Whitepaper

The Need for Network Service Composition in GAIA-X

GAIA-X Position Paper

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The Need for Network Service Composition in GAIA-X –
GAIA-X Position Paper

GAIA-X Open Work Package Interconnection and Network
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Content

List of Acronyms

AMQP	Advanced Message Queuing Protocol
BE	Best Effort
CCN	Content-centric Networking
CSP	Cloud Service Provider
DML	Data Modeling Language
ETSI	European Telecommunications Standards Institute
HPC	High Performance Computing
IaaS	Infrastructure as a Service
ICP	Inter-Cloud Provider
IDL	Interface Description Language
IoT	Internet of Things
ISP	Internet Service Provider
LoRa	Long Range
MQTT	Message Queuing Telemetry Transport
NDN	Named-data Networking
NFV	Network Functions Virtualization
NIC	Network Interface Card
ONF	Open Networking Foundation
OPC UA	Open Platform Communications Unified Architecture
PaaS	Platform as a Service
QoE	Quality of Experience
QoS	Quality of Service
SaaS	Software as a Service
SDN	Software-Defined Networking
SSC	Sector Specific Cloud
YANG	Yet Another Next Generation

1 Introduction

The purpose of this paper is to ignite a debate regarding the need to support network service composition in GAIA-X, in order to best support current and future services, offered and consumed in GAIA-X.

The position paper is organized into 4 sections. After this brief introduction, Section 2 debates on the GAIA-X architectural aspects supporting infrastructure, network, and interconnection aspects. The section explains reasons to consider network service composition, derived from a review of the Architecture Document delivered in June 2020, and from our identification of possible needs that still need to be supported. This analysis reveals the need to embed network service composition in a way that is adequately intertwined with applications and data services.

Section 3 debates on initial aspects that we believe should be supported to fully deliver GAIA-X users' expectations.

The last section debates on what such a network service composition could contain, aiming at supporting the GAIA-X relevant aspects of interoperability, policy rules, and federated services objectives.

2 GAIA-X Architecture, Infrastructure, Network, and Interconnection Aspects

The main purpose of GAIA-X is the design and establishment of federated, open Infrastructure and Data Ecosystems based on European values for data and cloud sovereignty. These ecosystems bring together customers and providers with different service needs and holding different, highly heterogeneous architectures. To best accommodate such multitude of services and data, the GAIA-X architecture is based on the notion of a sovereign and flexible interconnection of networks and data ecosystems, where data may be flexibly exchanged between different customers and providers. In order to implement the concept of Infrastructure and Data Ecosystems in GAIA-X, a *Federated Catalog* with a list of different types of services plays a pivotal role in GAIA-X. The Federated Catalog consists of a list of GAIA-X-certified services that GAIA-X compliant providers are offering to customers. In order to understand service offerings and describe it in more detail, the service offerings are described with a *self-description* language. self-descriptions provide the basis to characterize offered services and are flexible enough to accommodate both functional as well as non-functional attributes of the offered services.

Due to the distributed and decentralized nature of the GAIA-X Infrastructure and Data Ecosystems, there is the need to integrate a way to allow the composition of services derived from components/assets from different service providers. As it cannot be assumed that the different service components will always be hosted in the same data center, there is also the need to provide a way to interconnect the different distributed service components in order to deliver end-to-end services to the customer. Consequently, different requirements arise for those interconnections.

Taking into consideration the need for service composition, GAIA-X defines specific components, both on the Data Ecosystem and Infrastructure Ecosystem. This allows GAIA-X offerings to be the instantiation of services on GAIA-X nodes. Nodes are key

components of the GAIA-X infrastructure composition. Infrastructure and networking interconnecting components are based on three basic building blocks, as addressed in the next sub-section.

2.1 Interconnection and Networking Services

Currently, GAIA-X addresses the architectural needs for networking and interconnection via three building blocks:

1. a self-description model, which considers connectivity attributes such as type of networking interface (NIC); supported data rates; latency (where latency refers to the time interval between a source sending a first packet of a flow, until the instant of reception of the last packet of that flow);
2. Inter-Cloud Provider (ICP) measurements, describing connectivity between nodes/providers;
3. Interconnection and networking services based on Internet *Quality of Service* (QoS) indicators.

Given these three building blocks, the focus is mainly on the self-description of GAIA-X nodes, where interconnection and networking are addressed via the definition of attributes. The self-descriptions for the GAIA-X infrastructure currently consider QoS functional parameters relevant for the support of real-time data services, e.g., latency, data rates, bandwidth.

However, today's data services across the Internet and across private Clouds bring in additional challenges and additional requirements, derived from the needs of advanced applications. Non- functional requirements for services need also to be supported. For instance, *service time to completion* is a non-functional QoS requirement corresponding to the instant between the submission of a service (e.g., program/process/thread/task in an operating system) until the execution and the return of the output of the service to the customer. Therefore, it does not suit a hard QoS guarantee such as latency.

Such non-functional requirements, in GAIA-X, can be checked against the use-cases under development, as well as from the already existing security and data sovereignty requirements.

2.2 The Support of Differentiated Interconnection Services

The GAIA-X architecture incorporates already a requirements analysis from an infrastructure perspective, derived from the different use cases in GAIA-X. Based on such an analysis, a high- level overview has been created, which outlines the needs of the use cases in GAIA-X with respect to interconnection and networking services. Figure 1 provides an overview of the interconnections between different entities in GAIA-X and the requirements on the network, which should interconnect them. Such a perspective enables a differentiated services capability between "Best Effort" (BE) services, e.g., basic Internet connectivity, and more elevated services, which could be provided by dedicated interconnection and networking services.

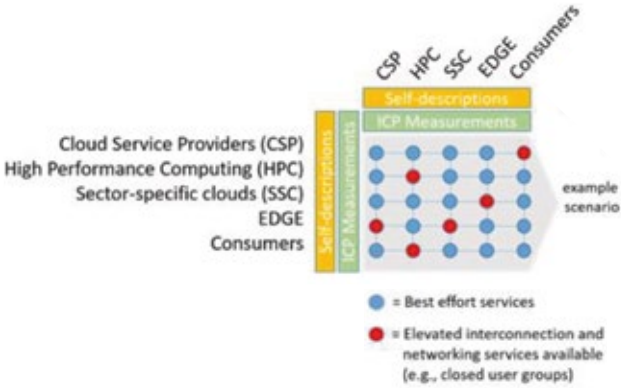

Figure 1: GAIA-X network requirements to use case mapping.

Given the aforementioned description in Section 2.1 about the need for dedicated interconnection and given the overview of the use case analysis, it becomes apparent that networking and interconnection services represent an indispensable building block to carry out the establishment of GAIA-X with its Infrastructure and Data Ecosystems. Consequently, the Federated Catalog with its plethora of services must be extended with adequate networking and interconnection services, considering, for instance, requirements such as functional and non-functional QoS, security, and portability. Examples for different types of use cases, which rely on dedicated interconnection and networking services are briefly explained in the next section.

2.3 Examples of New Challenges to be Accommodated

As a first simple example justifying the need to accommodate more flexibility in terms of entity description and a need to integrate both functional

and non-functional networking and interconnection requirements, let us consider the current evolution of Internet based services towards an Internet of Things (IoT), from a consumer or industrial service perspective.

Novel services, such as *Mobile Crowd Sensing* services derived from Cloudlets and supported by devices placed on the so-called "Far Edge" (field-level devices, end-user devices) bring in challenges and requirements for providers and customers in GAIA-X, e.g., the need to address mobility of private Edge-Clouds; portability and decentralized accountability, for instance. Novel infrastructure technologies, such as long-distance wireless/cellular (e.g., LoRa/LoRaWAN, 5G/6G, and also an Internet of Space) introduce new requirements and the need to revise attributes and the self-descriptions of nodes, and of their interconnections. Services, such as monitoring and even service management, will also most likely require the support of meta-data from an infrastructure perspective, e.g., the integration of an "Application Model" onto the infrastructure self-description entities.

Another more centralized example can be deduced from the envisioned use cases in GAIA-X, belonging to the healthcare, industry, or financial sectors, where customers need to transfer their data to external locations. Examples comprise the storage or backup of data at an external Cloud, the transfer to an HPC cluster for an extensive analysis, or to share data with one or multiple suppliers. For the exchange of data, it has to be ensured in any cases, that the different parties can be interconnected and that additional requirements are addressed, covering guarantees on bandwidth, security and compliance aspects (such as data separation at network level), and the paths (redundant, country restrictions etc.), the data has to travel to reach the intended destination.

Both the new as well as already known challenges can be accommodated via a network service composition model and also via adding more flexibility to the self-descriptions of networking and interconnection attributes.

2.4 Moving Ahead: the Need for Network Service Composition

As a flexible architecture that can support Cloud, Edge (including private Industrial Edges), Edge-Cloud, and any future data center computational architectures, GAIA-X is being developed with enough flexibility to foster the dynamic establishment and selection of relationships between stakeholders. The role that each actor can play, including network and interconnection service providers, has to be decided by customers and tenants who must be given the possibility to select and contract services with candidate service providers.

Such flexibility is essential to support new challenges and accommodate new Cloud architectures, and new service/value-chains. A suitable, flexible description and composition of infrastructure

/interconnection/networking services needs to be adequately integrated and addressed in the GAIA-X architecture, in order to allow for a greater degree of flexibility in accommodating new offerings. This can be achieved via embedding the infrastructure, networking, and interconnection services in the GAIA-X architecture meta-model and service offerings. Networking and interconnection services can be composed via heterogeneous offerings from multiple providers and technologies and can also be delegated completely to a provider by customer decision and approval through negotiation.

Further sovereignty and trust can only be ensured if a number of key requirements and features are included in the meta-model. Besides obvious requirements such as portability, other requirements need to be accounted for, such as high availability, security, isolation, protection and monitoring. Beyond monitoring, means for auditing and certification, by tenants and consumers, have to be an integral part of the meta-model. The architecture needs to enable the control and configuration of this visibility and auditing capabilities and features. GAIA-X also intends to enable the establishment of dynamic policies, including data protection and routing policies.

The right approach to achieve this is to support network service composition in the GAIA-X architectural meta-model. It is also relevant to consider the capability to describe interconnection and networking services in a flexible way. Network service composition needs to take into consideration, in an integrated way, aspects that go beyond a rich description of connectivity and that define Cloud and Edge services to be a composition of node description, functional and non- functional requirements of the access to those nodes, and interconnection description. Notice that this composition is slightly more sophisticated than the models available today, e.g., for 5G and Software-Defined Networking (SDN) (network slices and their management); still, such composition can be built on SDN principles

and needs to be as rich as composing a slice for verticals, via private and public Clouds, since vertical industries can own wireless spectrum licenses and their own Cloud infrastructure and associated services.

2.5 Summary of Missing Aspects

- **The self-description of interconnection and networking services needs to accommodate more flexibility**, taking into consideration the need to address Quality of Experience (QoE)/QoS with the interconnection services and also a need to accommodate aspects such as finer-grained differentiated services; specific characteristics of applications being served. While this implies accommodating state-of-the-art, such as the 3GPP network slice definition and management principles, this also implies going beyond the network management aspects and integrating the capabilities to handle heterogeneous services at the data and networking levels.

- **The GAIA-X architectural meta-model should integrate networking service composition.** The GAIA-X architectural meta-model does not cover network service composition. This aspect must be added into the architecture description and scope in order to enable interoperability and compatibility at the multi-tenant and multi-provider service composition level while ensuring independence of users and providers.

3 Debate on Needed Improvements

To facilitate the adequate support of different data and infrastructure ecosystems, there is the need to support, in GAIA-X, an atomic network service composition. The latter integrates both functional and non-functional service requirements and has the capability to integrate meta-data, e.g., in the form of intents; offering the capability to consider abstract descriptions of the networking service components, and also their functional requirements. For this purpose, specific improvements are debated next.

3.1 Functional Elements Composition

A first improvement is to adopt an *Interface Definition Language* (IDL) to support network service composition. Moreover, *Data Modeling Languages* (DML) such as the *Yet Another Next Generation* (YANG) model both configuration data as well as state data of network elements. These are aspects, which are relevant to support, for instance, non-functional QoS requirements, and should also be considered in the network service composition framework of GAIA-X.

Applying IDLs and DMLs assist in a better intertwining between the networking services and upper layer services, thus contributing to bringing in more flexibility to the GAIA-X architecture.

Ontologies will help to assure coherent and compatible results by design. For networking services, these ontologies shall cover the classes and fields that make up the interfaces.

In addition to a non-constraining IDL, the overall networking service description framework needs to be agreed upon. This requires identification of the underlying fundamental services to compose and manage the life cycle of application level services and network level services (also known as network services nowadays). Examples of available service description frameworks that are relevant to consider in GAIA-X are, for instance, the OASIS Topology and Orchestration Specification for Cloud Applications (TOSCA)[1], in regards to network service management and orchestration; the ONF[2] Software Defined Network[3] (SDN) architecture and the ETSI Standards

1 http://docs.oasis-open.org/tosca/TOSCA/v1.0/TOSCA-v1.0.html
2 https://opennetworking.org/
3 https://opennetworking.org/sdn-definition/

for Network Function Virtualization (ETSI NFV)[4]. SDN supports the means to dynamically control and provision networks as a service; NFV provides the capability to manage and orchestrate resource virtualization on the network and their composition into higher-layer network services. While state of the art work needs to be accommodated, there is also the need to evaluate, which languages could better suit the description of networking services, for the specific context of GAIA-X use-cases.

3.2 Non-functional Elements Composition

Composition of non-functional elements for network services and going beyond to application level services or end user services, must be addressed via a common framework. Such framework needs to integrate network service composition, orchestration, and service life cycle management principles.

The GAIA-X process for such composition should ideally be specified and illustrated via a set of appropriate use cases, selected to lead to completeness. This requires that the fundamental and atomic services and processes, needed to compose network services, are fully identified and specified.

To provide flexibility to integrate non-functional requirements, the selected IDL has to be coupled with a DML to be able to integrate non-functional elements (properties, intents, attributes). Such a network composition framework needs also to accommodate schema translation in real-time. Another aspect that needs to be considered is the need to accommodate dynamic offloading of services between GAIA-X nodes.

3.3 Flexible Networking Services Offering

A crucial aspect to achieve an adequate network service composition is to integrate support for an adequate intertwining of networking services and application level requirements. This is a must if the objective is to enable autonomic composition of services based on service self-descriptions.

Thus, both semantic and syntactic interoperability needs to be ensured. Specifically, an adequate and semantic support for several communication protocols available is required. This relates with the OSI Layer 2 and 3 communication aspects, but it has also to accommodate additional protocols, like the support of IP-based messaging protocols such as MQTT/AMQP/ZeroMQ; Publish/Subscribe communication architectures, such as OPC UA or even novel information- centric networking architectures, such as NDN/CCN. Each use case has its own set of building blocks, so the interconnection services should cover diverse scenarios ranging from a single point to point connection to complex multi-point architectures, also considering host-reachability and content-oriented developments as well. Examples for creating those different architectures cover the open IX-API[5] as well as solutions from the area of SDN, to flexibly interconnect and configure these architectures.

By addressing network service composition and providing adequate interfacing derived from IDLs/DMLs, it is feasible to accommodate reliability, offloading of services without requiring, for instance, changes to the descriptions of the respective network interfaces and interconnections.

For this to be possible, the interconnection services need to be composed according to customers' requirements and applications being served.

Semantic and syntactic interoperability needs therefore to be addressed also by ensuring that the described networking and interconnection services can be adequately associated with self- descriptions, offered as GAIA-X services, so that they can be looked up in the catalog and can be used in composing more complex services by GAIA-X users.

4 https://www.etsi.org/technologies/nfv

5 https://ix-api.net/

4 Summary: Benefits of Network Service Composition in GAIA-X

Throughout the previous sections, we discussed the need to consider network service composition as part of the GAIA-X architecture. We highlighted initial aspects to address, pinpointing specific operational solutions that can support the development of such a network composition framework.

Our take is that it is feasible today to assist in a more flexible description of network and interconnection services in GAIA-X, in a way that enables and facilitates interoperability. By composing GAIA-X services with already interoperable building blocks, widely used by Cloud Service Providers or Interconnection Service Providers, we can guarantee the conditions for interoperability of GAIA-X composed services. One of the main goals of the entire GAIA-X project.

Still, GAIA-X also has to guarantee that its policy rules will protect the end user. Therefore, the network service composition is a way to avoid the black box effect of overall service definition.

This black box effect exists already for SaaS and IaaS services, but it is easier to expose it in the framework of IaaS policy rules. IaaS policy rules imply that users can define the country where their information may legally be stored, assuming a storage service. However, Cloud Storage Services are not only Storage Services because the only way to access or store the data is through a networking service. Networking services are a key component of Cloud-Edge offerings.

Technically speaking, a Cloud or Edge service (e.g., storage, computation) exposed to the user is **always** a composition of a network service, and an Application Level service. But only the external network attributes are observable by the user. To certify an application level service against GAIA-X IaaS policy rules, all the interconnections between networking services and application level services must be described in a unique way.

A network service composition framework is an elegant and flexible way to describe such interconnections between services at an infrastructure and data level.

GAIA-X users may have for sure other needs than purely functional ones, but we may consider that the GAIA-X Federated Catalog should also address requests that are purely functional. By purely functional, we mean that neither providers nor locations are defined in the request, but just the need to implement a defined functionality. Here, networking service composition will guarantee that end user requests will be defined in a way that does not provide advantage or does not enhance the position of any Cloud/Edge provider or of any particular services, by adopting an objective data model to interrogate the Federated Service Catalog.

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