**VIRGO**

An Innovative Virtual Registry of Underground Infrastructure on Cloud

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**Abstract**—The purpose of this paper is to describe the research activities and recognize the realization of a European virtual registry of underground infrastructure on cloud. In order to create a harmonized virtual registry of infrastructures at European level, the research intends to develop procedures for the preparation of maps and regulatory provisions as well as the main cloud registry. The infrastructure will be realized and deployed through a standard system for all users and for all European countries, in order to store, manage data in a unique place and create a registry on cloud of networks with related services. The registry will also be realized in several pilot areas, characterized by a high density of heterogeneous infrastructures and by factors that may be representative and compared to different types of areas characterized by a large number of utilities registered (electricity, gas and telecommunications). The detailed knowledge of existing underground infrastructures will allow a rapid economic of innovative organizations and the development of new ultra-broadband services for effective smart cities in EU.

**Keywords**—innovative services; cloud; automation and innovation; change management; integrated information systems; ICT adoption; underground inventory; smart cities; public sector

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**I. INTRODUCTION**

The aim of this article is to describe the VIRGO project, focusing on the objectives, the implementation, the expected impact and the results of it. The European VIRGO project has been financed in the field of the Competitiveness and Innovation Framework Programme (CIP) (2007-2013). It involves 12 partners (Infratel, Ericsson, Lombardia Region, Italdeta, Aemcom, EDP Energia Distribuzione, Portgas, Intergraph, the municipality of Brasov and Porto and universities Tudor and plus) and the activities started on January 2014, with a kick off meeting that allowed the various partners to coordinate and plan the future activities for the realization of the project in the next 3 years. The main purpose of the VIRGO project is to create a digital registry of infrastructures, in line with the INSPIRE European Directive and the new Directive 2014/61/EU of the European Parliament and of the Council of 15 May 2014. It is oriented to reduce the installation costs of high speed communications networks, capable of supporting the government in the census of available infrastructure, considered an indispensable tool for the development of smart cities. This project consists on the implementation of a cloud virtual registry of utilities infrastructures in order to offer aggregated and innovative services [1] to several target groups, on line with the focus of “test and validate a set of cloud-based services in view of wider deployment of such public services and, in particular, to prepare the migration by public authorities to cloud computing based solutions to deliver online public services”. At the moment, European countries are not obliged to dispose of a registry of under – on – aboveground infrastructures, this is mainly due to the fact that there is no legislation to oblige the countries to create and update such registry. The lack of a harmonized, standardized and European (virtual) registry of infrastructures generates several specific problems faced by public administrators, private companies and citizens, as synthesized below:

- **Public administrations**: daily management of the infrastructures either for the regular maintenance of all the various utilities infrastructures and for extraordinary works related to the infrastructures as well as more specific management issues, such as problems related to who does what. Problems faced by the public sector start from preparing and monitoring [2] the tenders for the regular and extraordinary management of the infrastructures to the actual monitoring of the efficiency and efficacy of the various infrastructures guaranteeing that the services are promptly delivered to citizens and companies;

- **Private and public owners of the infrastructures**: energy, water, telecommunication, and utilities, as well as third parties carrying out the regular and extraordinary works to the infrastructure: geographical localization of the infrastructures, i.e. they do not know where the infrastructures are placed and are obliged to recur to alternatives means to find the underground infrastructure;

- **Citizens**: not having transparent indication on what infrastructures actually reach their household and therefore, may not compare and choose the private company for the utility, which is not in line with the liberalized market (including also the energy-liberalized market).

The goal of the VIRGO project is to achieve of a virtual registry of infrastructure on cloud, in several European countries to be adopted throughout Europe. The under infrastructure will be realized through standardized system for all users and for all countries in Europe in order to store and
manage data in a unique European manner. The project intends to develop procedures for the preparation of detailed maps and regulatory provisions, in order to create a registry on cloud of the networks of the infrastructures and related services. The registry will also be realized in several EU pilot areas, characterized by high density of heterogeneous infrastructure and by factors that may be representative and compared to different types of areas Union: Italy, Portugal and Rumania characterized by the number of utilities registered (energy: electricity / gas, telecommunication). Therefore, the pilots will have the following characteristics: geographical coverage, mono or multi-utilities and type of utilities included. The main outputs and results of the project will therefore be:
- an overall knowledge [3] on how infrastructures are managed and the overview of the relative legislation in each European countries;
- an harmonized structure for a European virtual registry on cloud;
- guidelines to the various private and public stakeholders on how to implement a local/Regional/National European virtual registry on cloud (addressing the private company owner of the infrastructure as well as the governmental institute responsible of the national infrastructures);
- a white book for National/European legal framework to make the European virtual registry on cloud compulsory [4] in all countries;
- the implementation of a virtual registry on cloud in 3 European countries (Italy, Romania, and Portugal) through a pilot project and all the resources [5] needed to manage it;
- a well-defined and tested structure for a European virtual registry on cloud to be adopted in all European countries.

II. MATURITY OF THE SOLUTION AND EXPECTED OUTCOMES

The Virtual Registry of Infrastructure is the first implementation on cloud that delivers services (in absence of harmonized and standardized processes across European Union) related to infrastructure data. Therefore, it has to be considered a System Integration project based on the usage of standard products already available on the market. The solution is based on a Cloud platform that will provide services built on the following main architectural layers:
- Security layer: aim of this component is to ensure the protection of the data (not only infrastructure data) and guarantee that only authorized users can access and used the platform according the users’ profile [6] defined during the registration phase and the governance needed;
- Presentation layer: aim of this component is to host the presentation tier. A user web portal will be used for user managements and service catalogue purpose;
- GIS layer: aim of this component is to manage the geospatial data for all the infrastructures. The layer will public Inspire compliant data;
- Data layer: aim of this component is to acting as repository for all the data (GIS, business data, personal data);
- Network engineer: a standard product for planning and infrastructure data management;
- Business layer: aim of the component is to manage all the workflows for the infrastructures management. This layer offers APIs for the interaction with external system. This layer [7] offers also a communication platform to connect Public administrations, utilities and citizens (Fig. 1).

![Fig. 1. An overview of the interoperability of the VIRGO solution and the interfaces.](image)

VIRGO is a 36-month project addressing in general the EU policy priorities of the Digital Agenda for Europe. It will deliver, as its main output, the creation of an ICT interoperable [8] open-data cloud-based platform for the virtual registry of utilities infrastructures containing digitalized and standardized data on the various utilities mapped and registered in the platform, initially energy (both gas and electricity) and telecommunication to be then exploited also through the integration of further utilities. As the aim of the project is to create and implement an “European” virtual registry, i.e. a registry tested in three countries but built on an European
analysis of the state of the art (including best practices and user cases) in order to be replicable in all European countries (with common, standardized standards, methodologies, etc.). A real European dimension is needed therefore to build a registry with these characteristics. The impact of VIRGO by the end of the project will be:

- increased usage of cloud computing by public services: the pilot will develop a full business case for public administrations [9] to migrate to the new architecture. In fact the virtual registry will be built and managed entirely on cloud and the various public authorities will then have to implement and further manage the registry thus use a cloud-based ICT system;
- more agile, trusted and transparent administrative services: the registry will be based on open-data and will therefore be available to all stake holders;
- increased new services offered using public information and services: the virtual registry will integrate and aggregate services already offered with new service thanks to open-data and operability of the system;
- increased use of innovative architectures that can be used and applied across different legal environments in order to demonstrate that the aggregation of services works also across border.

The virtual registry will be built using an innovative architecture [10], which will enable its exploitation and take-up in all European countries as a registry of the market [11] of the ground infrastructures. Further its structure and architecture may be transferred as a registry of other geographical, characteristic and mixed data enabling its deployment not only across borders but also in different sectors and legal environments;
- establishment of common strategies, methodologies, standards and certification for delivering user-driven, innovative cloud-based services through “open” platforms;
- improved capabilities for ICT companies and SMEs in general towards developing, validating and scaling-up new services.

The pilot actions within the VIRGO project will last at least 12 months and foresees the following phases:
- digitalization, standardization and harmonization of the infrastructure data in order to satisfy the criteria and conditions of the registry data;
- data entry within the virtual cloud registry;
- delivery of the new services to public authorities, private / public companies and citizens;
- monitoring of the delivery of the offered services and collection of inputs from target users on the efficacy and usefulness of the registry, including also possible suggestions on how to improve the services offered or insert new ones, as well as on the technical issues related to the friendliness [12], including suggestions on how to improve and make the registry a user-friendly tool adapt to all citizens also those which are less technologically educated;
- optimizing and defining the cloud virtual registry of the infrastructures according to the inputs received during the testing phase.

**III. SCIENTIFIC AND TECHNICAL APPROACH**

The goal of the scientific and educational dissemination is to bring the ICT features to key actors of the ICT market, to promote the acceptance of the developed solution also in other sectors and legal environments and to promote a multi-disciplinary vision of ICTs as cross-section with human resources [13] in the business environment. This type of dissemination covers the elaboration and production of scientific and technical articles, papers, posters and oral presentations under relevant international conferences, symposiums and workshops. The main criterion for the target selection of this dissemination will be the subject, taking into account journals and conferences with high-relevance in the domain of cataloguing and weighting multilingual cross-media information, ICTs and human-technology interaction and those that have a strong impact on scientific community and society. The VIRGO work plan includes three phases for the registry preparation in order to be easily immediately exploited and used after the end of the project by the partners as well as other stakeholders from other European countries. Within the duration of the VIRGO project, the virtual cloud registry will be:

- defined and structured building on the actual state of the art of existing solutions (analysis; Wp2 and Wp3);
- realized and implemented according to the results of the previous phase and to the iterative feedbacks from users and targets [14] involved in the all design, testing and valorization processes (implementation; Wp4);
- validated through a wide testing & evaluation processes, that will allow an extensive data entry in the virtual registry and service delivery to the various target groups and its fine tuning for sustainable exploitation (pilot project; Wp5 and Wp6).

The project architecture is then completed and sustained by specific communication processes (dissemination - Wp7 and exploitation - Wp8), transversal to project activities and aimed to assure an effective, wide and sustainable valorization [15] of project goal, results and resources.

Consistently, the project plan is organized in 8 self consistent and interrelated work packages, over a total period of 36 months, to achieve the best potential amount of results.

**IV. PRIVACY, INTEROPERABILITY AND STANDARDS**

The VIRGO project is designed to be an innovative cloud application and will use a mix of proprietary and open solution in order to get the maximum efficiency for what concerns Security, privacy, inclusiveness, interoperability and economic benefit derived by the usage of open-source software. The interoperability aspects of VIRGO are guaranteed through:

- the GI network infrastructures data are INSPIRE compliant (core data set D2.8.III.6);
- the adoption of standards (OGC, INSPIRE) to manage the GI network infrastructures data (i.e.: WFS, WMS, CSW).
Within the VIRGO project, the following products have been selected: Network Engineer, a geospatial environment for the comprehensive design and management of the networks [16] and the inventory. It represents a powerful extension of the ESRI ArcGIS™, platform used to document and design an end-to-end standard [17] model of all network elements. It also facilitates seamless data integration between systems on the network including provisioning and service assurance systems.

An open-source workflow manager used to design business process and implement cloud services according to the SOA principles has been identified as the best open-product to reach the interoperability target. The VIRGO graphical user interface careful designed for intuitive usage (based on type of access and available services) in combination with the Cloud infrastructure will ensure the inclusiveness maximizing the user-experience. A web application, developed using a responsive web template adopting the standards HTML 5 and CSS3, will guarantee an access from any device having an Internet connection. For what concerns security and privacy aspects, two main data categories will be managed within the VIRGO solution:

- **Personal Identifiable Information (PII):** used to identify, locate and contact a single identity (e.g. citizens). An example of PII data are:
  - full name;
  - country;
  - state or home town;
  - age;
  - gender;
  - email address;
  - national identification number;
  - IP address;
  - birthdate;
  - birthplace;
  - phone number;
  - login name.

- **Infrastructural Information Data:**
  - telecommunication networks data (e.g. fiber);
  - electric power distribution network data (e.g. transmission lines, power stations, substation, step down transformer, etc.);
  - water supply network data (e.g. drainage basin, water pipes, water towers, pumping stations, etc.).

Technological changes and Cloud computing have profoundly transformed the way of how personal data are collected, used and transferred. In particular, with the cloud computing we can have data can be transferred even outside the UE. This is one of reason why most people want to maintain control over personal information and this is one of the reasons why we may have privacy issues when those data are collected and stored. VIRGO innovative solution will address these aspects implementing principles stated in “The Data Protection Directive” (Directive 95/46/EC) like

- **Purpose limitation:** is the principle that a data controller can only collect and use personal data for a specific purpose.

This purpose must be properly defined and communicated to the person (“data subject”) whose data are being processed. This permits the data subject to know what will happen to his/her personal data.

- **Consent to Data processing:** is the principle that a data controller can process personal data on the condition that data subject provide an explicit consent to such processing.

- **Security:** is the principle that collected data should be kept secure from any potential abuses.

- **Access:** is the principle that data subjects should be allowed to access their data and make corrections to any inaccurate data.

VIRGO solution will take under consideration the “General Data Protection Regulation (GDPR) a single law that the European Commission is planning to unify data protection within the European Union (EU) to overcome the limitation on the current EU Data Protection Directive 95/46/EC. The latter does not consider important aspects like globalization and technological developments like social networks and cloud computing sufficiently and new guidelines for data protection and privacy were required. Therefore, a proposal for the regulation has been released on January 25, 2012. The adoption is aimed on 2014 and the regulation is planned to take effect in 2016 after a transition period of 2 years.

Discussions regarding specific contents are still ongoing. Principles are:

- transfers of personal data to third countries or international organizations, including onward transfers;
- rules on the confidentiality;
- data protection by design and by default;
- right to be forgotten and to erasure;
- security of processing.

In particular, there will be a DMZ (Demilitarized Zone) with the aim to separate the LAN from public Internet and segregate public-facing servers like the web-server and the notification server.

The communication protocol used to establish a secure connection from/to the DMS host servers is HTTPS with SSL one-way certification. This protocol will be also used to allow the communication among different VIRGO instances (e.g. multi-instance deploys). Security and privacy will be ensured by a “Security Layer”, a logical layer designed to provide services privacy settings that are set at high level by default. This layer is composed by:

- **Authentication and authorization engine:** it is based on an open source management solution provided by the Forgerock. OpenAM, is the Identity Relationship Manager (IRM) has been selected for user authentication and authorization. It will support oauth/oauth2, SAML2 and identity federation;

- **Logging engine:** customized logger with the purpose to trace all activities performed on the platform;

- **Interoperability layer:** aim of this layer is to provide an interface for publishing GeoData according to INSPIRE directives. GeoData can be consumed by the presentation layer as well as external systems through: Download
services (e.g. WMS, WFS) and Discovery Services (e.g. CSW);
- **BPM engine**: it will act as a Business Process Manager used to design and run e2e processes for citizens, public administrations and businesses;
- **Public API**: a set of public API with the aim of encourages independent developers and researchers to use them to create new apps and data visualizations that support the project’s goal.

In addition, thanks to the multi-tenant capability will be possible to define ad hoc business processes for a local need. Segregating data in layers and defining authorizations, roles and profiles, will be possible to define exactly what a VIRGO’s user can either see or do on the platform (Fig. 3).

Fig. 3. An example of data layer segregation and user profile.

Following the end of the project, thanks to the creation of structured communication flows with all the national and European sector actors, the partners will be able to maintain a constant two-way communication flow with them and to ask for their collaboration in the dissemination and exploitation activities to be further implemented.

V. DISSEMINATION AND CONCLUSIONS

Thanks to the innovative experiments planned in several municipalities in Lombardy region (that will host EXPO 2015 in Milan), the consortium will be able to replicate the project in three pilot countries: Italy, Romania and Portugal. In this case with the aim of providing to the communities not only a register of infrastructure, but also a number of application services that will facilitate the management of the subsoil, creating an overview of the existing infrastructures and going to reduce the resulting inconvenience to citizens and enterprises.

The innovative [18] integrated system will deliver to various end-users (public authorities, citizens, businesses, services and professionals working on infrastructure) different services that will optimize public spending, improve [19] the coordination of resources and reducing the environmental impact of the interventions. The reasons that lead to the realization of the project and its dissemination are varied, since the project will implement a number of advantages such as: simplifying the procedure for issuing authorizations, improve [20] the quality and accessibility of data of public services on the part of Public administration, the multi-utility organizations and privates; increase the efficiency of the offices and public infrastructure [21] in order to achieve cost savings (reduction of costs and timing of implementation [22] of interventions); share databases to simplify the administrative burdens resulting in a reduction of charges for citizens and businesses; transparency [23] in making accountable for their actions on the part of those who have positions of responsibility towards society and stakeholders, implementation of smart cities [24].

The goal of VIRGO is to satisfy the needs of the various stakeholders [25, 26, 27] of the project: Public Administration; Regional administrations; Municipal governments; TLC operators and citizens. Project’s partners produced a large list of technical and scientific articles; participated in congresses and symposiums, which the partners attended and verified the preliminary results. The platform developed on cloud will allow municipal governments to dematerialize paper in “historical” archives, existing infrastructure [21] and enable the development of applications [28] available to the designers of networks and plants. This in respect of the possibility of using the system for both the design and VIRGO issuing permits for the final documentation of “as built” to be delivered to the Administration. The system will also provide the path of the instances of permits for excavation monitoring compliance [22] giving the possibilities to reduce the time required to obtain permits for the granting of the concession.

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REFERENCES


