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Summary

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Glossary

All the specialized terms, acronyms or abbreviations used in this document will be collected below, in order to facilitate its reading.

Term	Definition
EFINTIS	Enhancing Efficiency of The Intermodal Transport Flows by Improved ICT Systems
KPIs	Key Performance Indicator - key performance indicator is a measurable value that demonstrates the effectiveness with which the main objectives set are being achieved.
ICT	Information and Communication Technologies

Premise

This document exhaustively describes the definitive project for the implementation of the EFINTIS pilot system, a telematic platform for environmental monitoring integrated in the port context.

The software platform created for **environmental monitoring is** able to collect, memorize and analyze environmental data (such as air, water, weather, etc.), acquire information from a network of installed sensors and databases in the field to provide, thanks to simulation models, the forecast of the dispersion of the main pollutants on the basis of weather forecasts and the state of the traffic that insists on the port.

Stakeholders

The roles for the system are defined below. Each role will be granted specific actions within the business domain.

Role	Description
Platform manager	It has access to the management part of the system and to the master data control of the entire system.
Port authorities	Anyone who needs to monitor the ships present in the port. He is allowed to view the ships on the map in real time. Furthermore, he can consult the registry of the boats.
ARPA Molise	Observe the air quality indicators to carry out preventive and/or conservative actions.

Software architecture and platform

The software platform of the system uses a microservices application architecture , capable of managing IoT protocols, performing big-data analyzes and creating the digital twin of the port context through the representation of the port on a 3D map with ships and systems of interest.

It represents the current situation of the port and of the ships, reporting the information relating to their status, effectively creating a convergence platform for the collection and analysis of data that can evolve over time thanks to the addition of new information sources.

The pilot system has been set up to collect and analyze useful information in order to evaluate the impact of port and support activities sea pollution analysis activities. The language to be used on the platform will be Italian.

Architecture

The architecture created is designed to be able to integrate with different external sources. The external sources of data are represented by the set of sensors, databases and information systems that generate the information used in the monitoring and analysis processes.

The pilot system is designed to horizontally acquire data from sensors, hardware devices, historical databases which can be integrated once installed in the field. The middleware architecture is explained below.

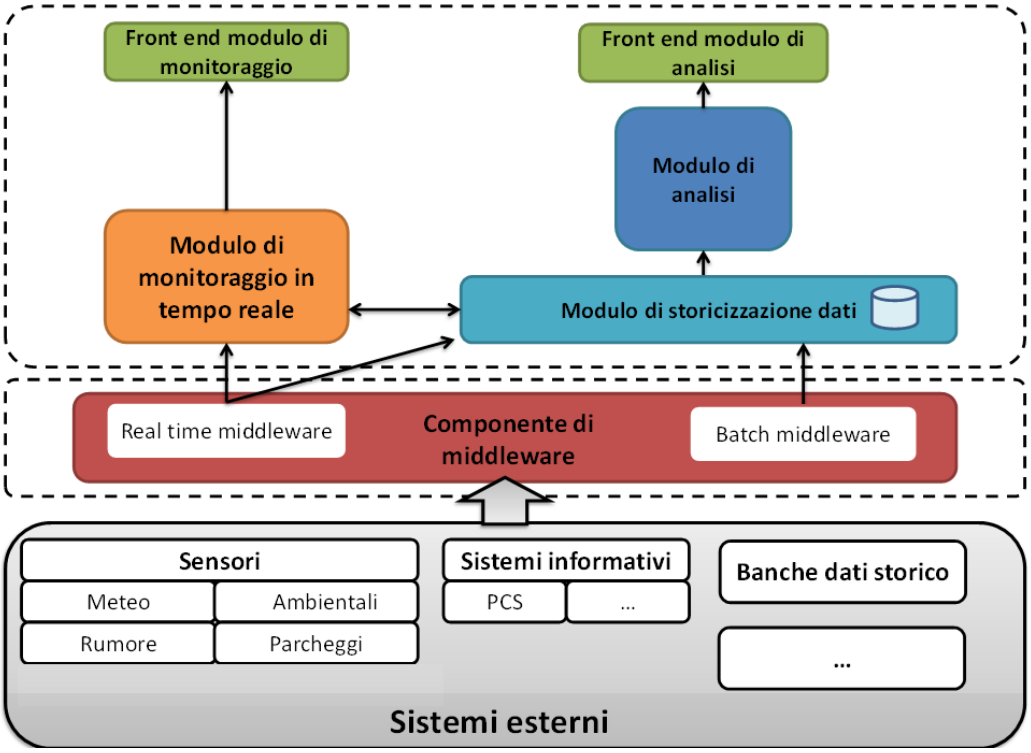

Figure 1– Middleware Architecture

Middleware component

The acquisition module is the middleware component responsible for receiving data from field sensors and external systems. The middleware component manages an intermediate layer between the external data sources and the central intelligence, making the heterogeneity of the various types of information received invisible to the latter. For this purpose, it implements , on the side facing the external sources, interfaces capable of homogeneously receiving the data coming from the outside.

The middleware component is divided into the "Real-time" subsystem and the "Batch" subsystem:

- the "Real-time" subsystem processes the data that must be managed in real time and transfers them to the logging module and to the monitoring module;
- the "Batch" subsystem handles the other types of data and transfers them to the historicization module only.

Central system

History module

It is the module in charge of logging all the data coming from the middleware component. It uses archiving technologies suitable for managing large amounts of data. It supplies the managed data to the modules that request it (monitoring module, forecasting module, analysis module).

The monitoring module takes care of the real-time monitoring of the domain to be controlled, based on the real- time data coming from external sources, in particular from the sensors, and on a series of predetermined rules, including correlation rules. The purpose of the module is to generate alerts following anomalous events that require operator intervention.

The *analysis module* works on data collected in periods in the order of weeks/months, and data from historical meteorological and environmental databases can also be used.

The front end of the analysis module offers the results of the search carried out by the module in a structured and readable way and also allows the insertion of any parameters on which to base the search.

Transversally to the various back end modules there are those of the front end. The archived and saved information is displayed in the web portal accessible via the most common browsers by system users, in addition to the 3D representation of the information.

Within a virtual 3D reconstruction of the port, the information will be contextualized with the exact georeferenced position of the data source. This type of reconstruction also makes it possible to virtually reconstruct the activities of the port in the near future real time, such as for example the arrival and departure of ships through the representation of AIS data (Automatic Identification System) .

Software platform: the integrated system

Figure Figure *2*– illustrates the high-level architecture of the data management web platform, it is a three-level architecture where each component of the system is implemented by a microservice or a group of microservices .

Presentation Layer web : it is a single page application built with HTML5 and the open source framework Angular . It is a framework for creating web- based user interfaces , provides building blocks to help you quickly configure a manageable and scalable application, allows you to create web applications to be enjoyed through mobile or desktop devices. The Layout is created using the Bootstrap framework which allows you to divide the system presented into reactive grids and extended pre-built components, it uses JavaScript plug-ins to improve the User Experience of the users. The layout of the web pages will be highly usable and will allow port operators to quickly carry out the desired operations; the responsive layout of the web pages will allow you to use the data management platform also on video walls or tablets or smartphones.

Presentation Layer 3D - It is built using the ThreeJS library which allows the creation of complex 3D scenes/animations by exploiting the graphics acceleration made available by a GPU (Graphics Processing Unit). A 3D environment navigation system is made available to the user. This system, in addition to updating the position in the scene based on the input, makes available specific events for each type of interaction with the assets loaded into the scene. This occurs by exploiting a communication bus to the web page within which the viewer is instantiated in order to notify the interaction event and giving the possibility of associating any type of side- effect .

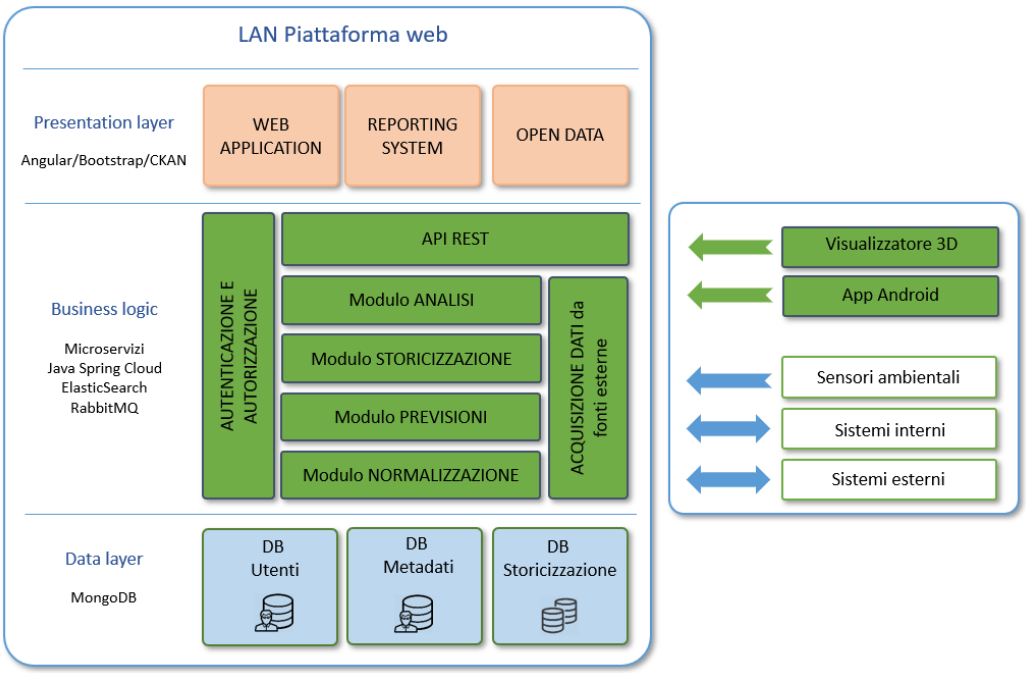

Figure 2– Architecture of the integrated system

Business Logic Layer - All microservices are built using the Spring Boot open source Java framework.

Data Layer : the database technology used in the proposed data management platform is MongoDB which is a document-oriented NoSQL database , based on the JSON format for storing and representing data.

Transversally to the various back end modules there are those of the front end of the real-time monitoring and data analysis modules. The archived and saved information will be displayed in the web portal accessible via the most common browsers by system users, in addition to the 3D representation of the information.

Within a 3D virtual reconstruction of the port, the information will be contextualized with the exact georeferenced position of the data source: for example, the possible environmental sensors are represented by virtual objects within the 3D reconstruction and are located in the same positions as their counterparts real.

This type of reconstruction also makes it possible to virtually reconstruct the port's activities in real time, such as for example the arrival and departure of ships through the representation of AIS (Automatic Identification System) collected through access to databases.

Pilot system functionality

The main functionalities of the pilot system are described in detail below:

- User authentication and profiling;
- Port Monitoring Main Dashboard;
- Weather data acquisition (wind/wave/pressure/humidity/temperature);
- Acquisition of ship data of interest for the port of Termoli;
- Presentation of maritime traffic situation on map;
- Historical data analysis of vessel movements;
- Carbon Footprint data analysis ;
- Management of linear and bar graphs for acquired/processed data;
- Dashboard with KPI indicators for CO2 management;
- Alert service for exceeding pre-established thresholds;
- 3D scenario of the city-port context and representation of moving ships;

System access

The data management platform offers user authentication and profiling functions. User profiles are used to filter the information that can be viewed and the actions that can be implemented by the various operators. The management of users and their privileges takes place through dedicated sections of the web application , with which platform managers can create new users and manage those already present in the system.

The port monitoring main dashboard

The system is characterized by a main Dashboard which shows the main information and the current status of the port. Vessels with detailed information and current weather forecast data.

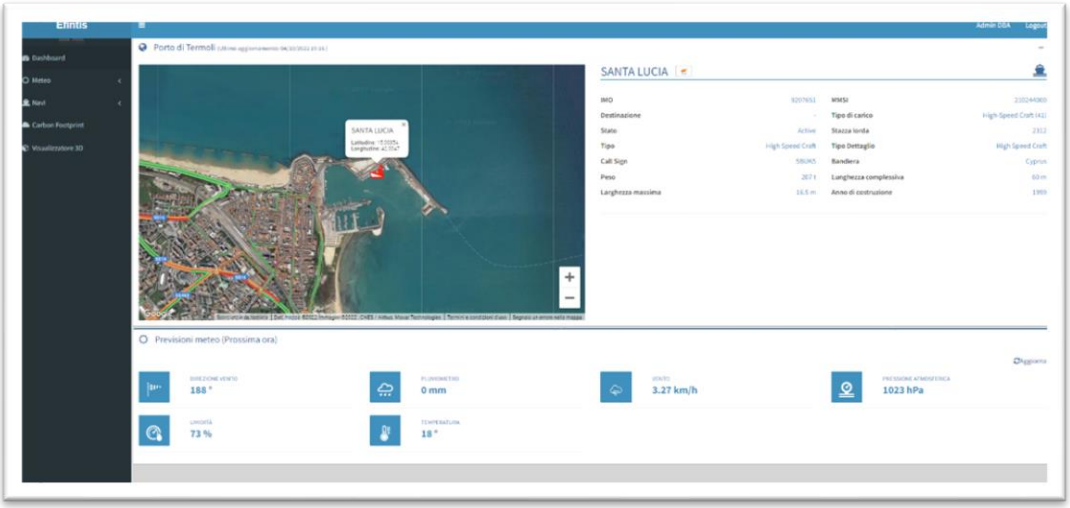

Figure 3– Main Dashboard

Forecast

Through the Arpa Emilia portal, the application presents the weather forecast data received on Termoli:

- *wind direction and intensity at an altitude of 10m above the surface and at an altitude of about 30m above the surface;*
- *atmospheric pressure at sea level;*
- *temperature and humidity at 2m from the surface;*
- *cumulative precipitation in one hour;*
- *solar radiation visible at the surface;*

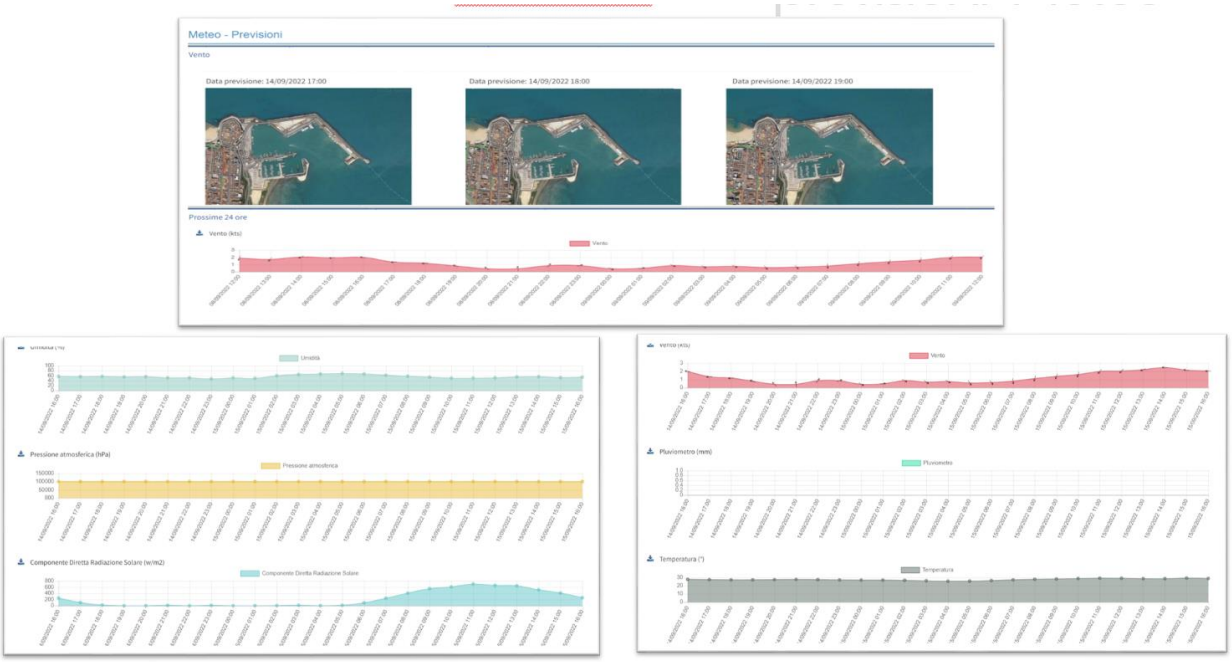

Figure 4– Weather Forecast

The application presents hourly charts for the next 24 hours. The graphs are interactive for the user. Through Meteo Data Analysis it is possible to make historical analyzes on the forecasts collected.

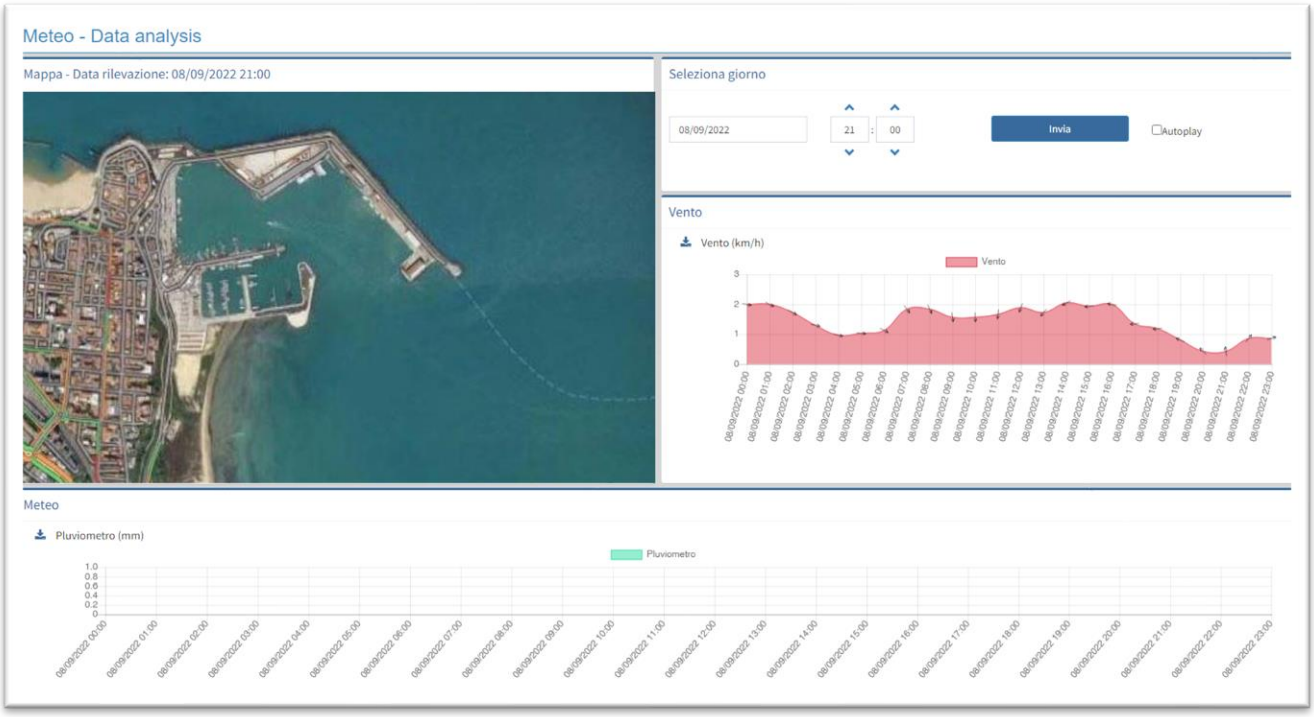

Figure 5– Data analysis forecasts

Ships traffic

This feature allows you to view the maritime traffic situation on a map within the web portal as well as on the 3D reconstruction of the port.

The 3D reconstruction allows the visualization, almost in real time, of the ships, represented through a catalog of models differentiated by type of vessel (e.g. fishing boat, ferry, cruise ship, etc.).

The position of the ships coincides with what is declared by the data collected by the AIS system through the interconnection to the database of the Marine Traffic service.

The user of the web portal and 3D can therefore analyze and view the situation of maritime traffic (fishing boats, ferries, etc.) on the map, as well as the registry of ships entering and leaving the port of Termoli.

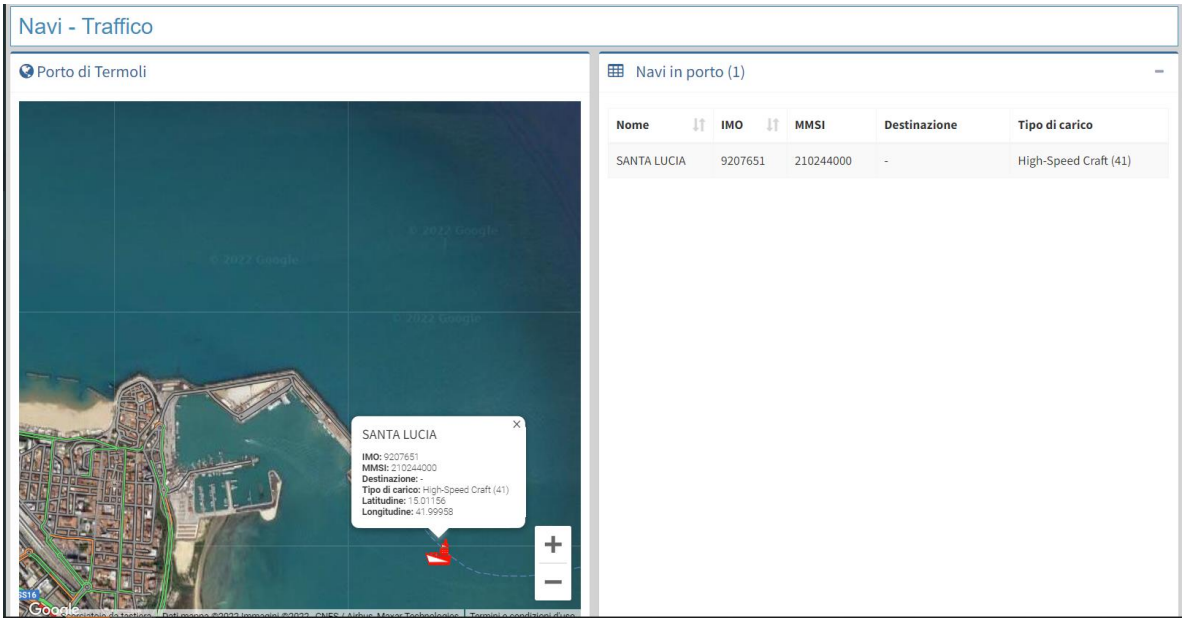

Figure 6– Vessel traffic

Vessel movement history

It will also be possible to view the history of vessel movements in the port, by selecting a past instant in time and reproducing the evolution of vessel movements for the period of interest in playback.

The service will allow for the analysis of the following parameters useful for monitoring the handling, mooring and stationing of boats: (*Figure 7*)

- date and time of arrival, departure and handling inside the port
- type of load;
- engine characteristics;
- gross tonnage.

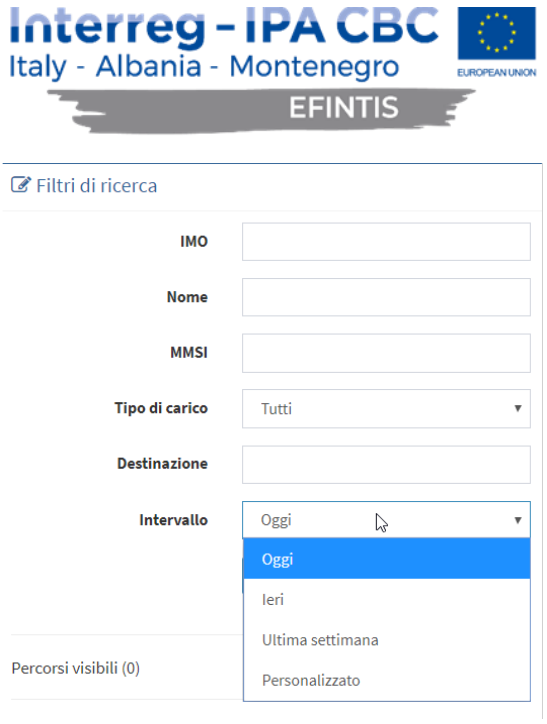

Figure 7 - Example of search form Maritime traffic module

The results will be expressed in tabular form and visible on the map.

Figure 8– Vessel search result – tabular representation

Figure 9– Vessel search result - representation on map

Reading data from external sources

The proposed platform is designed to acquire data from installed external sensors, if available in the port area. At the moment there are no sensors installed, it will still be possible to integrate sensors or other external data sources such as databases from other systems of interest when made available.

Data processing

The data acquisition and aggregation modules deal with the interfacing with the external systems of the platform, sensors, databases and information systems. The aggregation module is responsible for the data homogenization process in order to expose a uniform data model to the other modules of the system that is independent of the specific application context. The module is also capable of routing data to other modules in the system.

Through these modules, the system allows the integration between the different information sources and the various vertical modules, taking charge of the complexity deriving from heterogeneous data formats, processes and applications, and guaranteeing the decoupling of the internal modules of the system from the external context.

The data warehousing module takes care of data logging with particular attention to scalability and reliability requirements, in order to manage large data flows, guaranteeing data saving even under high load conditions. The module manages the available disk space transparently with respect to the underlying hardware, so as to facilitate any storage extension.

Calculation of the Carbon Footprint

The platform allows you to monitor the carbon footprint generated by the activities within the port.

The carbon footprint is a measure, expressed in CO2 equivalents (CO2e), which quantifies the greenhouse gas emissions directly or indirectly associated with a product, an organization or a service. CO2e expresses the impact on the global warming phenomenon of a certain quantity of greenhouse gases compared to the same quantity of carbon dioxide.

The emissions are differentiated by type of vessel:

- Bulk carriers
- Cargo ships
- Container ships
- Passenger ship
- Operating vessels

Figure 10– Example of representation for the carbon footprint in a 2D environment

The parameters that are used for the calculation of the CO_2 inside the port are the following:

- Sailing distance in port;
- Average load as a percentage of a vessel;
- The number of passengers on a vessel;
- Emission factor depending on the type of vessel.

CO_2 equivalent can be calculated based on user-defined ranges.

Line/Bar graphs

The data present in the platform can be consulted both in tabular form and through linear, bar or aerogram graphs.

Alarms for exceeding the threshold

In order to improve the monitoring of the port of Termoli, the system includes an alarm section, in which users can manage their own alarms for exceeding thresholds.

You can configure and receive email alerts for environmental data breaches within the port area. At the moment the thresholds are configured on the CO2 emissions calculated inside the port.

By integrating multiple sensors it will be possible to have a list of all the alarms generated by the platform and consult the alarms relating to the sensors under observation based on the threshold defined by the user. The list of alarms can be filtered based on the sensor and based on the time span of interest.

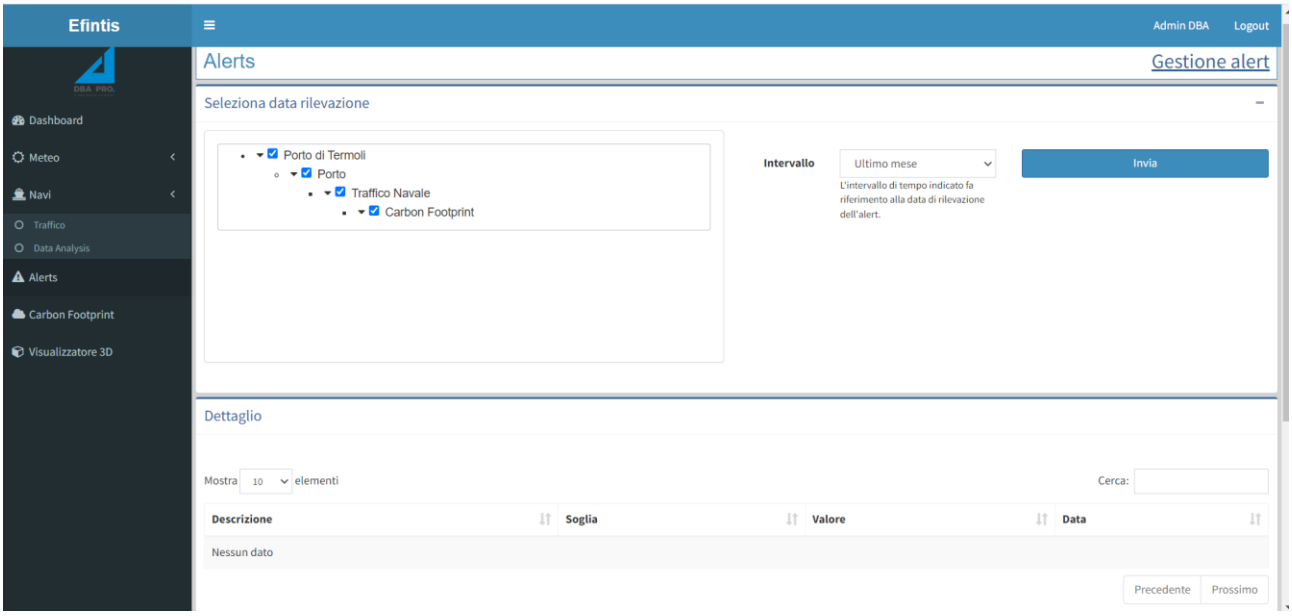

Figure 11– Example of alarm screen

The alarms are presented in tabular form in the "Alarm list" section.

Alarm rules management

In this section it is possible to manage the alarms created by the user.

All the alarms are displayed and on each of them it is possible to carry out actions such as modification and cancellation.

Also, you can add a new alarm rule via the “New Rule” button

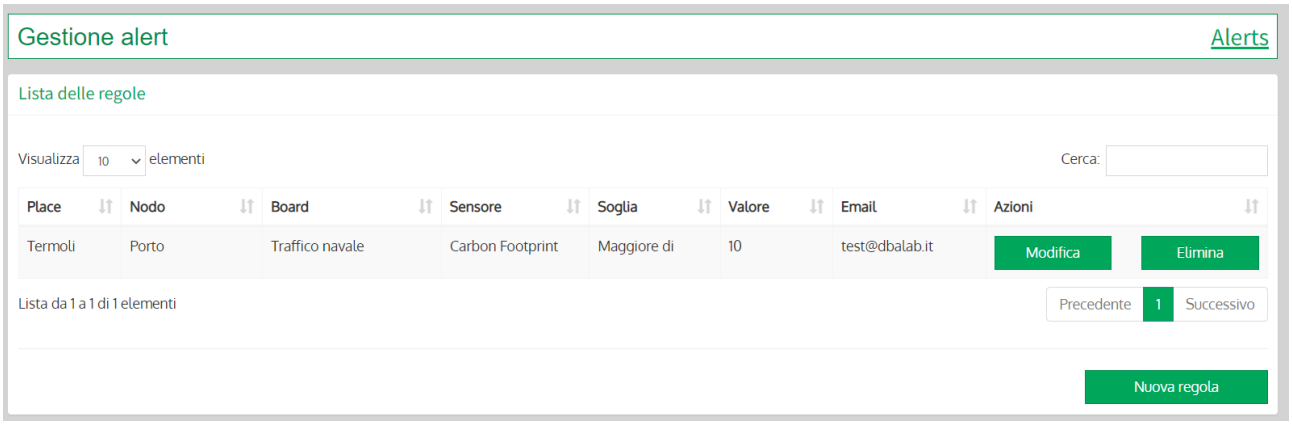

Figure 12– Example of screen relating to the list of set alarms

New alert rule

In this section it is possible to create a new alarm rule for exceeding the threshold.

The type of comparison that can be made is "Greater than" or "Less than" with respect to a pre-set threshold. In addition to the threshold value, the user can select the sensor (in the configured case) to be monitored by combining the fields: place, node, board.

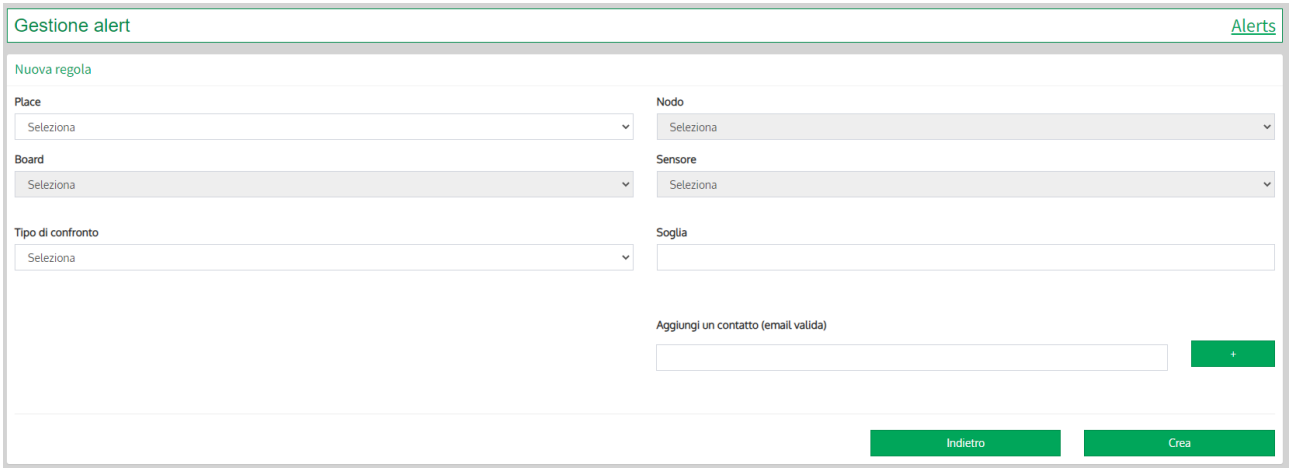

Figure 13– Example of new alarm rule screen

Editing alarm rules

In this section you can edit a previously created alarm rule.

All exposed parameters are modifiable, including: place, node, board, sensor, comparison type, threshold and contact email list.

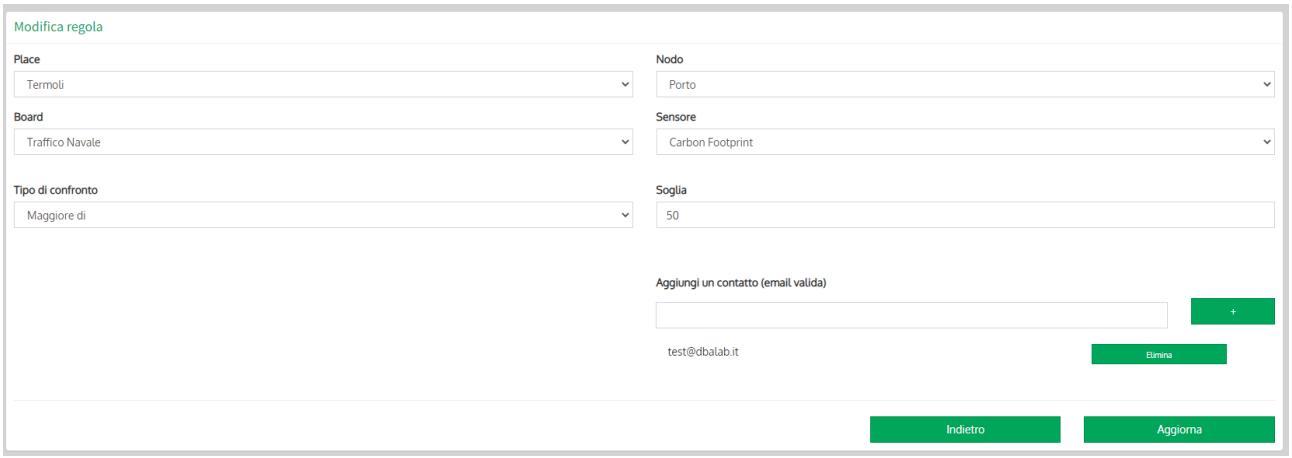

Figure 14– Example of alarm rule edit screen

3D-Viewer

The software platform is able to visualize the port through three-dimensional representation.

3D representation port city context

The 3D representation of the port of Termoli is interactive and navigable, including the piers and structures of interest within the port.

The user can navigate freely within the port through an aerial view or from predefined viewpoints. In the 3D scene, indicators of various kinds can be represented, including for example: the situation of waves and wind, weather conditions, positions of interest relating to environmental alarms, etc.

Ships and assets of interest can be selected to view detailed information.

Figure 15- Example of 3D representation of the port of Termoli

Ships model display

The 3D view of the port shows the moving objects, ships and assets of interest; these can be selected to display detailed information.

Non-functional requirements

RnF code	Description
RnF_1	Scalability towards external systems, i.e. the possibility of increasing hardware resources to cope with an increase in data sources and connected flows;
RnF_2	High availability of sensor data reception services to avoid data loss;
RnF_3	Horizontal scalability of information aggregation capabilities starting from large volumes of data;
RnF_4	High speed capture and storage of data streams from sensors;
RnF_5	Large data buffering capacity to allow processing processes to work at speeds different from the one with which the sensors produce the data;
RnF_6	Horizontal scalability of data processing processes from sensors;

External Data Services

Marine Traffic Subscription

The offer includes the subscription to the Marine Traffic service (https://www.marinetraffic.com/) which will be offered for a period of one year, to be renewed later by the Client.

The integrated service will make it possible to analyze the following parameters useful for monitoring the handling, mooring and parking of boats:

- date and time of arrival, departure and handling inside the port (this information can be
- inferred from AIS messages transmitted by vessels);
- navigation data;
- vessel characteristics;
- gross tonnage;

Arpa Emilia integration

For the weather forecast service, access to the Arpa Emilia-Romagna database (https://www.arpae.it/it) is offered for a period of one year, to be subsequently renewed by the Client.

The Arpa-Emilia-Romagna database is currently among the most reliable providers of weather forecasts, the data provided by this service are:

- wind direction and intensity at an altitude of 10m above the surface and at an altitude of about 30m above the surface;
- atmospheric pressure at sea level;
- temperature and humidity at 2 m from the surface;
- cumulative precipitation in one hour;
- solar radiation visible at the surface;

The data provided by Arpa-Emilia has a daily basis and contains hourly forecasts for the following 24 hours.

References

In support of the final software project, the manuals necessary for users of the portal will be produced. User manuals will be in Italian.