning, traffic management, and policy decisions in the city.
- Transportation Authorities:
  Entities overseeing public transportation, roads, and infrastructure.
- Citizens:
  Citizens may be interested in this data to plan their daily commute.
- Environmental Groups:
  Organizations concerned with the environmental impact of traffic and interested in promoting sustainable transportation solutions as high levels of traffic congestion during peak hours may contribute to increased air pollution levels, leading to potential health problems and environmental degradation.

SALTED reference:

Initially, the application utilizes city-specific data, making informed decisions based on real-time insights garnered from sources like social media sentiments possible. This immediate data application aligns with SALTED's emphasis on dynamic data utilization.

Looking forward, the application envisions a progressive integration of gathered data. In the future, it aims to compare this data with actual IoT sensor measures, providing a comprehensive evaluation of traffic conditions. This forward-thinking strategy echoes SALTED's vision of converging different data sources for a holistic analysis. The application anticipates leveraging related datasets and maintaining a uniform format to facilitate seamless comparison.

Notably, the Traffic Analysis in Madrid application follows SALTED's lead in utilizing curated, linked, and enriched data. By incorporating these principles, the application ensures a nuanced exploration of traffic patterns.

In summary, the Traffic Analysis in Madrid application not only applies SALTED's principles for immediate decision-making based on real-time insights but also envisions a future where integrated data sets, including social media sentiments and IoT sensor data, will provide a more comprehensive understanding of urban traffic dynamics. This application serves as a practical extension of SALTED's forward-thinking approach.

The implementations can be found in the project's GitHub repository:

https://github.com/SALTED-Project/SentimentAnalysis-

Visualization of end user Frontend:

Here we can explore the sentiment distribution of tweets throughout the daily hours in the months of April, May, and June through some visualizations and gain valuable insights into the natural distribution of tweets and identify peak hours for both positive and negative sentiments. These types of visualizations provide an overview, allowing you to discern patterns in tweet sentiments.

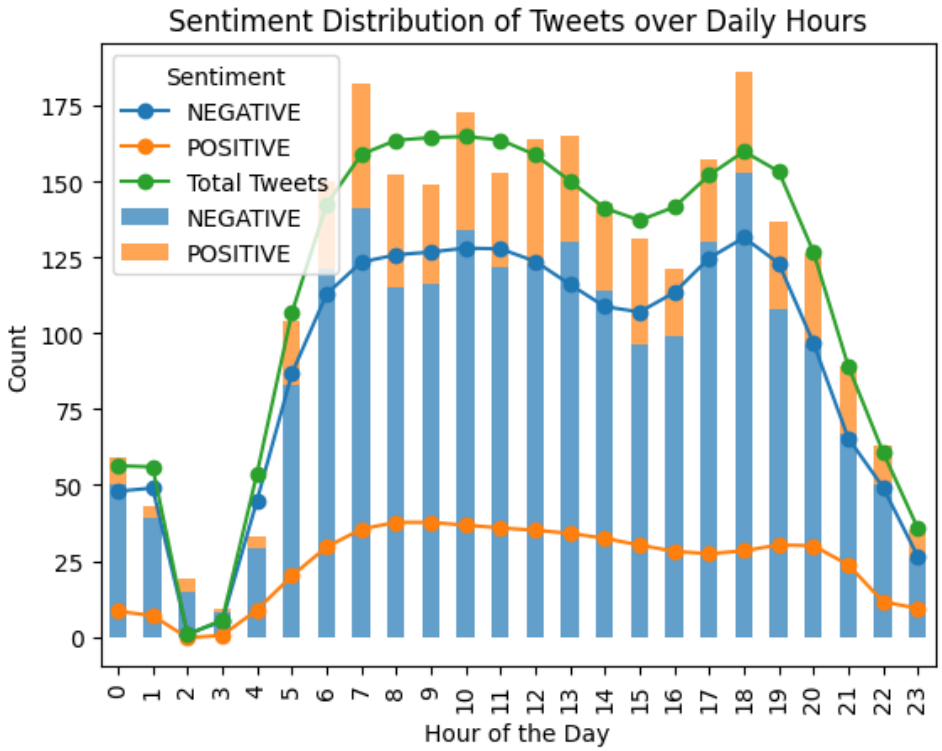


Figure 15: Sentiment distribution of tweets over daily hours in the month of April

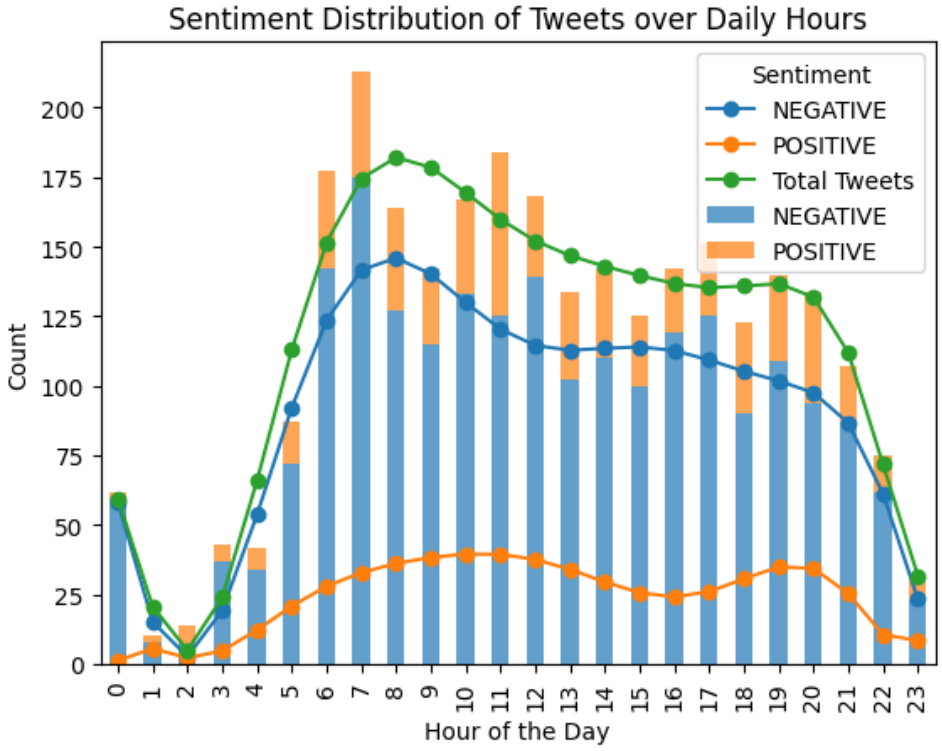


Figure 16: Sentiment distribution of tweets over daily hours in the month of May

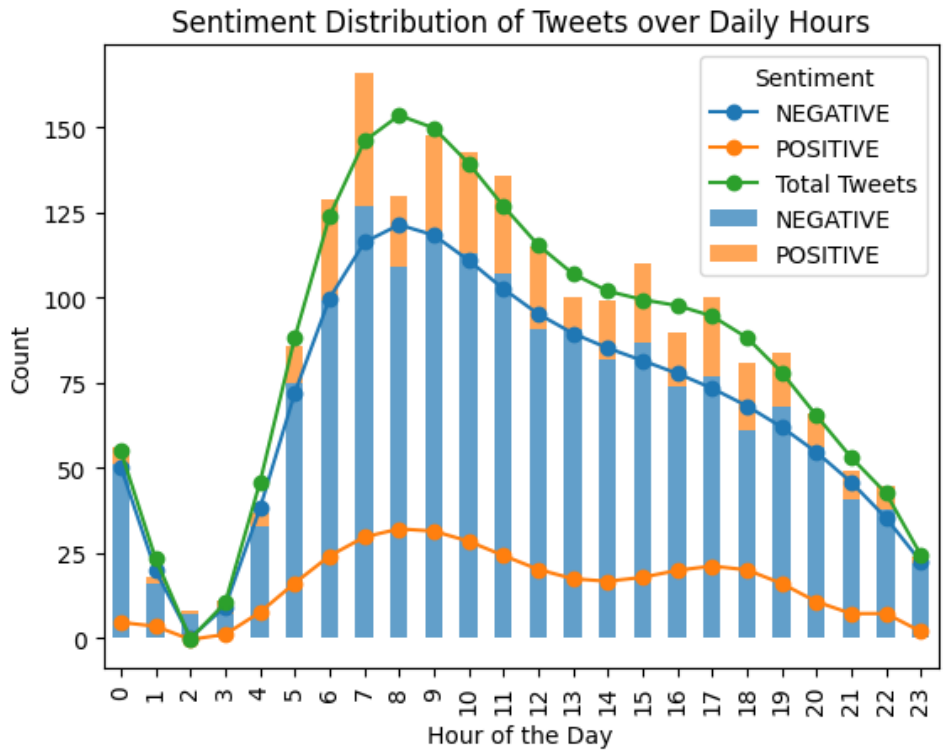


Figure 17: Sentiment distribution of tweets over daily hours in the month of June

Visualization of Data processed by the application:


```
{
    "id": "urn:ngsi-ld:SMPost:4260c2afdcd463e4cc80e9f1fac4bd5aca5117af68372ed10b90f38790d9537b",
    "type": "SMPost",
    "belongsToCollection": [],
    "createdBy": {
        "type": "Relationship",
        "object": "urn:ngsi-ld:SMUser:d536d1a219c733225ba47750cbf9b89a34a6cd4376b5c8af9748d09de855bc4f"
    },
    "hasAnalysis": [
        {
            "type": "Relationship",
            "object": "urn:ngsi-ld:Analysis:Sentiment:4260c2afdcd463e4cc80e9f1fac4bd5aca5117af68372ed10b90f38790d9537b",
            "datasetId": "urn:ngsi-ld:Dataset:SMCollection:0"
        }
    ],
    "platform": {
        "type": "Property",
        "value": "Twitter"
    },
    "postCreatedAt": {
        "type": "Property",
        "value": {
            "@type": "DateTime",
            "@value": "2023-06-30T08:19:00+00:00"
        }
    },
    "postId": {
        "type": "Property",
        "value": "1674694008780517376"
    },
    "@context": [
        "https://raw.githubusercontent.com/smart-data-models/dataModel.SocialMedia/master/context.jsonld"
    ]
},
```


Figure 18: NGSI-LD data for a social media post regarding traffic in Madrid

```
{
    "id": "urn:ngsi-ld:Analysis:Sentiment:4260c2afdcd463e4cc80e9f1fac4bd5aca5117af68372ed10b90f38790d9537b",
    "type": "SMAnalysis",
    "analyzedAt": {
        "type": "Property",
        "value": {
            "@type": "DateTime",
            "@value": "2023-09-25T03:12:53.458479"
        }
    },
    "hasAnalysisType": {
        "type": "Property",
        "value": "Sentiment"
    },
    "hasAnalysisValue": {
        "type": "Property",
        "value": "NEGATIVE"
    },
    "hasConfidence": {
        "type": "Property",
        "value": 0.9995569586753845
    },
    "isAnalysisOf": {
        "type": "Relationship",
        "object": "urn:ngsi-ld:SMPost:4260c2afdcd463e4cc80e9f1fac4bd5aca5117af68372ed10b90f38790d9537b"
    },
    "@context": [
        "https://raw.githubusercontent.com/smart-data-models/dataModel.SocialMedia/master/context.jsonld"
    ]
},
```


Figure 19: NGSI-LD data for sentiment analysis of a social media post

Acceptance criteria:

- Accuracy of Sentiment Analysis: The sentiment analysis algorithm achieves a predetermined level of accuracy in classifying sentiments from social media posts.
- Data Privacy and Ethics: The implementation adheres to data privacy regulations, ensuring ethical and responsible use of social media data for sentiment analysis.
- User Accessibility: The visualizations are designed to be accessible and understandable by a diverse range of stakeholders, including city officials, policymakers, and the general public.

3.6 CITY LIVEABILITY INDEX FLEXIBLE FRONTEND

Application Title:

CITY LIVEABILITY INDEX FLEXIBLE FRONTEND (CLIFF)

Application Description:

In this application, the datasets from EDP and other open datasets are linked and enriched. The linking includes matching data to the semantic information from external ontologies or sources such as Smart Data Models. The enrichment part includes creating "indices" that shows the performance of city related to UN SDGs and showcasing the liveability of smart districts in terms of various aspects such as air quality, weather, environment, traffic, and others such as facilities. In addition to the city liveability indices, the smart districts which have lack of data such as air quality will be enriched with machine learning predictions based on transfer learning. All linked and enriched data will be made available as NGSI-LD in the Scorpio Context Broker.

The data available in the NGSI-LD will be showcased in the "flexible frontend" for different cities over Europe. The flexible frontend will include hexagon areas that represent the districts, the locations of sensing data and all available information as different layers on the map of the region.

Value Proposition:

The flexible frontend provides a configurable visualization for various scenarios. In SALTED, we used this front end to visualize two use cases. It can also be used outside of the scope of SALTED by anyone who is using NGSI-LD.

The visualized sensor data and relationships enable stakeholders to visualize various aspects of city liveability related to the environment such as weather and air quality of different regions/districts defined as hexagons.

Stakeholders:

- City officials:
  City officials would be interested for their planning and future improvements on the liveability of different districts in their cities. They can also compare their índices with índices from other cities and explore the reasons of achievement in certain áspects of the city liveability (e.g., traffic, air quality).
- Citizens:
  Citizens would be interested to learn different aspects of their cities in terms of liveability to contribute in terms of the cities' environment and be aware of the possible improvement areas. They may also leverage it for deciding the districts to live or spend time based on their personal preferences.
- Environmental Groups:
  Environmental groups and agencies would be interested to learn the correlations between the dynamically sensed data as well as the records from the cities to understand/identify the causes of environmental problems in certain districts. They may also propose different solutions based on data available from other cities.

SALTED reference:

A primary goal of providing the SALTED platform is to make generic components and services available that allow new data sources to be connected quickly and new applications to be implemented easily. In line with this goal, the "CITY LIVEABILITY INDEX FLEXIBLE FRONTEND" is based on the characteristics of easy adaptability of front-end components and configurability of data access as a central requirement. These properties make it possible to integrate new content into CLIFF with little effort.

Visualization of end user Frontend:

The flexible frontend provides a general visualization of NGSI-LD entities, their historical evolution and relationships. The flexible frontend can be configured to execute multiple NGSI-LD queries and visualizes the resulting entities on a map if a location is provided. Additionally, a specific attribute needs to be provided to apply a color scale to the resulting geometries on the map. This flexibility allows us to use the flexible frontend not only for CLIFF but also for the Sentiment analysis.

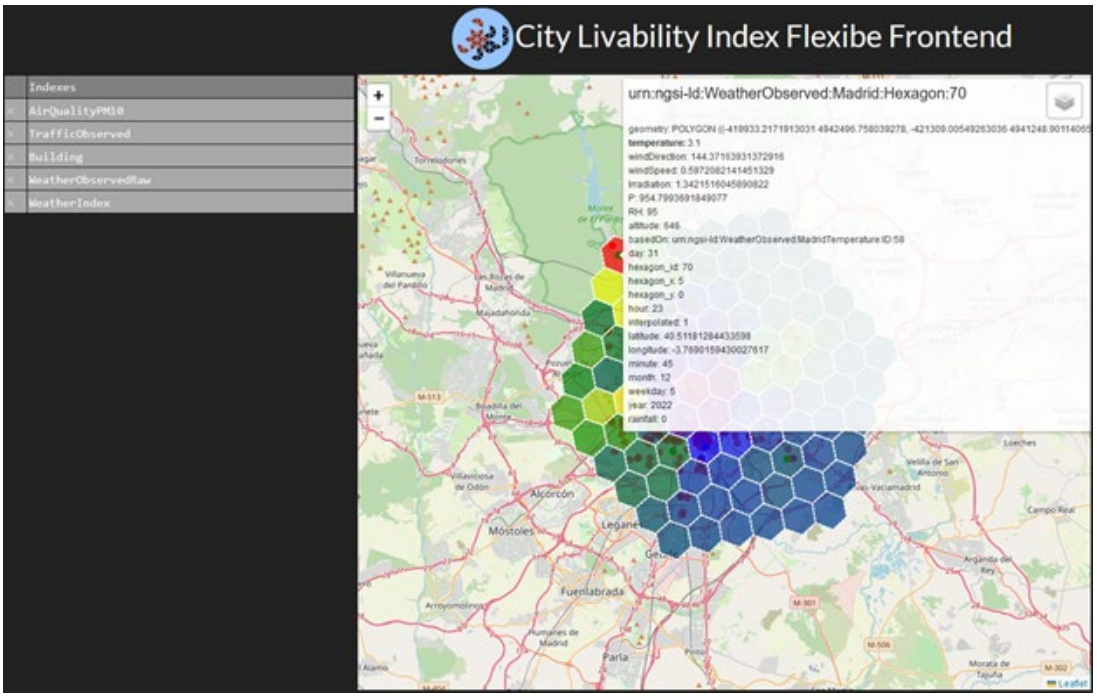


Figure 20: CLIFF Frontend

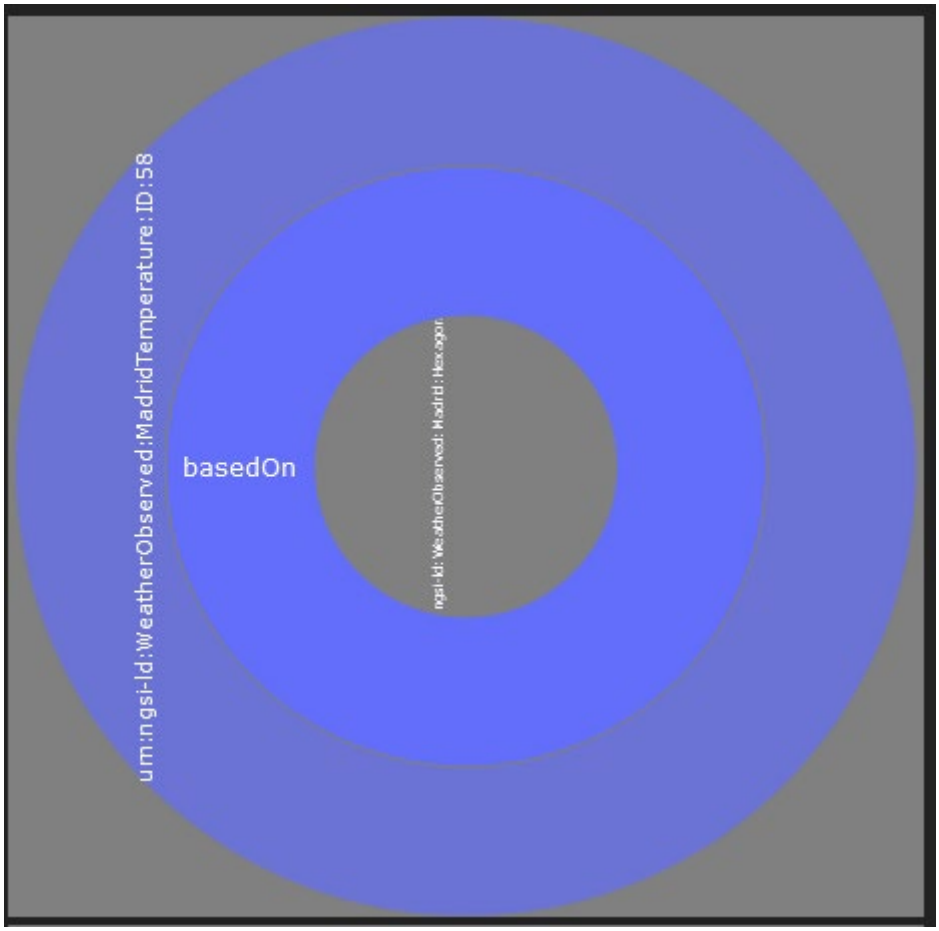


Figure 21: CLIFF Frontend Details

Visualization of Data processed by the application:

For the City Livability Index, we provide a set of predefined queries retrieving the indexes calculated. Calculated indexes contain NGSI-LD Relationships which transparently allow stake holders to understand the indexes. The flexible frontend provides an intuitive visualization of these relationships, which the end user can directly follow and retrieve more detail information on the linked entity.

Additionally, the flexible frontend provides visualizations for the historical evolution for a selected entity or index. Furthermore, aggregated data over a timeframe is visualized. The flexible frontend provides, if applicable, average, minimum, maximum, sum and standard deviation.

Since certain data, such as text or complex data, cannot be visualized in a graph we provide a table overview as a fallback solution. For easier access, the historical evolution is also available for individual attributes of an entity.

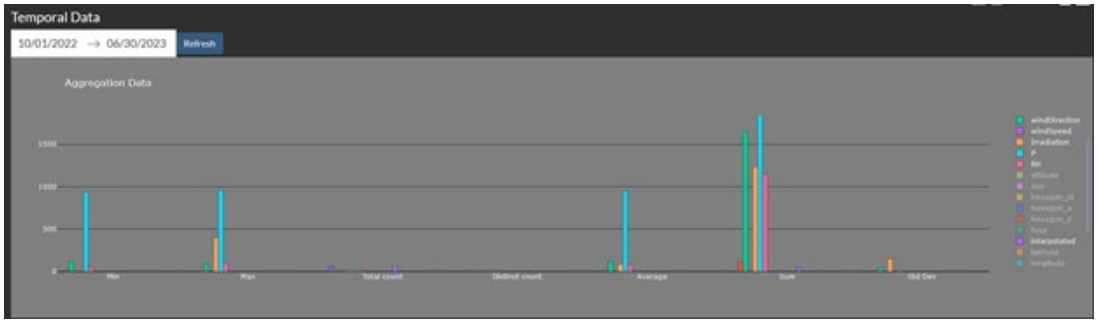
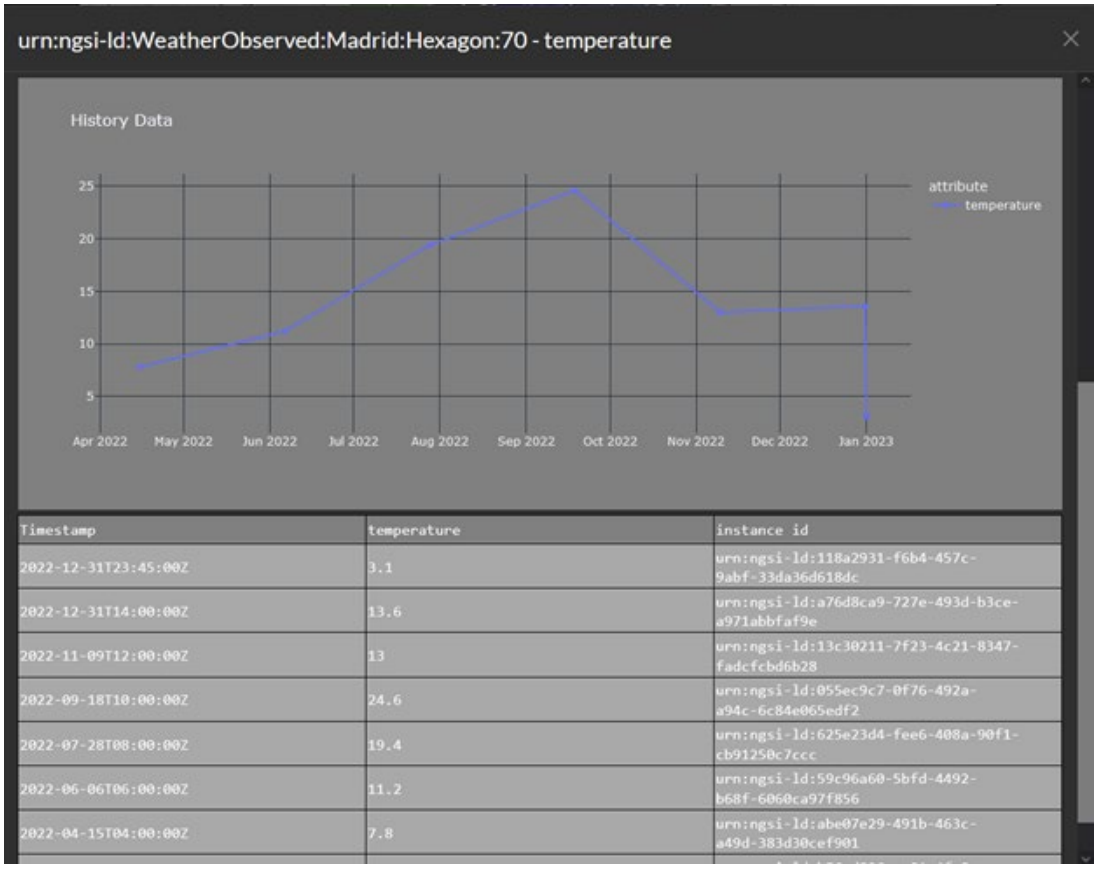


Figure 22: CLIFF Data Overview



Timestamp	temperature	instance id
2022-12-31T23:45:00Z	3.1	urn:ngsi-ld:118a2931-f6b4-457c-9abf-33da36d618dc
2022-12-31T14:00:00Z	13.6	urn:ngsi-ld:a76d8ca9-727e-493d-b3ce-a971abbfaf9e
2022-11-09T12:00:00Z	13	urn:ngsi-ld:13c30211-7f23-4c21-8347-fadcfcbd6b28
2022-09-18T10:00:00Z	24.6	urn:ngsi-ld:055ec9c7-0f76-492a-a94c-6c84e065edf2
2022-07-28T08:00:00Z	19.4	urn:ngsi-ld:625e23d4-fee6-408a-90f1-cb91250c7ccc
2022-06-06T06:00:00Z	11.2	urn:ngsi-ld:59c96a60-5bfd-4492-b68f-6060ca97f856
2022-04-15T04:00:00Z	7.8	urn:ngsi-ld:abe07e29-491b-463c-a49d-383d30cef901

Figure 23: CLIFF Historical Data

Acceptance criteria:

- Web frontend with good usability
- Different sensor data accessible
- Showcase of the potential of linked data

4 APPLICATIONS BACKLOG / POC'S

This chapter logs ideas, approaches and discussions on other applications that can be implemented on the basis of the infrastructure provided in SALTED, or that have a reference to open data developed or viewed within the framework of SALTED. For each of these possible applications, it will be briefly explained what is related to SALTED.

4.1 IDENTIFICATION OF URBAN HEAT ISLANDS & MANAGEMENT OF EXTREME HEAT EVENTS

Application Title:

IDENTIFICATION OF HEAT ISLANDS & MANAGEMENT OF EXTREME HEAT EVENTS (region: Mannheim, Germany)

Application Description:

The primary goal of the application is to notify users when meteorological data indicates a significant increase in temperature within the city. Users will receive messages on communication platforms supported by the Matrix framework, including Element, Telegram, and WhatsApp. Additionally, if users have enabled "Location Sharing" on the communication platform, the application will display nearby cool places.

The application draws data from multiple sources to ensure accuracy and reliability. The Scorpio Platform is a key contributor, offering information about cold places within the city. This platform is enriched by the integration of sensor data from building and area sensors. These sensors could either transmit data to Asset Administration Shells, which implement alarms in matrix rooms and stream the data into the SALTED Scorpio broker, or the sensors could directly push data to the Scorpio broker API and the subscription functionality of the Scorpio broker could be used for alarming.

Project "hyperMODE," initiated in 2022 by GeoNet.MRN, is a critical external partner providing meteorological data from a high-density measurement network. The project collaborates with PIKOBYTES GmbH, Dresden, a key partner with expertise in open sensor web technologies. Data accessibility is facilitated through http://ckan.geonet-mrn.de and may be extended to www.opensensorweb.de as a sensor data service.

The application could also be supported by the VRN (Verkehrsverbund Rhein-Neckar), which offers information on the fastest routes to nearby cool places. As part of Mannheim's commitment to being a climate-resilient city, the VRN may cover the cost of transportation for users following the recommended routes, further incentivizing the utilization of climate-friendly transportation options.

Value Proposition:

For example, the city of Mannheim could supports inhabitants to handle extreme climate situations (reactive and healthy city & handling of climate change results in cities).

SALTED reference:

The envisioned SALTED pipeline for this application promises a significant leap forward for the SALTED platform. This pipeline holds the potential to seamlessly integrate new datasets, including the addition of Cold Places and meteorological data, enhancing real-time information delivery and possibilities of more complex linked data use cases. Additionally, the possibility of integrating Mannheim, Germany, into the platform is being explored, aiming to cater to local needs effectively and promoting the setup locally.

Also, this application not only opens avenues for the validation of the technical adaptability of the SALTED platform / services but also presents the possibility of broadening its user base. Collaborations with projects like hyperMODE could facilitate outreach initiatives, creating awareness and engagement within the community. In essence, the potential implementation of this application pipeline signifies a substantial advancement for Scorpio in addressing the dynamic challenges of urban environments.

Visualization of end user Frontend:

Communication within the application is facilitated through the Matrix framework, ensuring a reliable and efficient communication protocol. Supported platforms include Element, Telegram, WhatsApp, and others enabled by bridges. Maubot, an open-source Matrix-Bot-Framework, enhances the messaging capabilities, enabling seamless communication and interaction with users.

Visualization of Data processed by the application:

The high-level processing approach could follow the below shown approach:

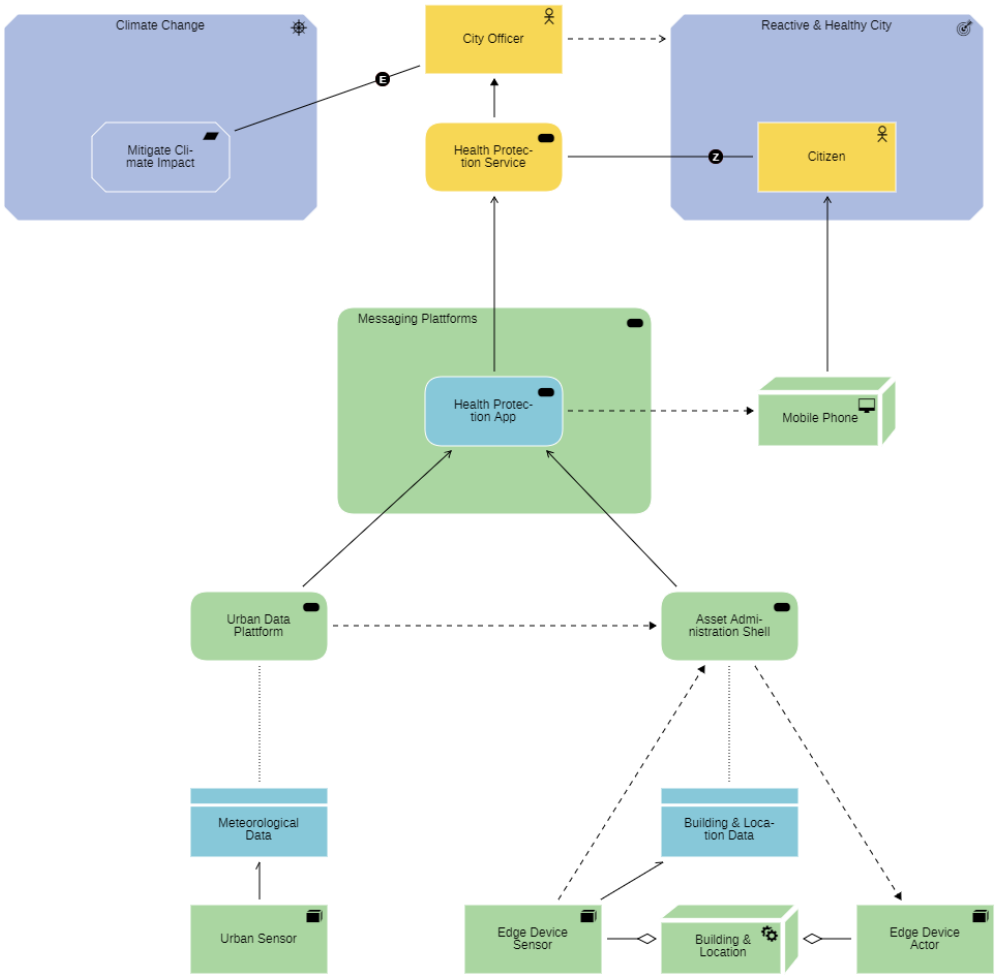


Figure 24: Concept Identification Of Urban Heat Islands

Acceptance criteria:

- Cooperation with hyperMODE & access to platform (www.opensensorweb.de) of Pikobytes on time
- Expression of interest by city of Mannheim

4.2 SHARE AND DISTRIBUTE SMART TOURISM DATA

Application Title:

SHARE AND DISTRIBUTE SMART TOURISM DATA
(region: Rhine-Neckar)

Application Description:

VRN ("Verkehrsverbund Rhein-Neckar") - a mobility intermediary in the MRN ("Metropolregion Rhein-Neckar") - would like to use this touristic place data, provided by the MRN GmbH, in order to distinguish itself as an end-to-end service provider for the organization of leisure time and as an intermediary for cultural offerings.

The SALTED project could extract the data from the MRN GmbH context broker, transfer it to NGSI-LD and enable therefor the implementation of an application leveraging the linked data approach.

The publication of the information as open data is also an offer to the creative industries in the region to develop attractive solutions to address end customers.

Value Proposition:

The SALTED application could bring different parties together and provide value to the broad public:

- MRN opens up new user groups for its data offering.
- SALTED gains new users for their application.

VRN provides its customers with valuable data

SALTED reference:

Integrates new data into the Scorpio broker. Gives incentives to new application developers to use new data. Broadens platform of companies knowing about SALTED, which could attract new interested parties.

Visualization of end user Frontend:

No own integration / set up planned yet. Bot on messenger portal could be used though as easy first user frontend.

Visualization of Data processed by the application:

For first glimpse of data from MRN see: https://contextbroker.digitale-mrn.de/entities

Acceptance criteria:

- Low-threshold availability of data
- Self-explanatory front end
- Availability of data for integration into other applications

4.3 MESSENGER AS A DATA PORTAL FRONTEND - CONTINUED

Application Title:

WHATSAPP – Chatbot – Topic: Location based news

Application Description:

WhatsApp-Bot is designed as a middle layer between WhatsApp and Scorpio, following the general concept of the Element / Matrix bot described above. This application uses WhatsApp as frontend for input and outputs.

Going one step further, this bot not only provides the POC for the WhatsApp setup, but also a new use case. For this setup news articles of the "Rhein Neckar Zeitung"[4] were uploaded to the scorpio broker using a private, not yet published, datamodel based on the DublinCore. The resulting entities within the broker not only represent the short summary of the news articles but also the location linked to them. With the WhatsApp-Bot, the user is therefor able to run real-time location-based queries on the news base within the scorpio broker. Given the location of a user, news articles in the user defined proximity are extracted based on keywords provided by the user.

Value Proposition:

This application offers yet another way to interact with the SALTED setup. Additionally, the application shows the added value by the linked data approach, that enabled the location-based news approach in the first place.

SALTED reference:

Integrated another messenger frontend, over which SALTED data can be used. It therefor contributes to the dissemination of the data over multiple channels. The POC further demonstarted the possibilities of the SALTED architecture.

Visualization of end user Frontend:

Location sharing and text message sending functionalities are provided by WhatsApp and WhatsApp Business API is used for integration. Communication is started by the user with a keyword or location information. The following shows an example interaction with the bot:

[4] Local news paper "Rhein Neckar Zeitung": https://www.rnz.de/

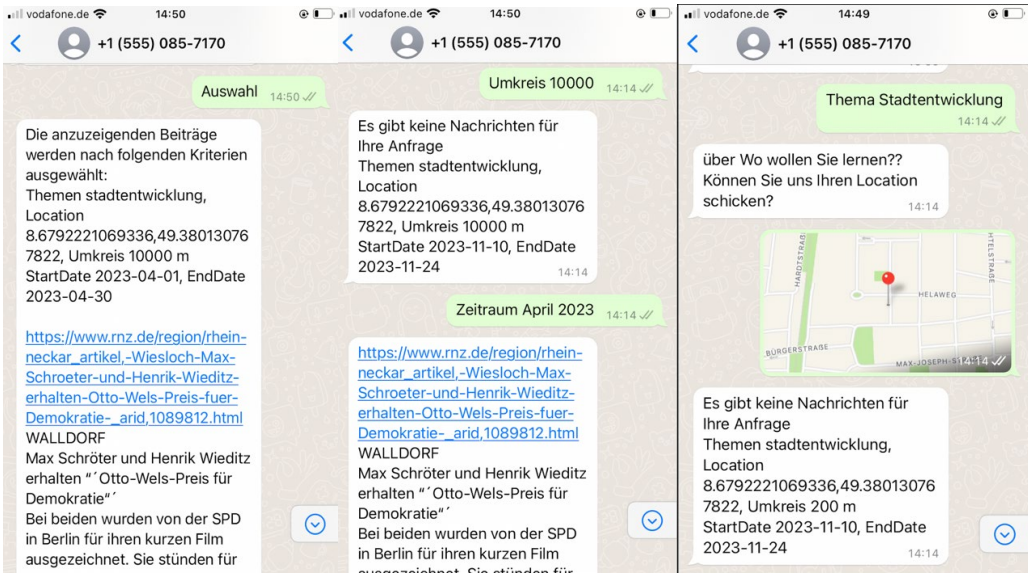


Figure 25: WhattsApp bot interaction

Visualization of Data processed by the application:

Application provides simple user-friendly frontend. With a keyword and location information, application runs a query for NGSI-LD entities near the current position and keyword-value patterns (see Element / Matrix bot described above in Figure 25).

Acceptance criteria:

- Relevant information from local media and the city administration,
- Simple and self-explanatory instructions for controlling the bot
- Linking to real places (e.g. with QR codes) to invite citizens

5 CONCLUSION

In conclusion, the SALTED project has successfully developed innovative smart city and smart agriculture applications reliant on the DET and linked data infrastructure of the SALTED project. The applications, such as **AGENDA ANALYTICS, LAND CROPS AND CARBON FOOTPRINT, CITY LIVEABILITY FLEXIBLE FRONTEND, MAUBOT FRONTEND** and **LD XPLORER** showcase the project's commitment to advanced technologies, open collaboration, and the democratization of valuable insights derived from public data.

The success of these applications is intricately tied to the DET, which serves as the backbone for data storage, retrieval, and interlinking. The NGSI-LD representation and query capabilities provided by the DET have played a pivotal role in enhancing the development of these applications. Overall, the SALTED project could showcase the possibilities arising from architecture centered around the NGSI-LD broker. But it also needs to be acknowledged, that potential updates to the Scorpio broker might impact the functionality of the developed apps, which underscores the need for a forward-looking development approach, ensuring that applications can adapt and capitalize on evolving capabilities (at least while the broker is under active development).

Looking forward, the SALTED project envisions growing added value by deepening the integration with different kinds of data (IoT sensor data, web data, ...), integrating new machine learning enhancements (e.g. leveraging the fast moving developments in natural language processing), and overall extending the amount of data processed, which acts a kind of catalysator. As the project embraces open-source principles, continuous innovation is anticipated.

6 BILIOGRAPHY

[1] SALTED, „D2.1: Report on Data Linking and Enrichment Architecture,“ 2022.

[2] SALTED, „D1.1: Report on semantic features extraction for heterogeneous data sources contextualization,“ 2022.

[3] SALTED, „D2.2:Report on data modelling and linking,“ 2023.

[4] SALTED, „D2.3-Report-on-Situation-aware-data-enrichment.pdf,“ 2023.