Managing and 3D Visualization of Real-time Big Geo-referenced Data from Las Palmas Port through a Flexible Open Source Computer Architecture

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Abstract: Nowadays, new technologies assist the capture and analysis of data for all kinds of organizations. A good example of this trend are the seaports that generate data regarding the management of marine traffic and other elements, as well as environmental conditions given by meteorological sensors and buoys. However, this enormous amount of data, also known as "Big Data", is useless without a proper system to visualize and organize them. Governments are fully aware of this and promote the creation of visualization and control systems that are useful to port authorities. In the line of management systems based on GIS, the SmartPort project has been developed. SmartPort offers a rich-internet application that allows the user to visualize and manage the different sources of information of a port environment. The "Big Data" management is based on the FI-WARE tools and architecture, as well as "The Internet of Things" solutions for the data acquisition. At the same time, the Glob3 Mobile SDK for the development of map apps will support the 3D visualization of the port's scenery and its data sources.

1 INTRODUCTION

A port is an environment that combines natural and human elements, that is extremely complex and dynamic and of great economic and social importance for coastal areas. Numerous activities of diverse nature take place in it, such as goods and travellers transportation or fishing as well as maintenance operations, rescue and protection of the natural surroundings.

The port authority is the body entrusted with the decision-making within the boundaries of the port, regarding all its activities and available resources. Therefore, it is of vital importance for this organization to have a system that allows the management, visualization and analysis of the elements present at the port just like all the natural ambient factors. Other examples of this kind of visualization platforms can be found, for instance, in other papers like (Georgas and Blumberg, 2010), regarding the data analysis of New York's Harbor and the environmental control of the Gdansk seaport conducted by (Kaminski et al., 2009). There are also

books in the bibliography about this specific subject such as (Claramunt et al., 2007) which lists several related projects and (Wright and Yoon, 2007) that presents a survey of many data types and their specific treatments.

In a general way, there are numerous sources of available data within a port area. They can be subdivided into two groups, depending on their nature. Human made resources and port activities. This group includes all the human elements within the port. These elements are important for the port authority that has to manage them and for the users of the port that could make use of them.

- Port infrastructure, buildings and maritime signals.
- Vessel's activities and positions. Routes and schedules.
- Available piers.
- Transported goods and passengers.
- Nearby locations of interest: Transportations, hospitals...

- Possible oil/trash spills.
- Emergency management assets.
- Road traffic within the seaport.

Natural environment. This second group includes both static and dynamic parameters of the natural surroundings.

- Surrounding topography and model of terrain.
- Bathymetric model and composition of the seabed.
- Water levels and tides.
- Ocean currents.
- Water salinity.
- Wave movements. Direction, frequency and height.
- Marine biosphere (presence of fish, cetaceans, seaweed...).
- Protected natural spaces.
- Meteorological measurements.

Personnel and rest of users will report the human activity, as well as vessel's sensors gather it. However, the natural data could be recorded in many ways as direct observation, field studies and mainly through sensors located on the port's surroundings.

The amount and variety of the recollected data makes necessary the use of "Big Data" techniques. "Big Data" is a quite new concept that involves the analysis of an organization data to leverage its intrinsic knowledge. This data should respond to the comprehensive definition given by the categories Volume, Velocity and Variety. Due to its scalable nature as well as the variety of its data sources, the SmartPort project fulfils the requirements to belong to this field. Regarding support systems for "Big Data" analysis other works on the area (Zhang et al., 2012) can be of great interest. In particular, the visualization of environmental data extracted of maritime areas has been the target of other studies (McCann, 2004) as there are many tools used in the bibliography (Talukder and Panangadan, 2009).

There are likewise a great number of possible roles for the users of the proposed application, such as sailors, port authorities, emergency management personnel, search and rescue teams, coastal engineers, or coastal scientists and oceanographers. For instance, sailors could be interested in tides, currents and maximum ship drafts while fisherman could need to know zones where fishing is allowed. The changing needs of any particular user make essential that an integral solution should be customizable.

The present project is named SmartPort and develops a visualization and management system for the data of Las Palmas de Gran Canaria's Port. This seaport, also known as "Puerto de la Luz", is one of the main ports of Spain and the first of the geographical area of West Africa. With more than 16 km. of docks this port serves as the crossroads between Europe, Africa and America.

The main idea is to display the current state of all the sensors available on the port's surroundings (nowcast) as well as their historical evolution. In addition, the system will show the geographical location of all the resources available to the port authority and the rest of users of the port and the routes of the nearby ships. Finally, SmartPort will support control tasks, through an alert management that monitors the value of many sensors.

Therefore, the first fundamental pillar of this project is the Future Internet platform of the European Community (FI-WARE) architecture (FI-WARE, 2014), a platform that allows the validation of new concepts, technologies, business models, applications and IF services in big scale. The University of Las Palmas de Gran Canaria as a partner of the FI-WARE project has the goal of developing innovative projects using this new technology. This platform belongs to the Program Future Internet Public Private Partnership (FI- PPP), which is a program of public-private cooperation in the field of Future Internet technologies funded by the European Commission involving more than 152 European companies and organizations (Villaseñor and Estrada, 2014).

The other pillar of SmartPort is the Glob3 Mobile virtual globe viewer developed by the IGO Software Company and the University of Las Palmas de Gran Canaria (Trujillo et al., 2013). This viewer provides all the drawing functionalities that our web user interface requires.

The main goal of this paper is not only to give an overview of the whole SmartPort project, but instead to be a guide for the development of any similar management system. We start with the functional requirements and data acquisition system established by the port authority of Las Palmas de Gran Canaria. From there, we outline the more relevant features and main modules of what we consider is a seaport management system that can be extrapolated to most seaport cases.

Section 2 of the present document explains the architecture and individual components of the SmartPort's back-end. Section 3 is an introduction to the User Interface and the project's front-end, specially the 3D viewer of the port. Finally, Section 4 state the achievements and final remarks of the project as well as some approaches to future work.

2 MANAGING REAL TIME GEO-BIG DATA THROUGH A OPEN SOURCE FLEXIBLE COMPUTER ARCHITECTURE

The SmartPort project was defined by a collaboration agreement between Las Palmas de Gran Canaria University and the port authority of Gran Canaria's Puerto de la Luz (Spain).

At that time, it was needed to gather data generated from physical sensors installed in the infrastructure of the Gran Canaria, Fuerteventura and Lanzarote seaports. The port sensors are connected to the Internet, a concept known as the Internet of Things (IoT). There are two types of sensors: the sea gauges and the meteorological stations, which generate big volumes of data.

Initial requirements focused on:

- Collecting the generated data.
- Analysing and processing the measurements.
- Visualize these data in a three-dimensional geospatial environment.

Apart from visualizing data geographically, a set of requirements was established. Some of those requirements were the visualization of the vessel's arrivals and departures and the alert management, which provides the possibility to create warnings when any sensor's measurements reach a determined value.

As a result of these requirements, SmartPort was developed. It is intended to be a web application, which back-end is implemented with FI-WARE, a group of back-end solutions.

The FI-WARE platform is based on utility modules, also known as Generic Enablers, that provide solutions of 'Big Data' analysis among others. The available data will be recollected and processed using 'Big Data' technologies, such as Hadoop. The data will be aggregated over time for their use in visualizations offered by the web front-end. This user interface will be based on a virtual globe, named Glob3 Mobile, displaying the seaport surroundings. All the data sources and other elements of importance will be placed within this 3D scene. The use of 3D on a web application makes this front-end a real Rich-Internet-Application (RIA) as some other examples on the bibliography (Kim et al., 2012).

2.1 Data Context

Starting with the data captured from the sensors, the Gran Canaria's Puerto de la Luz port authority allowed us to access to its database, where the latest values of the sensors can be read. The sensor's average update time is ten minutes.

Currently the Gran Canaria's Puerto de la Luz port provides the following data from Aandela Instruments series 3791-3798 series water level sensor and Geonica Datamar 2000C radar 26GHz sea level mareographmeter:

1. Significant wave height spectral moment of order zero. (meters)
2. Average height of the highest third of waves (meters)
3. Average height of 10% of maximum wave (meters)
4. Maximum wave height (seconds)
5. Average period of all waves (seconds)
6. Peak wave period (seconds)
7. Average pitch period by the upward zero (seconds)
8. Mean direction at the peak wave direction (clockwise arc degrees)
9. Scattering of wave direction at peak power (clockwise arc degrees)
10. Average direction from which the waves (clockwise arc degrees)
11. Directionality index (custom indicator)
12. Pressure of the water column above the sensor AWAC (decibars)
13. Orbital speed about AWAC sensor surface (meters per second)
14. Current direction on AWAC surface sensor (clockwise arc degrees)
15. Energy density spectrum for time series (spectral band)

The seaport also has meteorological sensors such as Geonica 41001 for temperature and air humidity, Geonica 05106 for wind speed and Geonica 52203 for rain gauge.

Once the sensors read the latest values, they are sent to the Orion Context Broker. Orion is an implementation of the Publish/Subscribe Context Broker GE, providing the NGSI9 and NGSI10 interfaces. Using these interfaces, clients can do several operations:

- Registering context producer applications, e.g. a temperature sensor within a room.
- Updating context information, e.g. send updates of temperature.

- Being notified when changes on context information take place (e.g. the temperature has changed) or with a given frequency (e.g. get the temperature each minute).

- Querying context information. The Orion Context Broker stores context information updated from applications, so queries are resolved based on that information.

Several Python scripts were set up to perform these operations. They take advantage of the Requests library, to simplify the HTTP (Hypertext Transfer Protocol) transactions. Thanks to this utility SmartPort is able to get a real time visualization of the port's situation.

Once data were available, it was developed a web application which shows the geo-referenced sensors in a three dimensional map.

It is important to mention that, in order to give the application a dynamic interaction with the data sources, the communication between client and server was developed making use of AJAX web techniques (Asynchronous JavaScript And XML). Thus, the front-end development was basically done in JavaScript.

Due to certain application components are available as "iframes" and they have the necessity to exchange information between them, an API (Application Programming Interface) that allows easy messaging exchange between "iframes" was created.

In order to find an agile development, instead of making direct requests to the Publish/Subscribe Orion architecture, an abstraction layer has been created to access the sensors information by GET requests to our servers. This intermediate layer enables us to preprocess the data so it can be sent in a friendlier and more compact format. In addition, they also help developers to withdraw from specific Orion aspects.

For instance, to get all the vessels data this query is generated:

```
http://<<IP>>:<<Port>>/orion/query.html?
sensorType=ship&sensorID=.&pattern=true
```

Another example is to get the meteorological sensors temperature with id 2001:

```
http://<<IP>>:<<Port>>/orion/query.html?
sensorType=meteo&sensorID=2001
&attributes=[temperature]
```

Another advantage of this new abstraction layer is the potential to take more restricted user control, making use of sessions and avoiding the well known stateless of the REST (Representational State Transfer) API's.

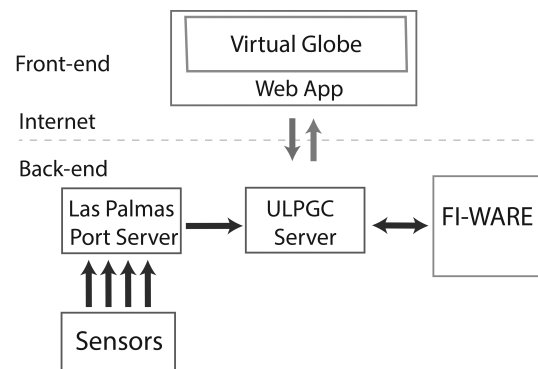The architecture proposed for managing the recollection of the data is shown in Figure 1.

Figure 1: General architecture proposed.

2.2 Analysis of Big Data in SmartPort

The next request functionality to be undertaken was the possibility to display the time evolution of the sensors data and even make an analysis on a given dataset.

For this purpose, it was decided to make use of the Big Data Analysis Cosmos. Cosmos is an implementation of the Big Data GE, allowing the deployment of private computing clusters based on Hadoop ecosystem. Current version of Cosmos allows users to:

- I/O operations regarding Infinity, a persistent storage cluster based on Hadoop Distributed File System (HDFS).

- Creation, usage and deletion of private computing clusters based on MapReduce and SQL-like querying systems such as Hive or Pig.

- Manage the platform, in many aspects such as services, users, clusters, etc, from the Cosmos API or the Cosmos CLI.

There is also a component called Cygnus in charge of receiving context data from Orion (Context Broker GE implementation) and storing it in a HDFS. This can be seen in Figure 2.
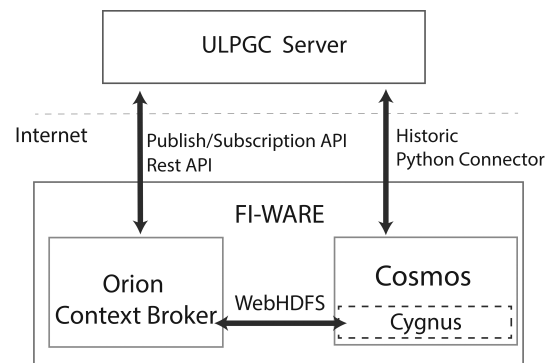

Figure 2: Proposed general architecture.

Firstly, Orion needed to be connected with Cosmos by Cygnus, that creates the connection with Cosmos and manages the data queue to be stored.

At this point, the historical data has not been yet stored. Orion works with a MongoDB database. For this reason, uploading all the data in chronological order to Orion and relying on Cygnus for sending the data to Cosmos, showed a poor performance.

The solution that was implemented consists in adding data to Cosmos using the WebHDFS API.

In the application front-end, for security reasons, the Cosmos instance was only accessible from some machines. For this cause, making requests directly from the client was dismissed. Thus, another abstraction layer was necessary.

The technologies and techniques used to process and store the data allow to achieve high data availability and ensure that the whole system is scalable. However, some technologies like Hive or Hadoop imply a performance trade off, as seen in Table 1. The proposed architecture minimizes the impact of these modules by integrating intermediate layers. This way the data transactions achieve the speed that the interactive user interface demands.

For the time series visualization, there is a wide range of web technologies and components available. It was decided to make use of the Highcharts library, developed by Highsoft AS, which covered our necessities. Specifically, the component stockCharts, seen in Figure 3, was used since these charts are perfectly adapted to our timing representation necessities.
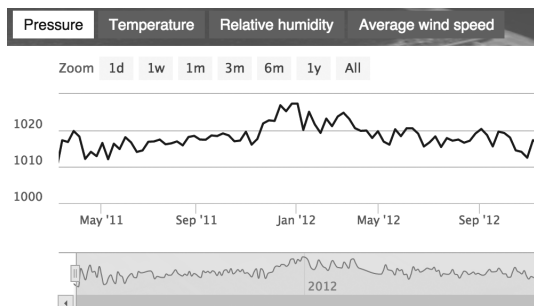

Figure 3: Historic chart showing pressure evolution over time.

It has been developed a set of intermediate layers that improve the performance of data analysis and retrieving. This enhancement allows creating on-the-fly sets of charts to show our historical data. These charts will be split into tabs showing all the data gathered by a specific sensor. A final business layer implements the logic that decides the sensor to be shown according to messages of other modules.

The requests are made by a Python connector that sends HIVE requests, using the hive_utils library, in a server with access to the Cosmos global instance. Once this connector is enabled, the requests are analogous to the ones that would be made to a MySQL database. From the front-end's point of view, the request is reduced to ask for a specific sensors data. An example is the following request that asks for all meteorological sensor data with id 2001.

```
http://<<IP>>:<<Port>>/historic.html?
sensorType=meteo&sensorID=2001
```

The data are provided in a JSON format (Javascript Object Notation). This format is almost ready to be used by the charts present in the front-end.

2.3 Enabling Data Alert Notifications

In addition, due to the huge volume of data to be considered, a system of alerts is a desirable functionality. This system must inform the user than certain values have reached given thresholds. For example, the emergency management system could use these alerts to take quick decisions on reliable and up-to-date data.

The Orion's API Pub/Sub covered all the needed functionalities to implement this system. A subscription for each sensor to be watched is created. Thus, whenever an alert is created, it is checked if a subscription to that sensor attribute already exists and it is made if needed. On the other hand, every alert with its activation conditions is stored in a database.

Finally, there is a service that receives the Cosmos subscriptions notifications. The front-ends shows a relation of the current alerts and gives the possibility to activate or deactivate them, as seen in Figure 4.

In the next section, it is described how all this data extracted from the seaport is displayed in 3D. With this purpose, the Glob3 Mobile map application platform allows us to create an interactive seaport scene, providing a rich and inmersive experience to the final user.

Table 1: Costs of a single record retrieval in microseconds.

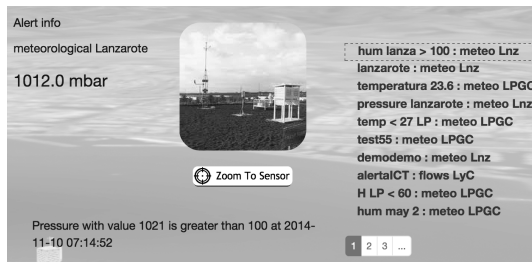| Time (µs)	MySQL	PostgreSQL	Hive
All meteorological data	3,03	4,99	59,51
One attribute sorted by date	1,55	2,53	74,83

Figure 4: Notifications and alert center showed when data reaches a prescribed margin.

3 VISUALIZATION OF GEOREFERENCED DATA

Modern web technologies allow us to develop rich 3D environments to display our georeferenced data.

Since the SmartPort Project was defined it was clear that the front-end of the application needs a viewer for the available georeferenced data. In a resource management system like SmartPort, it is important for the final user to spatially locate the existing items and data sources. This makes the application much easier for users that already know the port, and richer in content for those who don't.

Thus, the main element of the user interface is a virtual globe viewer. This element displays a 3D scene that represents the natural environment and the human-made resources of the port area. Within this scene, the application will locate three-dimensional and two-dimensional representations of the elements of interest.

The Glob3 Mobile framework (Pedriza et al., 2012), also known as G3m, was chosen to develop our virtual globe viewer, as it provides all the features demanded by the SmartPort's. G3m is a development API for map applications oriented to mobile platforms and the web. It is a project developed by the IGO Software Company in collaboration with the University of Las Palmas de Gran Canaria.

3.1 G3m Integration Architecture

The web-based version of G3m can be embedded as a web widget in our front-end. This element can be generated from a WebApp project, based on GWT and written in Java. This WebApp allows two main ways of interaction with the developer and the rest of the interface elements.

The G3m API and source-codes are available in Java. Therefore, the virtual globe is fully configurable from the initialization parameters of the WebApp code, setting different options as the desired imagery,

the navigation controls or the initial position of the camera.

It is possible as well to develop all the functionality required for our viewer in Java and to make it accessible to the browser through Javascript bindings. This allows dynamic behaviours of our virtual globe controlled by other elements present in the user interface. The G3m widget break down and interactions are shown in Figure 5.
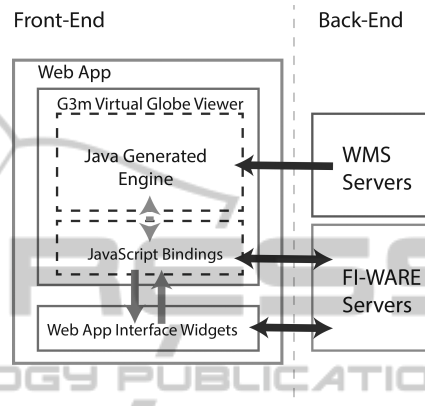

Figure 5: Main interactions between G3m, the rest of the UI and the back-end of SmartPort.

The main difference of G3m inside the open-source 3D maps community is its multiplatform approach. At this moment, the deployment methodology allows us to add new capabilities to the main engine programming in C++. These changes will be directly applied to all the platforms, meaning iOS, Android and Web.

Despite the current SmartPort user interface is built on Web, support of mobile platforms such as Android and iOS is a key step on future developments. Besides, G3m focus on mobile platforms implies a native support for multitouch interaction. Therefore, that multitouch interaction is integrated on our web front-end and can be used from devices with capacitive screens.

3.2 Online Terrain Imagery

From a functional point of view, the G3m engine should provide certain features to support the operational requirements of the SmartPort's user interface.

One key feature is displaying different layers of imagery over the terrain depending on the particular interest of the user. There are many ways that the georeferenced images could be fetched. In our case, it was decided to utilize the Web Map Service (WMS) protocol developed by the Open Geospatial

Consortium community. Using this protocol based on HTTP, it is possible to obtain imagery to cover our representation of the globe's surface. These images can be synthetic such as street maps, political maps, LiDAR (Laser Imaging Detection and Ranging) visualization or aerospatial photographies as satellite imagery.

In our case, the SmartPort viewer uses as general imagery source the Virtual Earth project. This image set is provided by Microsoft and covers the whole planet with high-resolution aerial photographies. However, an application aimed to represent the elements present in a port environment requires an even higher image resolution.

These images will be used as textures to cover the terrain tiles, composed by RTIN of 16x16 triangles (Suárez and Plaza, 2009). The tiling algortihm that determines the terrain representation given a certain camera position has been discussed on previous publications (Trujillo et al., 2015).

The surroundings of the Gran Canaria's port will be drawn using images fetched from a local WMS service. In this case, SmartPort uses images from GrafCan, a public company responsible for the maintenance of the geographical data of the Canary Islands. These two layers will form the default base image set that defines the appearance of the terrain on the viewer.

In addition to this base layers, the G3m system allows to merge these base images with other semi-transparent layers to enrich the information content. A WMS server can provide these added images as well. In this case, the SmartPort project allows the user to merge information from bathymetry maps, as is shown in Figure 6. These maps make easy for the final user to make well-informed decisions concerning routes or maximum draft of ships.

In addition, the system also provides by default a layer of natural spaces. These images can be
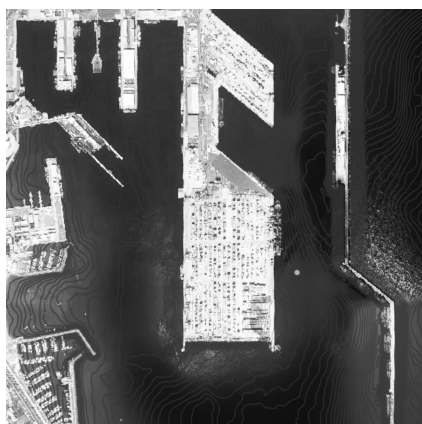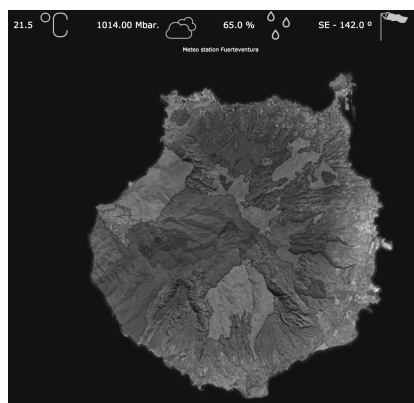

Figure 6: Bathymetry layer.

Figure 7: Natural spaces of Gran Canaria layer.

overlaid on the base imagery, showing important natural spaces in the surroundings of the port (see Figure 7).

The SmartPort project also allows the final user to fetch his own WMS services. The interface provides an easy-to-use dialog in which the user indicates the URL of the server and, automatically, the system gives him the whole list of maps that server provides.

The selected layers will be from then on available as thematic layers. These thematic layers can be merged on the base layers with a selectable degree of transparency.

3.3 Digital Elevation Model for 3D Earth Representation

An elevation model could seem not very relevant on a port control system. However, ports are often surrounded by mountains and other terrain features that make easy for their user to locate themselves and the nearby elements. This effect is remarkable in a mountainous landscape as Gran Canaria. Besides, the inclusion of an elevation model makes the viewer easier to use and much more visually attractive, as seen in Figure 8.

Using data extracted from LiDAR scanning, the terrain features surrounding the seaport is represented in an accurate way. That makes easier for the user to orientate himself within the 3D view and makes it more immersive.

In the case of Gran Canaria, it has been used a regular elevations map of 1000x1000 values to shape the island. This map is preloaded during the initialization of the user interface as a single file in Band Interleaved by Line (BIL) image format. This enables the system to be independent of any online elevation data server, which makes the changes on the terrain faster to perform.

Figure 8: Horizon landscape of Gran Canaria with an elevation model.

Figure 10: Aerial view showing most of the markers that the application can show.

The G3m system allows the use of multiple sources of elevation data at different resolutions. Therefore, the developer can use highly detailed elevations files only on zones of interest and use broader approximations on other areas. Furthermore, plain areas, such as the sea can be displayed without the need of loading any elevation data.

GPU's that avoids the need of maintaining a 3D model for each mark. In addition, the G3m SDK adds an abstraction layer that prevents the user from dealing with GPU's programming (Trujillo et al., 2014). This way, rendering numerous markers does not increase considerably the frame drawing time.

Respecting the generation of icons for the markers, the G3m project provides a multiplatform canvas API for the creation of these images. This API enables us to generate "on the fly" icons combining different images or even add text to them. Finally, G3m supports marker user interaction. This way the system is capable of determining whether the user is touching a given mark. Whenever a marker is touched the system alerts the rest of the system so it performs the corresponding action. In this case, the system shows a web informative dialog, describing the nature of the entity represented by the mark.

3.4 Plotting Thematic Information using Map Markers

Despite the 3D nature of the G3m environment, sometimes the clearest way to show an item's location within the scene is simply to use a 2D icon, or mark, located on a fixed 3D position. The reason to prefer a 2D marker can be that the element to represent is too complex or it is just a location to be pointed. Some examples of markers can be found in Figure 9.

Figure 9: The application uses different icons to point places of interest.

One of the functionalities of The SmartPort project is to show several points of interest that are located near the port. These points of interest are locations that the user may want to find on the map, so there is no physical representation for them. Besides, in a typical use there could be a significant number of markers on the scene, as seen in Figure 10, which need to be rapidly drawn.

The G3m rendering pipeline permits drawing thousands of markers at a suitable frame rate. It uses a billboarding technique (Wolff, 2011, Ch. 6, p. 192) based on the programmable pipeline of mobile

3.5 Three-dimensional Models

SmartPort also uses 3D models to represent important assets within the port area. These entities are the buoys and maritime sensors. The users can easily recognize these elements by their position and shape.

In the Gran Canaria example, they have been located five buoys in the vicinity of the port. Each one of them is represented by its own 3D model. The G3m engine allows the developer to use color models, as the model shown on Figure 12, or textured models and render them using light and shading effects, as seen in Figure 11.

As happens with the markers, it is of high interest that all 3D objects of the scene are selectable so it is possible to perform actions and display information as the user interacts with them. In the case of SmartPort for web, this interaction could be through using the mouse device or multitouch screens.

The implementation of this selection criterion

Figure 11: Image of a model representing a buoy and associated information.

Figure 12: Image of a model representing a meteorological station.

is based on bounding box hierarchies that allow computing efficiently the intersection problem. Once the object has been selected, a message to the rest of the system is sent. This way a certain action could be performed, as could be displaying data collected by the selected sensor.

3.6 Heads-up Display Interaction

As has been previously stated, the G3m engine allows multitouch camera control as well as mouse/keyboard navigation. These control mechanism are enough for positioning the camera in any suitable location that the user may want to visualize. This camera position is configured by its geographical location (latitude and longitude), its elevation over the terrain and the heading and pitch of the view direction over the terrain.

However, the mouse/keyboard control system could be unfamiliar to the user. In this case, G3m allows us to display 2D interactive widgets on top of the 3D view that allow the user to control the camera. The SmartPort front-end has added two on-screen

controllers that allow the user to manage the height of the camera, its heading and the pitch of the view.

The first one is a vertical scrollbar that makes easy to take the camera up and down through the planet vertical direction. From a zenith perspective, this scrollbar can be used as a zoom controller, as seen in Figure 13.
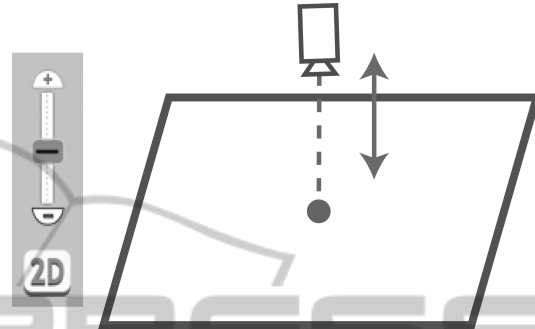

Figure 13: HUD Scrollbar camera interaction.

The second one is a dragging-ball widget that permits moving the camera direction in the same direction as the centre of the widget is dragged. The dragging direction has two components: X, which alters the heading of the camera, and Y, which affects the pitch of the current view. Figure 14 shows how this control allows the user to explore the scene from a static location.
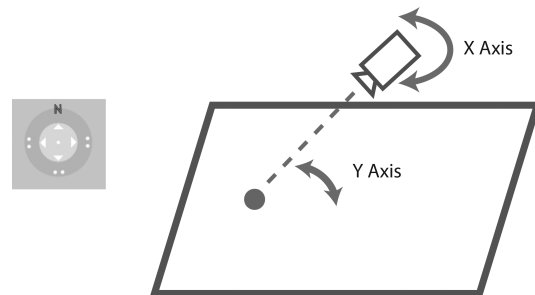

Figure 14: HUD Scrollbar camera interaction.

4 DISCUSSION AND CONCLUSION

The enormous amount of data generated by a regular seaport infrastructure is generally poorly used and often displayed through many channels. Due to this situation, most port authorities obtain a lesser benefit from their quite complex and expensive sensor networks. However, for the first time, it is now possible to process, store and show these Big Data environments so they can offer a truly added value.

SmartPort reveals itself as an integral tool to assist the analysis and control of all the data sources available for the Las Palmas Port Authority. The analysis offers a geospatial and temporal view of the recollected data, while the control is based on the alert management system. Despite there are some other ad-hoc solutions to the marine traffic and data analysis in port environments, our project adds a novel 3D experience in which the data displaying responds to the camera movements. Besides, SmartPort seeks to be an open project, offering and scalable and reliable back-end, a mutable data model and a highly customizable web user interface.

At the time this paper is written, the SmartPort project has been a successful development and it is about to be delivered to a real environment to play an important role in the decision-making process of the port authority.

At the domain study stage, we have fully examined the seaport's infrastructure to obtain a data model useful for the management of the port's resources. The biggest challenge however, was to offer a reliable, scalable and fast data treatment to support the user interface. In this sense, the Generic Enablers provided by FI-WARE offered us all the 'Big Data' needed resources.

On the other hand, Glob3 Mobile was a key element in the development of the front-end. Using latest WebGL technologies, it allows us to tailor a 3D user experience that was at the same time, interactive and customizable. This way the user is able to display the data he is really interested into and navigate through a representation of Las Palmas seaport. In a similar manner, the rest of the interface elements have been thought to offer the best user experience in terms of intuitive use and fast data visualization.

The main line of future work is the migration of the SmartPort to truly be supported on mobile handheld devices as smartphones and tablets, where Glob3 Mobile virtual globe has been proved and tested so far. Some other upcoming tasks are to keep improving the data transfer rates and usability of the user interface. Finally, some other features could be added based on the current available data, such as forecasting and automatic control systems.

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APPENDIX

Table 2: Index of Back-End technologies.

Name	Company - Author	Reference
Hadoop	Apache Software Foundation	http://hadoop.apache.org/
Requests Python Library	Kenneth Reitz	http://docs.python-requests.org/en/latest/
Hadoop Distributed File System	Apache Software Foundation	http://hadoop.apache.org/docs/r1.2.1/hdfs_user_guide.html
Hive	Apache Software Foundation	https://hive.apache.org/
Pig	Apache Software Foundation	http://pig.apache.org/
MongoDB	MongoDB, Inc.	http://www.mongodb.org/
Hive_Utils	Eventbrite and Contributors	https://pypi.python.org/pypi/hive_utils/0.0.1

Table 3: Index of Front-End technologies.

Name	Company - Author	Reference
HighCharts	Highsoft AS	http://www.highcharts.com/
Glob3 Mobile	IGO Software - ULPGC	http://www.glob3mobile.com/
Web Map Service	Open Geospatial Consortium	http://www.opengeospatial.org/standards/wms
WebGL	Khronos Group	https://www.khronos.org/webgl/