Gaia-X and European Smart Cities and Communities white paper

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Contributors

Tanguy Coenen, imec-EDiT

Nils Walraevens, imec-SMIT

Gaber Terseglav, ICT Innovation network

Ilkka Lakaniemi, Aalto University

Ulrich Ahle, FIWARE Foundation

Lieven Raes, Agentschap Digitaal Vlaanderen

Brigitte Lutz, City of Vienna

Nikolaus Reisel, City of Vienna

Wouter Van Den Bosch, imec-EDiT

Gert Vervaet, Agentschap Digitaal Vlaanderen

Martine Delannoy, imec-EDiT

About this white paper

GAIA-X has recently emerged as a key player in the European data policy and infrastructure domain. With this paper, we aim to reflect on what the application of GAIA-X could be in the European Smart Cities domain. Throughout the text, we will use the terms "Urban technology", "Smart City" or "Smart Cities and Communities" and "Local technology". Through these terms, we refer to the application of technologies in cities, but also in smaller geographical areas like villages and larger ones like provinces and regions. This refers to an evolution in Europe to go beyond smart cities by referring to "Local" systems or "Smart cities and communities", which are understood by the EU as applications beyond cities.

The paper combines multiple perspectives and aims to establish a common understanding of both the GAIA-X and key Local technology concepts and how they can be interrelated. It is not intended as an academic contribution, but rather addresses city administrations, IT industry actors, EU policy makers and GAIA-X members in general. At the time of writing, the Gaia-X specifications are still in flux, which means that describing detailed cases for Gaia-X applications in a Local context is somewhat premature. However, this paper makes a first attempt at framing the application domain of Gaia-X in the Local European Smart Cities and Communities context. In subsequent versions of this document, we will set out to specify the cases in more detail.

Introduction

Through the European Data Strategy[1] and in her 2020 State of the Union Address, the President of the European Commission, Ursula von der Leyen, pointed at the need for Europe to quickly become stronger in the use of industrial data and set a course that is more independent from non-European actors. She highlighted the need to build a data economy and to allow it to act as an engine for innovation and new jobs, by creating new data spaces. In these data spaces, companies and researchers would be able to access and collaborate on data[2]. Further underlining this ambition, the European Commission stated that "The aim is to create a single European data space – a genuine single market for data, open to data from across the world – where personal as well as non-personal data, including sensitive business data, are secure and businesses also have easy access to an almost infinite amount of high-quality industrial data, boosting growth and creating value, while minimising the human carbon and environmental footprint. It should be a space where EU law can be enforced effectively, and where all data-driven products and services comply with the relevant norms of the EU's single market. To this end, the EU should combine fit-for-purpose legislation and governance to ensure availability of data, with investments in standards, tools and infrastructures as well as competences for handling data. This favourable context, promoting incentives and choice, will lead to more data being stored and processed in the EU."[3]

The need for qualitative and diverse data about the processes affecting citizens is high. The evolution of an electronic society (e-government and e-commerce) in the early 2000's has moved towards a smarter society (smart-city) movement today. In the e-government area, governments were the primary data owner and were able to run many of the e-government processes without a significant need for private-sector data. Today, in the smart city area, the situation is entirely different. Much of the data that pertains to a city is owned by private or semi-public/private companies and

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[1] https://digital-strategy.ec.europa.eu/en/policies/strategy-data
[2] State of the Union Address by President von der Leyen at the European Parliament Plenary, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_20_1655
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0066&from=EN , p5

organisations. Much of the data used for evidence-based policymaking isn't available by the decision-makers and often affects decision-making quality. Public-private cooperation is required to ease how data can be obtained and applied to increase the quality of living in Europe.

The emerging European Local IT landscape

Figure 1 describes a high-level view of the Smart City IT Landscape as we see it unfold in the coming years. Central to the presented image is the Local Data Space, where we believe the main added value of GAIA-X to urban applications will lie. We now briefly describe each of these concepts in order to lay the basis for our discussion of how GAIA-X could support them.
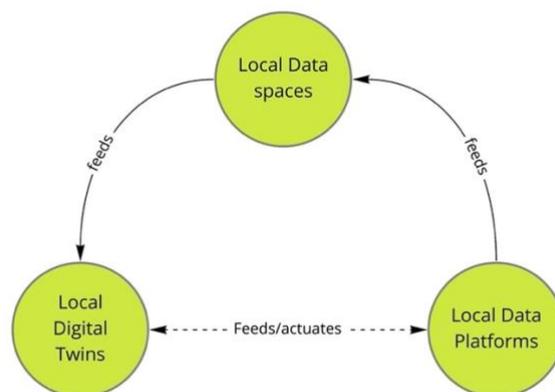

Figure 1: a view on the configuration of the Smart City IT landscape the years to come

Local Data Platforms

By "Local Data Platform", we refer to the IT infrastructure which either captures fast-moving data as it is produced by measurement equipment (i.e. sensors) or manages more slow-moving data like GIS data or data that is stored in various local databases of which the data does not change often. European cities have been actively reflecting on how they can improve the quality of life of their citizens through digital technologies while at the same time reducing the cost of operating a city as well as contributing to the Sustainable Development Goals. "Datafication" has been referred to as a societal innovation, akin to the steam engine or electrification[4]. A main innovation drive in Local Data Platforms has been in the dynamic or Internet of Things (IoT) data domain. However, cities also have other, more static datasets that are essential for urban decision support. By Local Data Platforms, we also include these relatively static data sources, coming from domains like urban planning and Geographical Information Systems (GIS). Local Data Platforms are well-understood from a functional, implementation and business perspective. Many vendors and technologies are currently in place that can bring about Local Data Platforms, serving static data or dynamic data from IoT sensors. Even though not all cities have proper Local Data Platforms yet, a market exists for them and they can be tendered whenever society deems it appropriate. An objective which has been part of the creation of Local Data Platforms for years has been to allow interoperability in order to avoid vendor lock-in,

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[4] https://www.imeccityofthings.be/drupal/sites/default/files/inline-files/open_city_vision_paper_final.pdf

facilitate Local Data Platform evolution and the exchange of data across Local Data Platforms. The latter is required to create Local Data Spaces.

Local Data Spaces

Given the increasing availability of Local Data Platforms, the new challenge has become how to share data between them, to allow new cross-domain and cross policy level decision making to occur in local contexts. To support this, Local Data Spaces are needed. GAIX-X defines a Data Space as "a virtual data integration concept defined as a set of participants and a set of relationships among them, where participants provide their data resources and computing services"[5]. It seems important to point to the fact that GAIA-X sees a data spaces as the exchange of both data and computing services. These computing services can refer to the (often US or Chines dominated) cloud services which are necessary for the hosting of modern applications. However, we will in what follows mainly refer to data spaces as the being about sharing of data services. The move from hosting applications on premise to in the cloud or even in a EU-based cloud environment does not seem like a prime benefit or concern to local administrations at the time of writing.

There is not one Local Data Space, but one or more Local Data Spaces in each local context. It is best visualised as a network of nodes and edges that is continuously configured and re-configured in order to support cross-domain decisions. Local Data spaces constitute the main Smart City aspect that GAIA-X can support and it is therefore on this aspect that a part of this paper will focus. Local Data Spaces are only about the sharing of the data. Yet data sharing in itself has little value, except if the data is used to support decisions over the different societal domains that produce the data. This is where Local Digital Twins have a role to play.

Local Digital Twins

Such cross-domain decision making is the remit of Local Digital Twins. A Digital Twin in general is to be understood as a virtual representation of a physical entity with a bi-directional communication link. An "Urban" Digital Twin is a version where the physical entity is a city and is used to support decisions that pertain to this city. Various local administrations (e.g. in Amsterdam, Rotterdam, Santander, Helsinki, Antwerp, Vienna, Athens, Pilsen, Flanders and Bruges) are investigating how such a virtual replica of a physical city can improve the decision making process. Local Digital Twins, as shown in figure 1, are "fed" by Local Data Space data. Indeed, they are one of the applications that most need the cross-domain data sharing which the Local Data Spaces allows. For more on Local Digital Twins, we refer the reader to the Local Digital Twin white paper published by imec's digital transformation department[6].

An intro to GAIA-X

GAIA-X is focusing on 3 main activities. First, there is the specification of an architecture that can support a federated data economy. This means reflecting on components, standards, API specifications, data models and design principles. A second type of activity is the creation of open source tools that can implement the architectural components that are not yet available on the market. Finally, GAIA-X aims to set-up services that allow various components of the GAIA-X ecosystem to be certified, so they can be trusted by all dataspace participants.

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[5] https://www.gaia-x.eu/pdf/Gaia-X_Architecture_Document_2103.pdf
[6] https://www.imeccityofthings.be/en/blog/open-urban-digital-twins

The objective of GAIA-X is to advance and strengthen the European data economy. To do so, GAIA-X introduces a set of concepts that distinguish it from the way in which data services and platforms exist in today's cloud landscape. A distinguishing feature is related to ownership. Where most of the existing platforms are owned by one party, in a winner-takes all type of logic, GAIA-X aims to achieve a type of ownership that is distributed over many actors, yet is not state-owned. This aligns with the way in which many data platforms and services can be perceived these days, i.e. more like an ecosystem of actors and the technical components they own, than as a central system in which power is concentrated with the actor who owns it. In other words, as building on top of Data Spaces. Together with this decentralised/federated ecosystem approach comes an approach to building data-centric systems that can be engaged with by many and thus needs to be open. This refers to the development of the platforms as well as to the ability to access them.

To allow the creation of Data Spaces, the following GAIA-X "federation services" have been defined and are being designed and implemented: Identity and trust management, Sovereign data exchange, Federated catalogue and Compliance. Identity and trust management are essential to allow the various actors in the system to be certain that they are dealing with the entities that they think they are dealing with and to make sure that the resources which they are exchanging can be trusted. Sovereign data exchange is about allowing data to be exchanged between parties while its owner retains the control over the data. The federated catalogue is about allowing data to be findable by data consumers. Finally, compliance is about increasing the trust which actors in the GAIA-X ecosystem have towards each other and each other's data. This can be done by proving compliance to common agreements, tough e.g. certification.

The way GAIA-X is set out to function, is presented in the architecture document[7], which is built around the conceptual model in Figure 2. We will not describe the model in detail, but direct the interested reader to the architecture document to better understand its ins and outs. The conceptual model represents the various constituting parts of a GAIA-X based data space, in which a consumer of data-based services interacts with a provider of data-based services. To facilitate this data sharing, a federator is present in the dataspace, to make sure that the necessary trust can be established between the consumer and the provider and that data services can be easily found by data consumers. Who will play the role of federator in Local Data Spaces is a question that deserves some thought. Candidates are city administrations, regional governments, nation state governments, supranational entities like the EU and member organisations that represent the local domain. Initial GAIA-X implementation in smart cities and communities will require some thought on who plays the federator role and what this role entails in a particular local implementation context.

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[7] https://www.gaia-x.eu/pdf/Gaia-X_Architecture_Document_2103.pdf
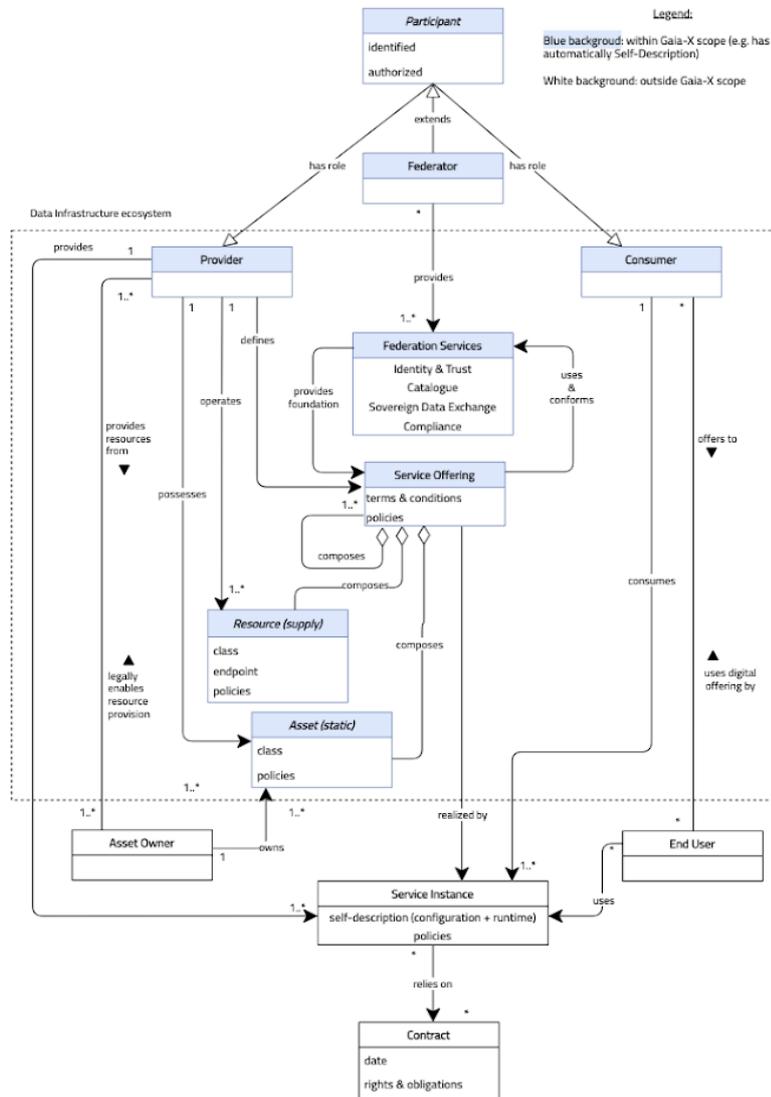
Figure 2: GAIA-X conceptual model[8]

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[8] https://www.gaia-x.eu/pdf/Gaia-X_Architecture_Document_2103.pdf

GAIA-X and the emerging Local IT landscape

Now that we have introduced the Smart Cities IT domain as well as GAIA-X, we are ready to expand on how the two could be related to each other. As explained before, we see the main relevance of GAIA-X as allowing European Local Data Spaces to evolve. Local Data Spaces will need to be open and interoperable, allowing a free flow of data. Local Digital Twins require this data to produce value.

Architecture

A first potential application of GAIA-X, through the creation of Local Data Spaces, will be to facilitate the crossing of data flows across silos in the different departments, cities, regions and countries, to support decision making. This could be done by making available and supporting the application of standards and semantic technologies that offer the possibility of interaction between the different stakeholders that are involved in the process of local decision making. It will therefore first and foremost be a matter of drawing the attention to the various smart city standards and design principles that are out there and further their understanding by city administrations and IT services throughout the EU[9] to make sure that the existing standards are applied with maximal impact. If more local IT stacks would be building on standardised components with best practices to utilise them and would use salient data standards and data models, it would become easier to integrate with these components, services and datasets across cities.

This would have both commercial benefits, as companies would be confronted with a larger market, as well as a societal benefit, as investments that are made at a regional level could be applied to a wider array of cities within the region. In addition, a local IT infrastructure that is built on the GAIA-X architecture would make sure that municipalities understand how they can tender new IT infrastructure without becoming vendor locked-in. This is an aspect where local and EU support on innovation procurement[10] and GAIA-X can interact to make sure that the proper technical and business specifications are requested from commercial actors by local authorities.

The time of designing and tendering systems with a monolithic architecture is long gone, meaning that tendering should be done based on a robust architectural insight in what an local IT system is to achieve. This understanding should further a cities' understanding of what components are needed, how they should be implemented, tested and maintained and how they should all interact. These are key insights to which GAIA-X can contribute.

To make sure that the various constituting parts of the localIT infrastructure are available, economically sustainable and easily findable, marketplaces that offer raw datasets or datasets that are the result of certain value added services like machine learning would be beneficial to the data economy. Finding out what these marketplaces should do, how they should be built and who should manage them seems like a key question to focus on and that GAIA-X needs to take up. The ensuing roles could be key ones to play for a local federator in the GAIA-X conceptual model as presented in Figure 2.

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[9] https://digital-strategy.ec.europa.eu/en/events/workshop-local-digital-twins-technology

[10] https://ec.europa.eu/growth/single-market/public-procurement/innovative_en#:~:text=Innovation%20procurement%20includes%3A,not%20exist%20on%20the%20market

Analogous to the EU open data portal and the EU Inspire data portal, Local Data Spaces can be automatically connected to offer an EU wide and up to data search mechanism. Both portals use automated metadata harvesting mechanisms to provide wide coverage. The structure of both EU data portals is hierarchical: the EU portals harvest the data from the member state portals, while the member state portals harvest from regional and city portals. It is to be expected that this will not necessarily be the case in the future. Since there may be less hierarchy between local data spaces, alternatives are needed to improve the data search process. The most convenient user-oriented way is to publish and make data findable via search optimisation techniques via existing search engines. Open linked data publication through W3C adopted and open standards like schema.org and RDFa make it possible to publish metadata on the web in a fully automated and well-defined way.

Finally, GAIA-X places much emphasis on security and trust, which is an aspect that is not always top of mind or well-understood. Aligning with GAIA-X could allow local authorities to become more aware of and prepared to deal with adverse effects of IT, like bias in machine learning, data breaches and privacy concerns.

Open Source Software Code

In terms of Open Source software, the architectural view to build Local Data Spaces that would be produced by GAIA-X can be implemented through a number of reference building blocks. Describing architectures and design principles only takes you so far and there is no better way to refine designs than to build the designed components and evaluate them. If these components can be created and released at a high technology readiness level, this would be very beneficial to the local technological domain, as this would lower the cost of deploying and maintaining local IT infrastructure. Not all the components of a GAIA-X based Local Data Space architecture will need to be developed, as many are already out there, either available as open source or proprietary commercial components. If an objective of a city administration is to avoid vendor lock-in, it is important that the components do not integrate too deeply with services of cloud vendors or that the necessary abstraction software components are created on top of vendor-specific cloud services to allow interoperability. This can be done by leveraging containerized microservice components that remain as portable as possible across clouds.

To show that the building blocks, when put together, meet the objectives of a specific Local Data Space, having a reference implementation in which the various components that fit together are deployed and tested is necessary. This is why we would advocate setting up such a reference implementation that can act as a test suite in which newly developed components or versions of components can be tested. This reference implementation would span the 3 local technology concepts that we have discussed before, i.e. Local Data Platforms, Local Data Spaces and Local Digital Twins. The functional and non-functional objectives which would need to be achieved for a Local Data Space are still to be drafted, but this should be done with a high priority. Minimal Interoperability Mechanisms[11] would need to be part of a solution, through open interfaces, to facilitate the decoupling between the 3 local technology concepts. Such a decoupling would allow one concept to be changed without the need to change the entire system.

The creation of open source code is traditionally done through Open Source communities, spanning multiple developers from a variety of organisations. There are many such communities already, working on components that are highly relevant to Local Data Spaces. It remains to be seen what components GAIA-X will choose to work on in the local technology domain and how the community around it will be organised.

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[11] https://oascities.org/minimal-interoperability-mechanisms/

Compliance

The various data sources, machine learning models and other components that will be available in the GAIA-X Local Data Space will need to play by the rules that are set out in the architectural definition process. In order to use certain parts of the Local Data Space, these parts will need to be trustworthy. Increasing this trustworthiness is an area in which we expect GAIA-X to play a key role, but providing training and certification activities. Managing and testing interoperability requirements of data sources could add a lot of value to the local technology domain.

Potential GAIA-X local technology deployments in the EU

In this section, we present a number of cases that can potentially benefit from GAIA-X. More cases are forthcoming from other EU countries like Germany and Luxemburg and will be published in updates to this document. Future work will be to complete the list, select the most promising cases and further elaborate how these cases can benefit from GAIA-X and what GAIA-X can learn from them in terms of local requirements.

Flanders - Local Data Spaces through a Data Utility Company

Solution

The Flemish Minister President recently decided to start the design and development of a "Data Utility Company" (Datanutsbedrijf in Dutch). As part of Flanders' post-covid investment "relanceplan", the regional government aims to build a federated data-sharing infrastructure in which a large variety of data sources will be made available. The aim is to stimulate the data economy by allowing new applications and business models to be built on top of the data sources that are made available through this Data Utility Company. This is very similar to the objectives of GAIA-X, as discussed before. Therefore, the components that are investigated in the context of this Data Utility Company initiative are worth reflecting on as a potential use case for GAIA-X in Flemish Smart Cities.

The local data spaces that can be created through a GAIA-X compatible Data Utility Company would allow Local Digital Twins to grow and thrive. As explained above, the key added value of Local Digital Twins is their support of cross-domain decisions, which requires data to be shared across organisations or organisational departments. Thus, Local Digital Twins require Local Data Spaces, which can be orchestrated by GAIA-X.

In 2018, a first prototype of a Local Digital Twin was created with the city of Antwerp as a central focus. These were the very early days of Urban Digital Twins in Europe, when the concept was still largely unknown by the various local administrations around the continent. The Antwerp Digital Twin was instrumental to show quadruple helix stakeholders at various locations in the EU what a Local Digital Twin could be and allowed a common understanding to grow.

Based on the experience in Antwerp, a project was started to create a Local Digital Twin for the city of Bruges. The Bruges Digital Twin builds on architectural insights that are created in the DUET H2020 project[12]. The public administration of the City of Bruges expressed the need to understand how changes to the traffic layout of the city would influence the air quality. This is only a first step towards cross-domain decision support, as a Local Digital Twin is meant to be a decision support

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[12] https://www.digitalurbantwins.com/

system that can expand into new areas of decision support by plugging in new models (i.e. algorithms) and data sources. The latter topic is the remit of Local Data Spaces, which is where we see the potential involvement of GAIA-X.

In sum, this case proposes to build a Data Utility Company that aligns with GAIA-X and which can be used by various types of cross-domain decision support applications, among which Local Digital Twins are one of the most innovative ones and are high on the priority list of Flemish and European cities.

Problem solved

Flanders is a region in Belgium that is highly urbanised. The Flemish Government has the ambition to transform Flanders into a smart region with international reach and local strength. This is illustrated by governmental investments that aim to support local Flemish cities in their Smart City ambitions. However, there is still a long way to go. Indeed, most local governments in Flanders have been working on their own on the digitalisation of their infrastructure. With the rise of the IoT paradigm, many have started their own programs to understand what IoT can bring them. Now that various data platforms exist in Flemish cities, the question arises how to interconnect these platforms. This is where this use case could make a contribution:

- Allow various data platform to become inter-operable, along the lines of the EIF4SCC framework
- Allow producers of data to publish data in a cost effective way
- Accelerate innovation in the Urban domain by providing existing and new companies easy access to data sources that pertain to the local context
- Reduce the market power of companies to build data-monopolistic positions based on reduced access to proprietary datasets, thereby levelling the playing field
- Reduce the vendor lock-in of cities by regulating and standardising data sharing processes
- Allow new Local Digital Twin applications by addressing data sources across a variety of domains

Partners/ecosystem

The ecosystem can be subdivided among the main roles of the GAIA-X conceptual model (Figure 2): data providers, data consumers and data federators. Data consumers through their activities serve end-users. These are parties that build applications in the domains that are the prime concerns of Flemish cities, like mobility, air quality, pandemics, water management, energy, circular economy and urban planning. Many applications can be built in these domains, according to the principles of Local Digital Twins or according to other principles.

In terms of data providers we refer to the same domains as above. Each application domain has myriad potential data providers. To give an example, let's focus on air quality. In this domain, there can be providers of various types of sensor data (particulate matter, NO_2, CO_2,...), providers of enriched data produced by models (e.g. real-time interpolation or prediction based on the city's 3D structure), providers of GIS data, providers of weather data,...

Finally, regarding the data federating entity, this is a role that the Data Utility Company could play. The aim of the Flemish government is to in time transition this organisation from an entity that is mainly governmentally-led to an entity that is mainly commercial. This will necessitate a business model to drive commercial revenue. From what is currently known on the current thinking by GAIA-X regarding the federation services, the aim is to make them not-for-profit by design, which would not be compatible with the commercial aims of the Data Utility Company. This would be an issue to clarify.

Main technology/GAIA-X components

This use case would require all of the GAIA-X infrastructural components:

1. **Identity & Trust**: federated identity management for individuals and organizations

2. **Federated Catalogue**: to publish registration, consent and query services

3. **Sovereign Data Exchange**: to manage usage control

4. **Compliance**: rights management, onboarding and certification

In order to support the above elements, an architecture has been drafted around the concept of Linked Data Event Streams (LDES). LDES allows the publication of event streams as linked data in a federated and scalable manner. In order to align the Flemish Data Utility Company case with GAIA-X, it would be essential to investigate how the components that are part of this architecture can align with the core Gaia-X deliverables, like the conceptual model, the policy rules and the architecture of standards.

Concrete benefits

By investigating how the data space infrastructure that is being designed by the Flemish government can align with GAIA-X, we can advance the understanding of how a government can apply GAIA-X to sort positive effects on the local digital economy of an EU region. This would allow GAIA-X to move away from the design phase and quickly move into an implementation phase, allowing the learnings that are necessary to establish its practical relevance. The Flemish government would benefit form an increased alignment with GAIA-X by incorporating the EU values as represented by the EU data strategy and by working with some of the best in class actors in the EU data economy, both in terms of cloud infrastructure and data-sharing services. As the ideas that underlie the Data Utility Company are very much based on an ecosystem-wide approach and as ecosystems typically take into account regional nor nation-state borders, it is important for Flanders to contribute to the EU perspective, to assure the relevance of the deployed infrastructure.

Finland

Solution

The Finnish cities Helsinki, Turku and Kuopio are working on a joint project for human-centric public services. The project is funded by the Finnish Ministry of Finance and is developing shared best practices on the identification, management and harmonisation of data. The project is called "DigiPAVe", an acronym from the word "digital" and the Finnish word for services "palvelut". The project is a part of a wider Finnish effort to create uniformity and interoperability in public services, where serving the needs and objectives of the citizens are at the centre.

Problem solved

The project is currently building a dynamic service network planning process and aligning the required decision making processes for early childhood education and basic education in the participating cities. Access and usage of machine learning is at the core of the project. The new service network planning will be supported by machine-readable data products, which are opened in a trusted and usable development environment and without vendor lock-in. The open development environment allows for the creation of new, varied data-driven services.

Partners/ecosystem

As the joint project between the three Finnish cities progresses, it will be opened-up and distributed as harmonized and replicable best practice models for data-enabled planning and decision making to be applied by Finnish cities at large.

Main technology / GAIA-X components

In terms of relevance of GAIA-X to the domain of Smart Cities, the key development areas for data management, where GAIA-X could play a role in the Finnish context are:

- A service design-driven and holistic data architecture for city planning purposes.
- A reference architecture for predictive and human-centric service network planning processes.
- A technology roadmap with milestones for deploying the reference architecture.
- Shared best practices for the implementation and change management required to adapt the new data-driven ways of working among the city departments.
- Wider stakeholder engagement with the private sector developers, IoT vendors and cities internationally.
- A shared understanding and glossaries for key terminology.
- Developing universal and harmonised models for logical and machine-readable data processes in public services and the interoperability of the Finnish platforms used in the smart city-projects such as the Platform of Trust.
- Strong data security and privacy implementation in the cities.
- An ICT-governance model, which sees the new data-driven services as complementary and interoperable to the existing city ICT-architectures.

Austria

Solution

Vienna is one of the world's smartest cities. Aiming to have all their citizens benefiting from the digital transformation, Austria's capital has built its "Smart City Strategy" since 2014 and is consistently implementing it. This city is one of the pioneers in projects that use digital technologies to optimize various areas such as mobility, environment and e-health. Vienna is also the first German-speaking city to have launched Open Government Data – an open and transparent system that makes city data available to the public for their further use. In addition, the city has introduced a standardized monitoring system for all of its smart city projects. Everything is coordinated by the central Smart City Agency, a unit that pools technical expertise and promotes links between the city administration, research, business, and industry.

Problem solved

Cities have data that is more often than not kept in non-standard, legacy formats. The Vienna Local Data Platform aims to take various data sources and make them accessible via a single unified portal. The platform uses the FIWare Orion Context Broker, currently made available as a Connecting Europe Facility Building Block (CEF building block), providing a global standard NGSI-based API for large-scale contextual information management.

The FIWARE Orion Context Broker also works as a hub of contexts by sending data to several services, such as notifications, that can be used to automatically send every change to a historical database – in this particular case, a so-called "Data Lake." A security layer ensures that only whoever is authorized to do so can see and access the data. Thanks to the initiative, three use cases so far have come to life: Facility Management, Monitoring Mobility, and Harmonisation of Facility and Energy Information.

The vision for the Digital Twin of the City of Vienna is to provide for a living digital image of the city that allows the monitoring of existing processes in the city, the generation of new data, the simulation of planning in scenarios and thus in general to allow better data-driven decision making.

Already today, the city is working on the "Digital geoTwin" - and has decided to use the prefix "geo" to emphasize the geometric aspect of creating semantic 3D geo-objects.This Digital geoTwin is a virtual semantic 3D city model that contains all the objects of the city. It shall derive the necessary

geo-based data for the City of Vienna to guarantee their coherence in terms of content and time. It constitutes the nucleus of a comprehensive Local Digital Twin of the city of Vienna.

For Vienna, a virtual mirror image of the city is being created based on the city's data, which enables the capture and modeling of the interactions of urban objects and processes. The Digital Twin of the City of Vienna is based on the ViennaGIS geodata inventory and the data of the specialized applications that have been successfully managed for decades by many departments and which improves their quality and integration.

By making the existing and future data of the City of Vienna available faster, more cost-effectively and more comprehensively by the Digital Twin, it supports and promotes a further development of the Viennese Data Excellence vision: the benefits of the data are maximized, as related decision support questions can be answered effectively and efficiently.

Linking the objects of the Digital geoTwin with other data and information, e.g. demographic and socio-economic data, energy consumption, maintenance management and real-time sensor data, allows the creation of a City Information Model (CIM) for planning and simulation as the basis for a "living" Digital Twin of the City of Vienna.

The Digital Twin of the City of Vienna will create a common platform for a variety of potential specialized applications. It is not only the basis for the management of the City, but also essential for a better planning and simulation of interventions. The increased planning reliability can serve to reduce risks and improve the acceptance of projects through improved communication and transparency. In many areas, such as urban development, energy, transport and the environment, it can be used to support planning and projects, both by the city administrations and by third parties.

With the Local Digital GeoTwin, the City of Vienna pursues the vision of a broad, integrated, up-to-date and accessible mirror image of the City of Vienna and its processes. Since the city is constantly changing and evolving, the goal is not a finished product, but the creation of an open infrastructure, as well as ongoing improvement of usability.

Slovenia

Solution

The Slovenian ministry of public administration has published a Smart City and Communities public tender for Slovene municipalities. It amounts to 8 million EUR with a potential second phase later in 2021 with the same amount. The purpose of this public tender is to accelerate the introduction of innovative solutions in the field of digitalization of municipalities, which will be focused on the following domains:

1. Resource and infrastructure management

2. Concern for the environment

3. Healthy and active life

4. Mobility, logistics and transport

5. Culture, sport and tourism

6. Security and protection

Solutions will enable a better management, communication, proactive problem solving, coordination of resources and processes for rapid response, minimizing the consequences of unforeseen events and natural disasters. Slovenia will achieve this by introducing and using advanced digital technologies, establishing long-term partnerships with stakeholders and thus establishing an

ecosystem that will serve as a springboard for the digital transformation of Slovenia. In terms of GAIA-X, the described solution with the created ecosystem could constitute federated data spaces for local technologies in the EU and therefore benefit from GAIA-X.

Problem solved

One of the biggest obstacles in the development of high value-added applications in smart cities and communities is the interoperability gap between different vertical solutions. Even if different solutions already exist (e.g. smart parking, car sharing, tele-management, traffic optimisation, local self-sustainability...), they are not interoperable. This means that although end-users can use all of them, they can not benefit from potential innovation value which results from data sharing, as data is locked-into different data silos.

In order to unlock such value, local data spaces need to be introduced that would enable data exchange between different vertical solutions. To solve this problem, the Ministry of Public Administration in 2019 and 2020 made a detailed analysis of existing EU smart city reference projects and architectures. During this analysis, cooperation with the Slovene Chamber of Commerce resulted in an ICT Innovation network reference architecture for Smart Cities, which was also used as a reference point for the project architecture. Analysis furthermore identified different reference projects and initiatives/organizations (FIWARE, OASC…) with which to align.

Main technology/GAIA-X components

The Ministry of Public Administration selected an interoperability level that would support future development of smart city digitalization in Slovenia, based on the conducted analysis. The Ministry took the decision to host the CEF Context Broker components in their IT environment (OASC MIM 1) and that interoperability of the data models (OASC MIM 2), which should be supported by all municipalities and their stakeholders. This sets the future stage for interoperability between different vertical services nationwide and enables development of new cross-sector business models and services. In the future project phases, Slovenia will also add support for market place interoperability (OASC MIM 3).

Concrete benefits

Vertical solution vendors that will connect to local data spaces of the Ministry of Administration will start to think about new ways to conduct business and introduce innovative business models based on the data economy. Fusion of different vertical solutions into added value chains will result in new services and offerings for end-users and have a long-lasting positive impact on the national economy. The selected long-term interoperability roadmap aims to position Slovenia as a reference country for local technologies that understands the value of cooperation between stakeholders when building a smart city ecosystem as well as the importance of interoperability and standardisation.

India

Solution

This is a use case from outside of Europe but one which contains many lessons learned that could be applied, also in Europe. When Prime Minister Modi was elected for the first time back in 2014 he soon started the "100 Smart Cities program" in India. Several billion Euro were allocated to this program. Several of the large global consulting companies guided the cities in creating their Smart City strategy, brought first tenders to the market and observed the implementation of the first platforms and projects.

Problem solved

Back in 2019, the responsible Ministry for Housing and Urban Affairs in India identified that each city had built its own silo, that there were only limited synergies between the cities and that the wheel had been re-invented several times. This led to a strategy change in the public funding program and to the creation of the India Urban Data Exchange (IUDX) platform.

Partners/Ecosystem

The FIWARE Foundation, together with partners of its ecosystem like Trigyn from India, NEC from Japan and HOPU from Spain, supported the IUDX program together with the India Institute of Science in Bangalore from its inception in 2019. A standard reference architecture was developed which includes the European CEF Building Block NGSI-LD (MIM 1 of OASC) and the FIWare Standard Data Models (MIM 2), which were both developed in the FIWARE ecosystem. Subsequently, a standard smart city platform for India was developed using Open Source software building blocks from FIWARE and other parties. The platform as a whole is provided as Open Source and was implemented in the first pilot cities.

Main technology/GAIA-X components

Similar as in the above described use cases the case of India has a high potential to be based on GAIA-X and could be a valid candidate for a first GAIA-X implementation outside of Europe.

Concrete benefits

There are two main benefit areas for Indian cities and there are more than 4,200 cities in addition to the already selected 100 Smart Cities which implemented their proprietary solutions. First is the opportunity to benefit from the cost and flexibility advantages of cloud-based services. Second is the reduction of vendor lock in when creating solutions based on Open Source and open standards for APIs and data models which in total reduces the total cost of ownership and increases the replicability of solutions between cities not only on national level

Conclusion

This paper has aimed to present an overview of the aims and activities of GAIA-X and how this could fit with the European Smart City domain. We have explained that the relevance of GAIA-X will be mainly in the creation and maintenance of Local Data Spaces. The 3 main activities which GAIA-X sets out to undertake, i.e. architecture design, open source software development and compliance, are all relevant to European Smart Cities and we have aimed to provide some insights on what exactly this relevance could entail. Yet these insights now need to be expanded on and refined through reference implementations which show their relevance in real-life local contexts. With this paper, we hope to have helped guide and structure the discussion that is ongoing between the GAIA-X and European Local Smart City communities.

Annex - The European Smart Cities community

It is crucial that the various initiatives that have already been developed over the years in the Smart City domain maximally integrate and interface with GAIA-X. We see initiatives on the demand side, i.e. cities and and communities, as well as from the solution side, which aim to meet the needs of the demand side, either through "open" or proprietary offerings. We will discuss some of them in what follows, yet can not be exhaustive in discussing the full breadth of the local technological ecosystems that exist throughout the EU. The actors and initiatives which we will discuss next are the ones which have recently been salient in the discussions around GAIA-X in cities. Understanding the stakeholders that exist in each local data space and mapping their needs and capabilities is key to creating new local data spaces through GAIA-X.

Demand side

Open and Agile Smart Cities (OASC) has been working mainly on representing the demand side of the Smart Cities domain, i.e. the cities. OASC has plaid a key role in various initiatives like the Synchronicity[13] project that helps cities procure Local Data Platforms. OASC has drafted a list of Minimal Interoperability Mechanisms (MIMs), which are a "set of practical capabilities based on open technical specifications that allow cities and communities to replicate and scale solutions globally"[14]. The OASC MIMs are seeing increasing uptake in cities all over the world and it would certainly be advisable for GAIA-X to take a close look at them. Where OASC can be seens as bundling the demand side of the Smart Cities market, GAIA-X can be perceived as being mainly supplier-driven, which means that both organisations would have a lot to talk about.

Living-in.eu is a community which has formed around a declaration, supported by OASC, Eurocities[15], the European Network of Living Labs (ENOLL[16]) and that is supported by the EU. It stresses the need to engage in a European way on the digital transformation of cities and emphasizes the need to heavily engage citizens in doing so, as well as commercial players large and small. The initiative calls to support the use of commonly agreed digital solutions among regions, cities and communities. It is clear that if GAIA-X wishes to engage with the demand side of cities in Europe, Living-in.eu can be a good starting point.

The European Interoperability Framework for Smart Cities and Communities (EIF4SCC) aims to provide European Union local administrations with "definitions, principles, recommendations, practical case studies, and a common model for public service delivery across domains, cities, regions, and borders[17]" . Different interoperability dimensions are discussed: technical, semantic, organisational, legal and cultural interoperability. GAIA-X is set to make a contribution to all interoperability dimensions except perhaps for cultural cultural interoperability. Further work could investigate how the EIF4SCC concepts can be addressed by GAIA-X.

Solution side

The EU itself is an active player in the local technology domain, by drafting new policies that regulate the European digital process, but also by funding specific programs to accelerate the development

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[13] https://synchronicity-iot.eu/

[14] https://oascities.org/minimal-interoperability-mechanisms/

[15] https://eurocities.eu/

[16] https://enoll.org/

[17] https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/news/eif4scc-smart-cities-communities

and deployment of new technologies in European cities. A prominent initiative in this domain is the Connecting Europe Facility (CEF)[18], which makes available a number of components that can be used to build Local Data Platforms and Local Data Spaces. When drafting GAIA-X based reference architectures and implementations, the needed components can be compared to what is provided by the CEF.

An actor which has been working in the domain for almost a decade, is the FIWARE Foundation. It too has been working on the creation of standards and open source building blocks for the creation of Data Spaces in different domains like Smart Cities. The main current streams of activity are the Context Broker open source software components, the NGSI-LD API for context management in IoT systems and the creation of standard data models to represent various smart city domains. All results are openly published and are publicly available on Github.

It would be odd not to mention the commercial landscape of companies that are active in the Smart cities domain. However, there are many and their presence is often highly local to various EU member states, so we will not even try to list them in detail. It seems important to mention, however, that the core aims of the EU through its Data strategy is to make sure that data spaces are not dominated by GAFAM (Google, Apple, Facebook, Amazon) but that European players can grow and thrive.

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[18] https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/CEF+Digital+Home