Horizon 2020

Societal Challenge: Improving the air quality and reducing the carbon footprint of European cities

ICARUS

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Integrated Climate forcing and Air Pollution Reduction in Urban Systems

D7.5 Report on ICARUS DSS transferability

WP7: Motivating citizens towards the vision

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1 Introduction

The ICARUS Decision Support System is a software solution based on modular architecture that combines several different technologies in the fields of IoT, SQL, NoSQL and spatial databases, data processing and WebGIS. In the present deliverable we summarize the requirements for the several environments, servers and other technologies that are used by the modules of the DSS.

The ICARUS DSS relies on significant amounts of data of different nature to operate. It needs geo-spatial data so that the models can be run, timeseries of measurements collected by the IoT and wearables and a database containing the information that are necessary for the administration of the system. The data that are currently stored in the DSS concern the majority of the countries of geographical Europe. On top of that, data of higher resolution as well as policy details and model execution results are available only for the cities participating in the ICARUS research project. A possible expansion to new geographical areas outside the countries that are covered, or the estimation of different policy outcomes in cities other than the those that participated in the project requires importing new data to the DSS. The information needed for this purpose is detailed in the transferability chapter.

2 Infrastructure requirements

The DSS has several components that are deployed in different environments, as it can be seen in the following deployment diagram. In the sections of this chapter we give the information relative to each environment.

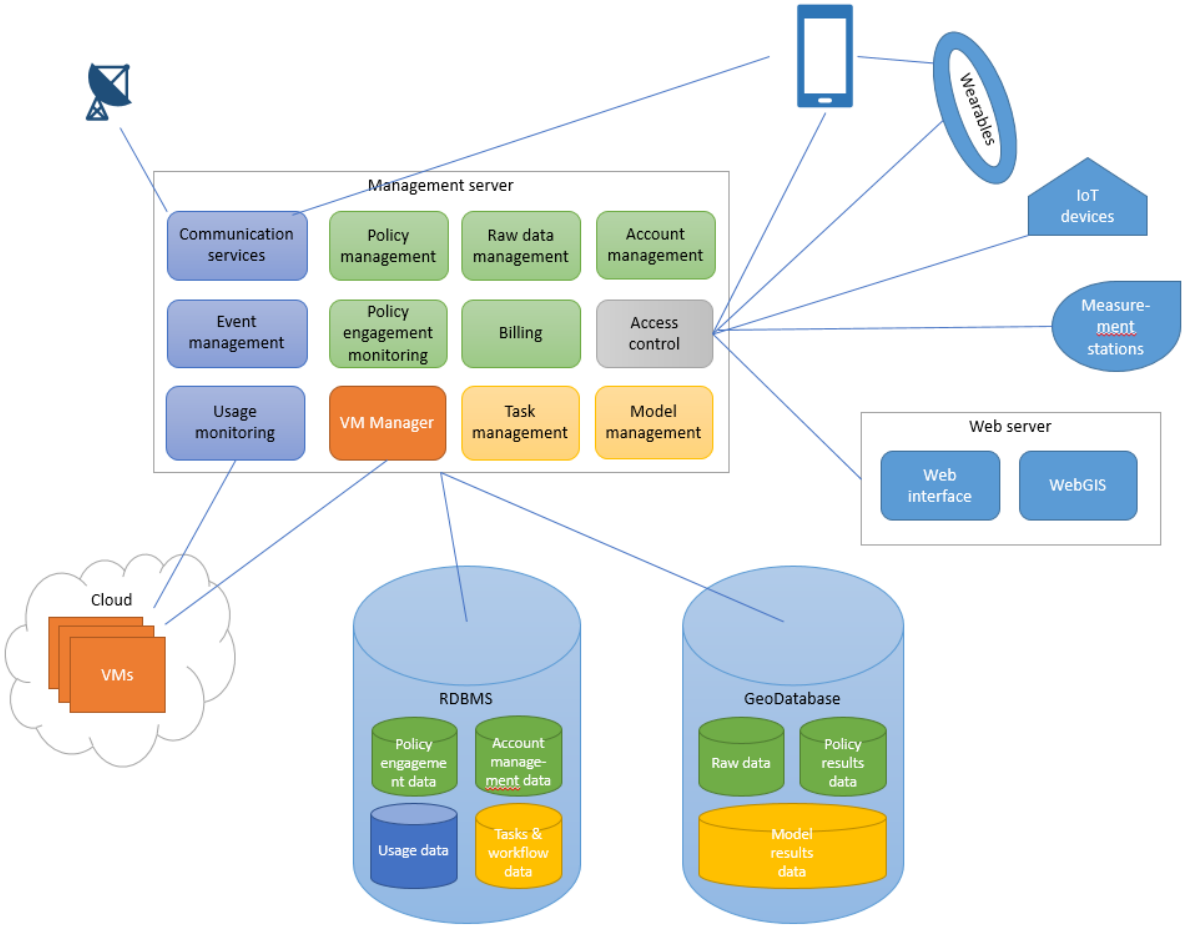

Figure 1: ICARUS DSS Deployment Diagram

2.1 Web Server

The Web Interface Application is developed using open source software (Spring Boot Framework and the Thymeleaf template engine) over virtual hosts on physical and cloud machines. Apache Tomcat and Nginx Server are capable with the specific configuration to perform high load of requests without consistency issues. Software development architecture is giving the opportunity due to layer independence to scale. The web server can be transferred as a whole in a new installation by using the minimum requirements as the current installation:

- Apache Tomcat version 7.0.67
- Java 1.8

- Thymeleaf 2.1.5

The DSS also uses a GIS server, which is a software installed on the web server. The GIS server used is Geoserver, an open source Java-based software server, that allows users to view and edit geospatial data. It produces high quality rendering of maps and can handle hundreds to thousands of map layers. It uses open standards set forth by the Open Geospatial Consortium (OGC), implementing the Web Map Service (WMS) standard and the Web Feature Service (WFS) standard, allowing for great flexibility in data sharing.

The version of Geoserver used is 2.14.2. For transferring the DSS in a new environment, the exact version is necessary to be installed, in order for the existing data to be incorporated without issues. With use of several configuration deployment can be tailored to fit in different environment without significant effort.

The machine on which those servers are hosted has the following characteristics:

- CPU 2 Intel(R) Xeon(R) CPU E5-1620 v2 @ 3.70GHz
- RAM: 8GB
- Storage: 50GB

2.2 Management Server

The Management server by design is the most easily configurable layer of the system. Micro-services architecture is giving the feature of expanding resources very easily by adding new virtual machines to scale up. Open source software is used during development so no cost is required in order to transfer the deployment to other servers. Pre-configured docker images are in place for hosting each service machine. With use of several configuration files deployment can be tailored to fit in different environment without significant effort. The Management Server is currently deployed on the same machine as the Web Server. Docker installation must be present in all hosts.

2.3 Database Management Systems

The need of a database to store all other information, different from the geospatial, made the team select a relational database. To be in line with the geospatial data and ease future management of the two databases, **PostgreSQL** has also been selected as the core RDMBS. Furthermore, a **Couchbase NoSQL Database** is used for the collection of the distributed user, IoT and other devices used by the ICARUS Project. The mixture of the two technologies, one RDBMS and a NoSQL database has been a successful choice from the development team in order to have parallel process of different kind of information. From the one hand the structured and precise data from the DSS application supporting the basic information model of the project and on the other hand the mass and unordered fluidity of the distributed external devices that must be stored in many formats. All installations have been made using virtual machines on physical hosts. Transferability of the system is very easy by using export capabilities of the two choices above.

2.3.1 PostgreSQL

As long as the data domain is the same at the target system no redesign will be further required.

The following phases might be performed for any new deployment:

1. **Testing**: The testing phase is where the database is tested and fine-tuned, usually in conjunction with the associated applications.
2. **Operation**: The operation phase is where the database is working normally, producing information for its users.
3. **Maintenance**: The maintenance phase is where changes are made to the database in response to new requirements or changed operating conditions, such as heavier load.

PostgreSQL requirements:

- Version: 11.1
- PostGIS extenstion version 2.5.1.
- Size: 1TB

For transferring the database to a new environment, the versions mentioned above or more recent should be installed for PostgreSQL and PostGIS. The existing data can be transferred easily with the use of tools offered by PostgreSQL, such as `pg_dump` for copying the database to a file and `psql` for restoring the database from a file.

In order to deploy the DBMS to another environment, network and firewall configurations must also take place.

2.3.2 Couchbase

Couchbase requirements:

- Version: 5.5.3
- Size: 1TB

As in the case of the PostgreSQL, network and firewall configurations must also take place.

2.4 Data Collection Devices

The DSS contains a RESTful API that allows for the acquisition of data from several different platforms, that include portable/wearable (through a mobile application or not) and stable measurement stations. The data sent to the DSS are stored in the Couchbase NoSQL database. Currently, data can be acquired from the following three solutions:

- **uHoo:** Data are acquired from the uHoo API by pull requests initiated by the DSS and stored in the Couchbase in the form of JSON objects. The device currently supported is uHoo Air. In order for other devices to be supported, the API must be extended.

- **Garmin:** The current implementation supports the acquisition of data collected by the Garmin Vivosmart device via Garmin Health API version 2.6.1. For this to work, a new application has been created within the Garmin Health API portal and configured to access the endpoints of the DSS that have been developed for this reason. Contrary to uHoo, Garmin Health API pushes the data to the DSS API via HTTP requests as long as new datasets are produced. Currently, endpoints exist for Garmin Dailies, Epochs, Sleep, Stress and MoveIQ summary types. In order for new summary types to be supported, new endpoints must be developed in the API.

- **IoTech Portable PM Sensor:** Data are sent by the IoTech server to the ICARUS DSS and stored in the Couchbase in the form of JSON objects.

In order for the DSS to support other devices of the same provider as well as other providers, new functionality will need to be added in the DSS API. The acquired data will be stored in the Couchbase as well.

3 Transferability

The ICARUS DSS is currently operational and populated with information on:

- **Landcover:** A file with the 2012 Corine Land Cover for all Europe, in raster format, presented according to the official Corine Land Cover legend.
- **Top down Emissions:** Emissions per sector and pollutant for the years 2015, 2020 and 2030, in vector format. The emissions are generated for each cell in a 1km x 1km grid, covering all Europe.
- **Population:** The population, as persons per cell in a grid of 1km x 1km cells, covering all Europe, in vector format. The grid is different from the one for emissions.
- **Administrative jurisdictions in 2 to 5 levels:** Different layers for each level of administration for all European countries. Each country is divided in 2 to 5 levels. The data is in vector format.

Those data cover the following countries:

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

For the cities participating in ICARUS (Madrid, Basel, Stuttgart, Milan, Ljubljana, Brno, Thessaloniki, and Athens), we have the following data:

- **Road Network:** Road network with specific classification of roads, distinguished in 27 categories.
- **Bottom up Emissions:** Emissions per sector and pollutant for the years 2015, 2020 and 2030. The emissions are generated for each cell in a 1km x 1km grid.
- **Policies:** Names and descriptions of 3 to 5 policies for each city.
- **Policy emissions:** Emissions per policy, sector and pollutant for the years 2020 and/or 2030. The emissions are generated for each cell in a 1km x 1km grid.

3.1 Expansion to other cities/regions within the existing countries

In order for new cities in European countries to use the DSS, some data are necessary to be imported to the system. These are the road network and the characteristics of the new policies to be evaluated. Bottom up emissions are also suggested to be added for more accuracy, in comparison with the top down emissions already available for all Europe.

The road network should use the common classification and have the same fields and field names as the existing data. The bottom up emissions, if provided, should be spatially distributed to the 1km x

1km grid used by the DSS and have the same fields, field names and units of measurement. Specific instructions, as well as a reference file will be provided by the system for both the road network and the emissions.

The above spatial data should be provided by the user in shapefile format, in **WGS84 coordinate system**.

The new policies can be introduced with the use of a user-friendly and intuitive interface, which offers the user different tools to construct the policy. These tools include:

- Selection from predefined lists, for instance the sector that the policy concerns, such as transport, energy etc and the item that will be changed, like cars, bicycles, firewood etc.
- Numeric data input for changes, such as percent of reduction or increase in an item and target years.
- Definition of areas and zones on the map where the policy will be applied.

3.2 Expansion to other countries

For countries outside Europe, except the data mentioned above, a few more data is necessary to be imported to the system. These are the administrative jurisdictions and population.

When a new country is introduced to the system, the first data necessary to be imported are the administrative jurisdictions. These will have to include the different levels of administration for the whole country. Different files will have to be uploaded for each level and each lower level will have to include information of the upper levels it belongs to. The fields and field names should be the same as the ones used by the DSS. A reference file will be provided by the system. The data should be topologically correct and the lines of the polygons should be generalized to approximately 100 - 400 meters, depending on the area, for faster performance of the system.

The population of the area will be provided in a grid format for the whole country. A grid will have to be introduced, which is suggested, but not necessary, to be 1km x 1km. The fields and field names should be the same as the ones used by the DSS. A reference file will be provided by the system.

The administrative jurisdictions and population will have to be provided in shapefile format, in WGS84 coordinate system. These files will be inspected and approved by an administrator, before the user is allowed to enter new policies.

After the above country data are approved, the files for the emissions and the road network will have to be provided for the area of interest and the new policies constructed, as these are described in the previous chapter.