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Development of a universal INFRAMOD tool for setting up infrastructural networks

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ABSTRACT
In order to develp smart cities and smart communities, one needs internet access with speeds of >30 Mbit/s. The EC budgeted this activity within the financial perspective 2014-2020 for member states with about 50mioEUR/ 1 mio inhabitants. Successful set-up of the infrastructure and the necessary internet access requires big data processing. These large amounts of data are collected by different institutions, each of them for their individual purpose. There is no comprehensive control over these data, the latter are thus not unified and not suitable for direct use when planning establishment of complex infrastructural networks.
This paper represents an innotive environment, called INFRAMOD, which enables automatic selection of the optimal scenario by using the artificial intelligence principles. It will also enable the emergence of high-tech enterprises and their operations anywhere, not only in privileged highly developed centers.
Key words: *European cohesion policy, next generation access, smart cities and communities, big data management*

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I. INTRODUCTION

The European commissions seeks to rationalize the national usage of taxpayers' money [1]. One of the initiatives that should contribute to achieving the goal of increasing investments into research and development is first and foremost the innovation union that is aimed at improving the framework conditions and access to funding of research and innovation, herewith ensuring that the innovative ideas turn into products and services that will increase growth and employment [2]. Unfortunately, over 30% of the available funding in the EU area is used irrationally and unevenly. Consequently the local communities and business in certain areas don't develop in accordance with the agreement between the local governments and the European Commission (further referred to as EC) [3].

According to Qiang, Zhen-Wei, C., Rossotto, C. M. and Kimura, K. [4], investments into broadband infrastructure result in greater competitiveness, innovation and productivity of the economy, also enabling more efficient public services and thereby contributing to overall better quality of life. Development of smart cities and communities requires access to the internet with speeds of >30 Mbit/s (next generation access, further referred to as: NGA) [5]. In order to meet this objective, the EC allocated approximately 50 mio EUR per 1 million inhabitants in the EU member states in the financial perspective 2014-2020. Due to the lack of standardisation, no connection between and lack of interest of public authorities there is a danger that this money will be spent contrary to the set objectives.

According to Cambini, C., Briglauer, W. and Grajek, M. [6], public support for development of NGA infrastructure is an excellent way for encouraging investments. Gulati, G. J. and Yates, D. J. [7] record a higher level of prevalence of NGA infrastructure in countries with a higher level of financial investments into ICT technologies, with simultaneous effective national regulatory function. In developing countries, a competitive telecommunication sector is the leader of the expansion of broadband access, while the national regulation would have a negative effect [7]. As an example of the key reason for economic underdevelopment in rural areas in the Balkans, the authors Požarnik, M., Kranjec A., Mohar Robič, L. and Taras, T. [8] discuss the unavailability of fast broadband internet access, primarily due to the lack of commercial interest of telecommunication operators, claiming that data processing of various institutions through the intelligent harmonization protocol resulted in an increase of the share of private investments in construction of NGA infrastructure in rural areas [9].

Groot, R. [10] concludes that a sustainable harmonization of geospatial data depends on the political responsibility and integrity, and a local regulatory environment which must be aligned with the national and supranational level.

A solution for a rational use of the available money is setting up a modular environment for construction of infrastructural networks (such as next generation telecommunication infrastructure), which would ensure objective, accurate and measurable information for all legal subjects/investors (public, private, mixed). Investors need concrete financial information and concrete geolocation guidelines for their projects and plans. This information is also needed for making decisions about placing the project into a concrete environment.

This research work also analysed and tested options for grouping objective, detailed and measurable information. A universal tool called INFRAMOD was developed, providing high useful value at setting up different types of infrastructure. A succesfull application of the INFRAMOD environment enables creation of high-tech companies and their operations anywhere, not only in privileged highly developed centers.

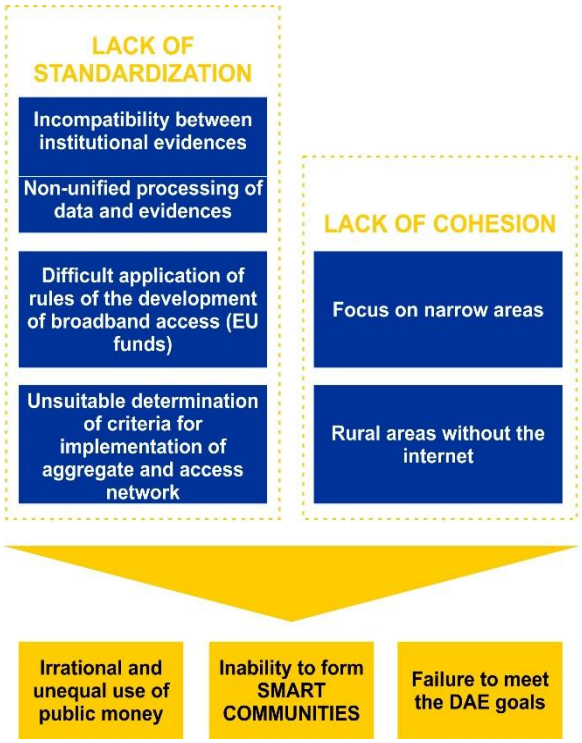

Figure 1: Consequences of lack of standardisation and cohesion.

II. RESEARCH METHODOLOGY

The process of developing the INFRAMOD environment was set systematically, logically and transparently. It includes an entire spectrum of activities, from design, development, verification and implementation of a completely new solution according to the following sequence:

Phase 1: Research and analysis
- Determine the most suitable data architecture
- Selection of relational database
- Determine relation between individual data groups
- Determine the required properties of data processing algorithms
- Determine limitation factors

Phase 2: Developing a comprehensive solution
- Determining and developing scenarios
- Development of data processing processes
- Development of an optimal path algorithm
- Development of solutions for individual solution of NGA access to the internet
- Development of a solution for mapping connectors
- Development of graphical user interface
- Creating a program code

Phase 3: Verification of developed comprehensive solution
- Static verification
- Dynamic verification
- Verification with regression analysis
- Verification of data access solutions
- Testing the efficiency of establishment of individual technological and financial solutions
- Verification of security elements

Phase 4: Implementation of the comprehensive solution
- Identification and implementation on the appropriate server infrastructure
- Defining business intelligence elements
- Pre-processing
- Post-processing

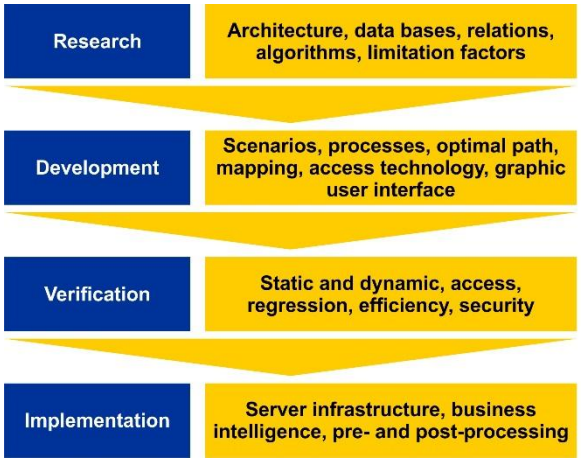

Figure 2: Development process.

III. RESULTS

In order to successfully establish the NGA internet access infrastructure, a large amount of data needs to be collected and processed. In accordance with the findings of Atul, S., Desale Girish, B. and Patil Swati, P. [11], big data comes from many sources and in many formats. There is no complete control over the data, they are therefore not unified and thus unsuitable for direct use when planning the setup of complex infrastructural networks. As suggested by Singh, P. [12], not having a good data governance plan can lead to security breaches, unreliable data, and unexpected expenses. The mass processing solutions, existing today on the market provide partial solutions in the field of implementation of infrastructural network.

None of them is intended exclusively for the establishment of infrastructural networks. The INFRAMOD solution is based on the principles of modularity, parametrization and open access.

Locations and the type of connections to next generation infrastructure networks depend on precise and complex rules. The latter are set in the EC documents and telecommunication standards. Implementation of rules into the modular environment INFRAMOD represents a global innovation since there is no system or environment that would have such rules already implemented.

By using the Monte Carlo[1] method, an optimal scenario is established for setting up infrastructure networks, which includes the geolocations of connections, access technology and financial construction.

Determining all possible connections to infrastructure networks does not suffice to ensure a rational use of taxpayers' money. One needs to define optimal scenarios for three areas: geolocation, access technology and financial resources, necessary for setting up the connection. The INFRAMOD environment when using the Monte Carlo method creates a large number of scenarios in each of the previously mentioned areas. On the basis of mutual comparison of variants, the system automatically selects the optimal scenario by using articifial intelligence principles.

Solutions, implemented in the INFRAMOD environment (precise geolocations, harmonized data, and unlimited technologies) are useful in all infrastructural network areas, not only in telecommunications. Modular design ensures the possibility of upgrading the connection by using new technologies and financial constructions.

Within the unified environment framework the INFRAMOD product provides all functions that the competitive solutions provide only partially. Such modular environment contains the necessary functionalities (mapping, access technologies, financial construction, optimal scenarios, the principle of the shortest route), aimed at establishing next generation infrastructural networks. It provides a comprehensive and complete solution of the presented issues.

The key issue in this topic is the absence of standardization of data, collected by various institutions. This is reflected in the discord between the institutional evidences and non-unified data processing and evidences.

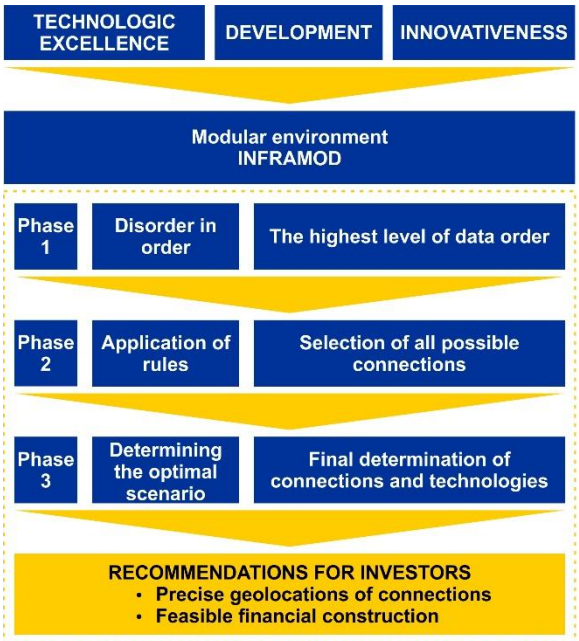

Figure 3: Research challenge – development of modular environment.

[1] Monte Carlo methods are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results.

The result of processes within the INFRAMOD environment is an accurate and comprehensive set of all possible connections to the infrastructure network. The geolocations of connections to the infrastructural network must be determined with an accuracy of ± 2m. One of the important functionalities of the INFRAMOD solution is increased quality of data, needed to establish infrastructure networks.

In order to ensure a rational use of taxpayers' money in the construction of NGA infrastructure networks, it is necessary to determine the optimal variant or the optimal scenario. This includes determining the geolocation of the individual connection, choosing the optimal technology and standards for providing NGA internet access (P2P, P2MP, DOCSIS 3.0, 4G) and a suitable financial construction. In determining the optimum technology, the best solutons currently used as well as future technologies (5G, DOCSIS 3.1, 10G-EPON) are taken into account.

With help of incorporated mathematical model, the algorithm enables optimal mutual harmonisation of government data with the goal to precisely assess the number of potential beneficiaries of the new NGA network.

STEP 1: Equation of data on the location of potential beneficiaries with unique data on locations of house numbers

Equation is done through a mathematic procedure that is shown with the following formula:

$$L_{PB}(c,t,s,h)=L_{HN}(c,t,s,h) \quad (1)$$

Whereby the following applies:
L_{PB} = *location of potential beneficiary,*
L_{HN} = *location of the house number,*
c = *county,*
t = *town,*
s = *street,*
h = *house number.*

STEP 2: Defining the number of potential beneficiaries on individual location

Defining the number of potential beneficiaries on individual location is done with help of a mathematic procedure that can be shown with the following formula:

$$GL_{PB}=x,y,z_{HTRS96}(L_{PB}) \quad (2)$$

$$N_{PB}(GL_{PB})=\sum N_{PB}(L_{PB}),\ L_{PB}=GL_{PB} \quad (3)$$

Whereby the following applies:
GL_{PB} = *geolocation of potential beneficiary,*
L_{PB} = *location of potential beneficiary,*
x,y,z_{HTRS96} = *actual physical location in a coordinate system HTRS96,*
N_{PB} = *number of potential beneficiaries.*

Only one technology can be defined as the optimal technology for access to the infrastructure network. In case INFRAMOD determines more than one optimal infrastructure access technology, additional parameters must be determined that influence the choice of optimal technology.

This new INFRAMOD environment integrates modern ADM (Advanced Data Merge) technologies, sequential algorithmic techniques, dynamic algorithms and core algorithms for pre and post processing. The product is developed on the principles of integrity, security and reference verification.

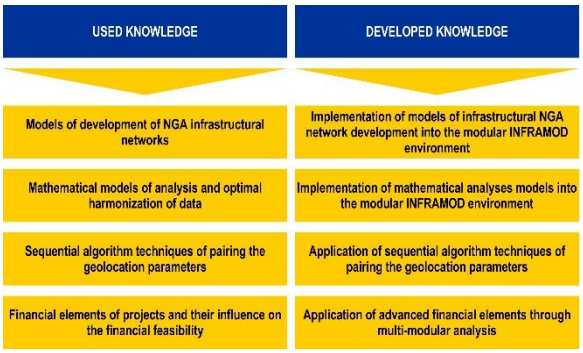

Figure 4: Technological excellence from the point of view of developed and used knowledge.

The modular INFRAMOD environment is developed on the principle of a 4-layer architecture :

- Presentation layer – users can view the data display using the WPF technology as the .NET platform subsystem.
- Business logic layer – implementation of business logic, consisting of business processes, business components and business rules, defined in the analysis process.
- Data layer – a relational database is provided. The use of SQL language is envisaged for data processing.
- Interface layer – it is possible to connect external data sources through purposeful communication interfaces.

IV. CONCLUSION

There is an enormous amount of data included in setting up the NGA infrastructural networks. Such large amounts of data can only be processed by using technologies that are called "big data management" technologies.

The vision of the development of a universal tool is in the direction of developing comprehensive solutions for current global challenges. The starting point is to combine development experiences, accumulated knowledge and innovation potentials, as well as use of

knowledge in diversified products with high added value. INFRAMOD stands for strengthening RR capacities in the area of high technologies. It creates an excellent environment for entrepreneurial and educated staff that has talent for quality innovations, while positioning itself as a knowledge-based environment that co-creates global trends. Such new product is the entry point for the internationalization of operations and digitization, enabling cooperation with leading institutions in complementary areas.

Target buyers of the INFRAMOD solution are investors into infrastructural networks, telecommunication operators, public institutions, project companies, geodetic companies, communal companies and those who build or maintain the other infrastructure networks (roads, gas pipelines, oil pipelines, hot water connections, etc.).

Further research is meaningful in terms of legislation and optimization of the algorithm. Due to possible changes of legislation and regulations in the field of NGA infrastructural networks, one needs to actively follow the legislation and regulations and in case of changes immediate incorporation of changes should be made in the project. In the event that the planned system performance is not achieved, the optimization of the algorithms must be performed, or a new algorithm must be developed that will ensure the necessary performance.

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