Vision Paper

Hub the Netherlands

How Gaia-X could foster the unbundling, composability and switchability of digital service offerings

A technical perspective on modularity of multi-provider software and infrastructures to enable future sustainable digital ecosystems

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This vision paper uses the official documents published by the Gaia-X AISBL, and the contributions to this work were fully sponsored by TNO. The vision presented will be shared with the Gaia-X international community to foster discussions around the modularity and switchability of digital services and how the Gaia-X core elements can be applied in this. Regarding the technical switching barriers in the current cloud landscape we adopted the situation and challenges described by the Market study into cloud services[1]. Moreover, the importance of portability to establish a more competitive market for cloud computing services was stressed by a published non-paper containing recommendations for the Data Act by the Dutch Government[2]. The recommendations presented were taken as driver for the analysis presented in this paper.

The authors of this paper are open to receive comments and feedback on the vision and viewpoints presented.

[1] Market Study Cloud Services of The Netherlands Authority for Consumers and Markets (ACM), 05/09/2022, https://www.acm.nl/en/publications/market-study-cloud-services

[2] Non-paper on the Data Act as attachment of the Informele Telecomraad, 14/10/2021, https://www.rijksoverheid.nl/documenten/kamerstukken/2021/10/01/bijlage-non-paper-on-the-data-act

About this vision paper

Ongoing digitalisation increases the dependence on cloud infrastructure and services, a market currently characterized by its **PLATFORM LOCK-IN EFFECTS** and its dominant share of non-European providers. The European Union sees a number of risks with this dependency and focuses on increasing the digital sovereignty by supporting interoperability initiatives and through the creation of new regulations. This document describes a technical viewpoint on how the Gaia-X initiative could enable sustainable digital ecosystems in the cloud market through unbundling, composability and switchability of service offerings. The target audience of this document are software architects familiar with the basic concepts and artifacts of Gaia-X. Moreover, the document provides various perspectives on digital infrastructures that aim to connect technology developments – in a simple and structured manner – with the expected future demand coming from the IT policy and (regulation) compliance domains.

We present three technical levels of unbundling: two different levels that decouple vertical offerings, and the horizontal decoupling between individual software resources. The technical levels of unbundling are described by the *resource* subtypes originating from the Gaia-X Architecture Document. Based on the three layers of unbundling, we define five **SWITCHING SCENARIOS** that can be performed in the unbundled landscape of cloud services. The objective of these switching scenarios is to facilitate discussions on the composability and *re*composability of service compositions. Moreover, the switching scenarios can also be used to describe the ability to connect or transfer services within the ecosystems.

Furthermore, we describe a preliminary approach how transfer or switching information could be described by means of the **GAIA-X SELF-DESCRIPTION** concept. The proposed **TRANSFERABILITY-LEVELS** can be used to denote the involved complexity to switch a certain service. This way consumers within the Gaia-X ecosystems benefit from transparent information to prevent future technical lock-in situations. When cloud switching regulations will be effectuated, the same information could be used by providers to show conformance for each individual service offering. We also show how the Gaia-X federator concept could help providers in this process. Both *with* and *without* active regulations in the area of cloud switching, Gaia-X could positively influence the current market dynamics. Additionally we show how the concept of **OPERATIONAL MODULARITY** relates to three characteristics of the current cloud market: *Network Effects*, *Vertical Integration* and *Barriers to entry*, based on a recent study of Netherlands Authority for Consumers and Markets. To mitigate the effects, the granularity of the service offerings is an important aspect that should be balanced such that both easy adoptability and the desired effect in the market is achieved.

Introduction

The expansion of the digital transformation forces business, politics and individuals to establish - and rethink - our **European values and principles in the digital landscape**. The dependence on digital infrastructures of the society as a whole increases, and the digital landscape itself is subject to continuous movement. Under the umbrella terms Digital Sovereignty[3] and Strategic Digital Autonomy[4] the European Union is planning and executing actions that aim to empower citizens and businesses to remain in control of their assets in the digital space.

An important aspect of digital sovereignty is the ability to have an open choice in selecting and composing digital services from various providers based on own preferences. Technical or business-level lock-ins should not prevent consumers from using additional services from other providers and connecting them with existing digital assets. Moreover, consumers should be able to switch between offerings from one provider to another. A sustainable digital economy demands **an open choice to prevent winner-takes-all effects**: Digital services should be able to travel between various infrastructure-providing entities, and that data should not end-up in silos that can only be used by a single organization.

Discussions concerning the **dynamics in the market of cloud services** happen on both the provider and consumer side of the value chain, as well as from a governmental perspective. In 2020 the 27 member states signed the 'declaration on EU cloud federation' with one of the main objectives to establish a greater choice regarding the trustworthy data processing infrastructure and needed services[5]. The IPCEI Cloud Infrastructure and Services[6] that aims to start in 2023 also addresses interoperability as one of the key points, and aims to develop new functionalities for seamless switching between providers[7]. At the consuming side, the "open choice"-topic is also becoming more prominent. For instance, *'Ensure easy switching to avoid lock-in'* is one of the 11 fair principles in B2B relationships between business users and their cloud providers that is jointly published by several sector representatives[8]. At governmental level the EU is targeting a new middleware layer within the

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[3] "'Digital sovereignty' refers to Europe's ability to act independently in the digital world and should be understood in terms of both protective mechanisms and offensive tools to foster digital innovation (including in cooperation with non-EU companies)" Source: Digital sovereignty for Europe, https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/651992/EPRS_BRI(2020)651992_EN.pdf

[4] "Strategic Autonomy refers to the ability of the EU and its Member States to independently set objectives and act upon them according to European interests. [..] High market concentration can lead to excessive reliance on a single provider or solution – so-called digital 'monocultures' – thereby exacerbating cybersecurity risks and reducing resilience in case of technical failures or system-specific attacks." Source: Rethinking strategic autonomy in the digital age, https://op.europa.eu/en/publication-detail/-/publication/889dd7b7-0cde-11ea-8c1f-01aa75ed71a1

[5] 15th of October, the Commission welcomes the Joint declaration by 27 EU Member States on building the next generation of cloud in Europe. Source: https://digital-strategy.ec.europa.eu/en/news/commission-welcomes-member-states-declaration-eu-cloud-federation

[6] "12 EU Member States join forces to create a common cloud and edge infrastructure and its associated smart services for the future" Source: https://www.bmwk.de/Redaktion/EN/Artikel/Industry/ipcei-cis.html

[7] IPCEI on Next Generation Cloud Infrastructure and Services (IPCEI-CIS) – Working Paper: "High interoperability and portability of services and data among all cloud-edge users and providers enabling seamless shifting between providers and overcome vendor lock-in for users". Source: https://www.bmwk.de/Redaktion/DE/Downloads/I/ipcei-cis-value-chain-description.pdf?__blob=publicationFile&v=8

[8] Source: https://www.cio-platform.nl/k/en/n626/news/view/11618/6599/business-users-associations-call-for-a-balanced-cloud-market-11-fair-principles-to-unleash-europe-s-digital-potential.html

Simpl project enabling federation across multiple providers[9]. Finally, at regulatory level the proposed regulations in the draft Data Act[10] aim to do several interventions in the market to, for instance, improve switching between data processing services[11]. Through these new regulations the EU will replace the self-regulatory approach that is currently formalized through the SWIPO initiative[12].

Federations and Gaia-X

The mission of Gaia-X is to create an open, transparent, and secure federated digital ecosystem. The Gaia-X Vision and Strategy document provides a definition of the term *federated* as shown in Citation 1. It presents two directions on interoperability: The concept of a distributed cloud model is presented to join up infrastructures within the first part, while the second part addresses the data exchange layer enabling applications and users to utilize data across multiple providers. Both perspectives of the *federated* definition require specific attention to make consuming services from multiple providers feasible without any technical burdens. **UNBUNDLING, COMPOSABILITY AND SWITCHABILITY ARE ESSENTIAL SYSTEM-DESIGN CONCEPTS TO IMPLEMENT THE OVERARCHING CONCEPT OF FEDERATION.**

Federated: *Gaia-X promotes and implements the concept of Federations.* ***[1]*** *Through Federations, service providers can join up their infrastructures in a trusted manner, to offer a distributed cloud model.* ***[2]*** *Through Federations, data owners (users) can exchange and utilise their data with commonly agreed upon rules and control on whom and for what to grant access. [..]*

Citation 1 Definition of 'Federated' that indicates two perspectives within the Gaia-X Vision & Strategy document[13].

This document describes a technical viewpoint on how the Gaia-X initiative could improve the dynamics within the current cloud market. We approach the concept of a federated ecosystem from the objective that consuming entities within future ecosystems have an open choice in selecting and composing services tailored to their demand, independently from the number of providing-entities needed. At the providing side of the value chain this should result in the situation in which network effects are reduced and entry barriers for new providers within the market are very limited.

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[9] Simpl is the smart middleware that will enable cloud-to-edge federations and support all major data initiatives funded by the European Commission, such as common European data spaces. Source: https://digital-strategy.ec.europa.eu/en/news/simpl-cloud-edge-federations-and-data-spaces-made-simple
[10] Data Act: Commission proposes measures for a fair and innovative data economy, https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1113
[11] Proposals specific object no 3 *"Facilitate switching between cloud and edge services"*, and *"With regard to cloud services, as the self-regulatory approach seems not to have affected market dynamics significantly, this proposal presents a regulatory approach to the problem highlighted in the Free Flow of Non-Personal Data Regulation"*. Source: Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on harmonised rules on fair access to and use of data (Data Act), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:68:FIN
[12] SWIPO (Switching Cloud Providers and Porting Data), is a multi-stakeholder association facilitated by the European Commission, in order to develop voluntary Codes of Conduct for the proper application of the EU Free Flow of Non-Personal Data Regulation / Article 6 "Porting of Data". Source: https://swipo.eu/about-2/
[13] Gaia-X, Vision & Strategy, Francesco Bonfiglio, CEO Gaia-X, December 16, 2021, https://gaia-x.eu/sites/default/files/2021-12/Vision & Strategy.pdf

The starting point of the document is the conceptual model of the Gaia-X Architecture Document, followed by an analysis of various directions with which unbundling can be achieved. An explorative analysis is made in how unbundling and the size and scope of services (i.e. the granularity of services offerings within the ecosystem) relate to the market dynamics. Based on the unbundling perspectives, a series of switching scenarios are described. The document concludes with a proposal on how the labeling framework and the architecture can incorporate switchability-information of the individual services.

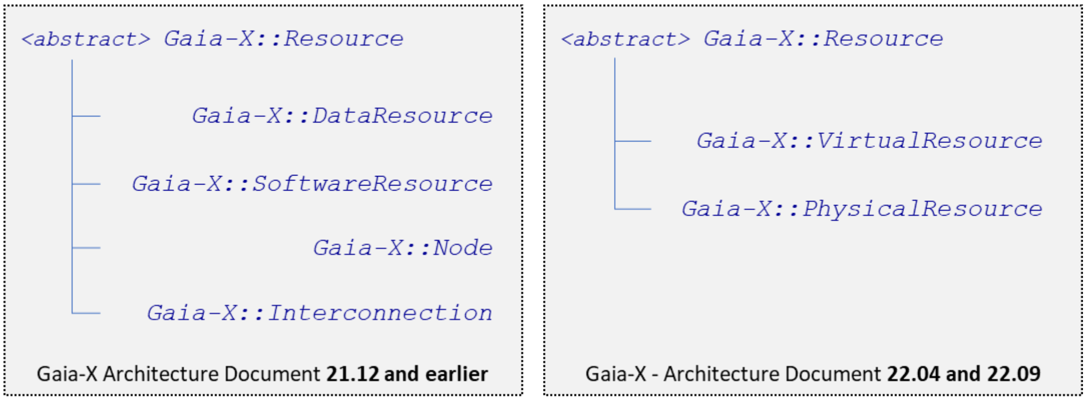
Gaia-X conceptual model as foundation

Gaia-X is described by various documents that together prescribe how – and under which conditions – a digital ecosystem operates. The documents used within this paper are the Architecture Document (AD), the Policy Rules Document, and the Labelling Criteria Document.

The AD describes the technical architecture of Gaia-X, including the conceptual model, proposed entity descriptions and an operational model. The Policy Rules Document defines objectives to safeguard European values in Gaia-X service offerings. The Labelling Criteria Document is meant to standardize the information (labels) presented in service offerings, this to enable qualified choices based on correct and transparent information within the procurement phase of cloud components or services.

The conceptual model sets the basis for all types of relations that can be described within the architecture, the policy and rules, and also the labelling framework. This way, the concepts and definitions in this model set the fundament for all future data driven ecosystems that are defined by federators using the Gaia-X federated data infrastructure.

In the update of the AD from version 21.12 to 22.04, the abstract property *resource* has been enhanced. In version 22.09 the *resource* concept has been left unchanged and defines the same implementations as within version 22.04: *VirtualResource* and *PhysicalResource*, as shown in Figure 1. While in version 21.12 and earlier four types of possible implementations were defined: *DataSource*, *SoftwareResource*, *Node* and *Interconnection*.



- ***Rich model***
- *Ability to express properties of four key assets within a digital ecosystem*
- ***Unbundling and modularity aspects can be described from various perspectives***

- ***Simplified model***
- *Ability to differentiate between the virtual and physical domain, relevant for a number of trust and legal aspects*

Figure 1 Different taxonomy for Resource between AD 21.12 and earlier versions, and the AD 22.04 and 22.09.

In the rest of this document we will use the 21.12 version of the model as this version provides us a better way to describe different perspectives on unbundling and modularity within federated data ecosystems. Furthermore, we use the corresponding definitions of these four resource-types from earlier versions of the AD:

- DataResource: Data (in any form) with corresponding information needed for data sharing. Can be existing data that is needed for the services (e.g., ML training sets) or generated by the used services.
- SoftwareResource: Any type of non-physical functions (can be the actual service implementation but also software infra components).
- Node: Computational or physical entity that hosts, manipulates, or interacts with other computational or physical entities.
- Interconnection: Connection between two or more Nodes (usually across different infrastructure domains). Can be seen as a path with special characteristics (e.g., latency, bandwidth, and security guarantees).

These resource types can be seen as key building blocks within a software engineering project that aim to deliver an operational service to a consumer. Figure 2 shows how these resource types are used in an engineering lifecycle. The diagram provides two cloud delivery models: The top model describes the traditional relation of a service consumer that uses a service of single provider. In this situation, guarantees, agreements and related information to the service offering is encompassing all resource types that are needed to deliver service to the consumer. The relation between the consumer and provider is a simple one-to-one relation. In contrast, the model at the bottom describes the federated approach, this model starts with a *(1)* demand for a certain application or service, *(2)* followed by a multi-provider integration phase, resulting an *(3)* integrated software-as-a-service offering, and finally *(4)* a delivered service in which certain level of guarantees can be given to the consumer of the integrated service. The main difference of the federated approach as opposed to the traditional model is within the second step of the workflow. In this step the conceptual model allows to describe elements coming from various providers. The Gaia-X self-descriptions catalog enables the trustworthy discoverability of resources in such multi-provider compositions.

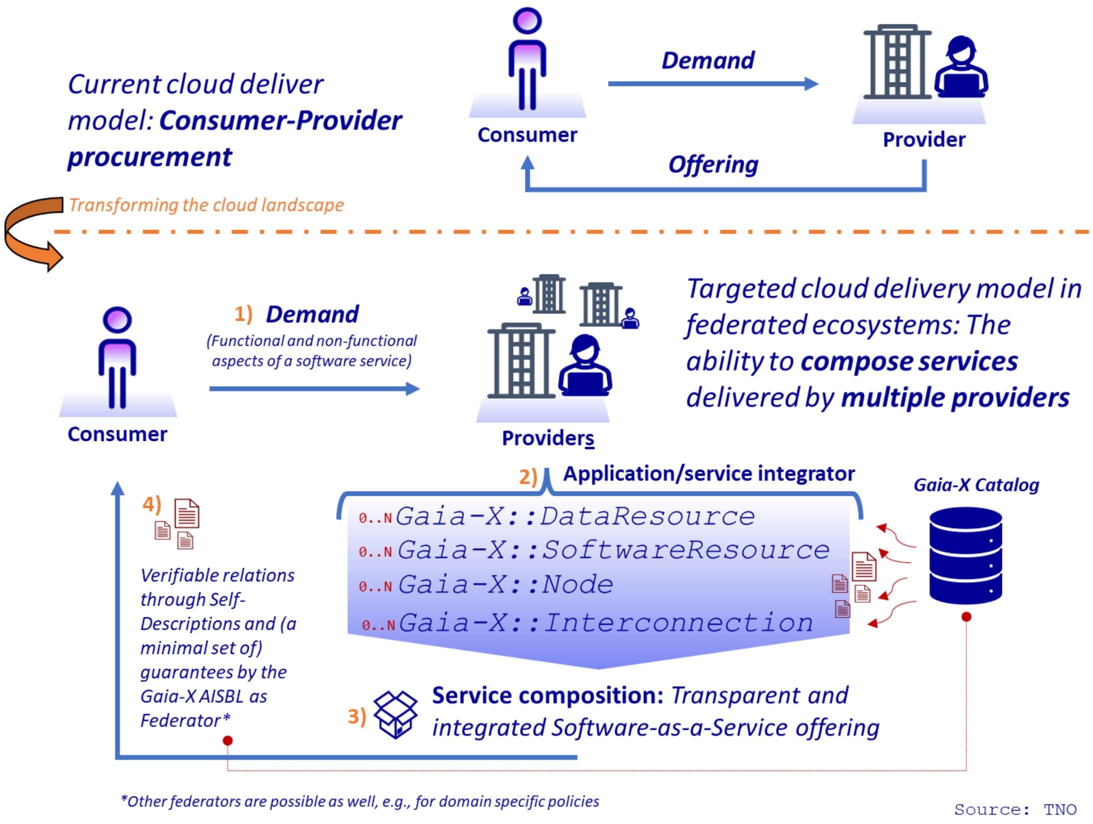


Figure 2 Description of the workflow before and after the application of federated ecosystems. In the targeted delivery model consumers are able to compose their solutions based on resources delivered by multiple providers.

Beyond the resources, the conceptual model consists of the core elements *Participant*, *Federator*, *Provider*, *Consumer* and *Federation Service*. *The Federation Services* are strongly interlinked with the *Service Compositions* defined by the *Providers*. In Figure 3 we show a part of the conceptual model proposed in the AD, drawn in such a way to make it clear that the defined *service offerings* within the ecosystem can be composed among different providers.

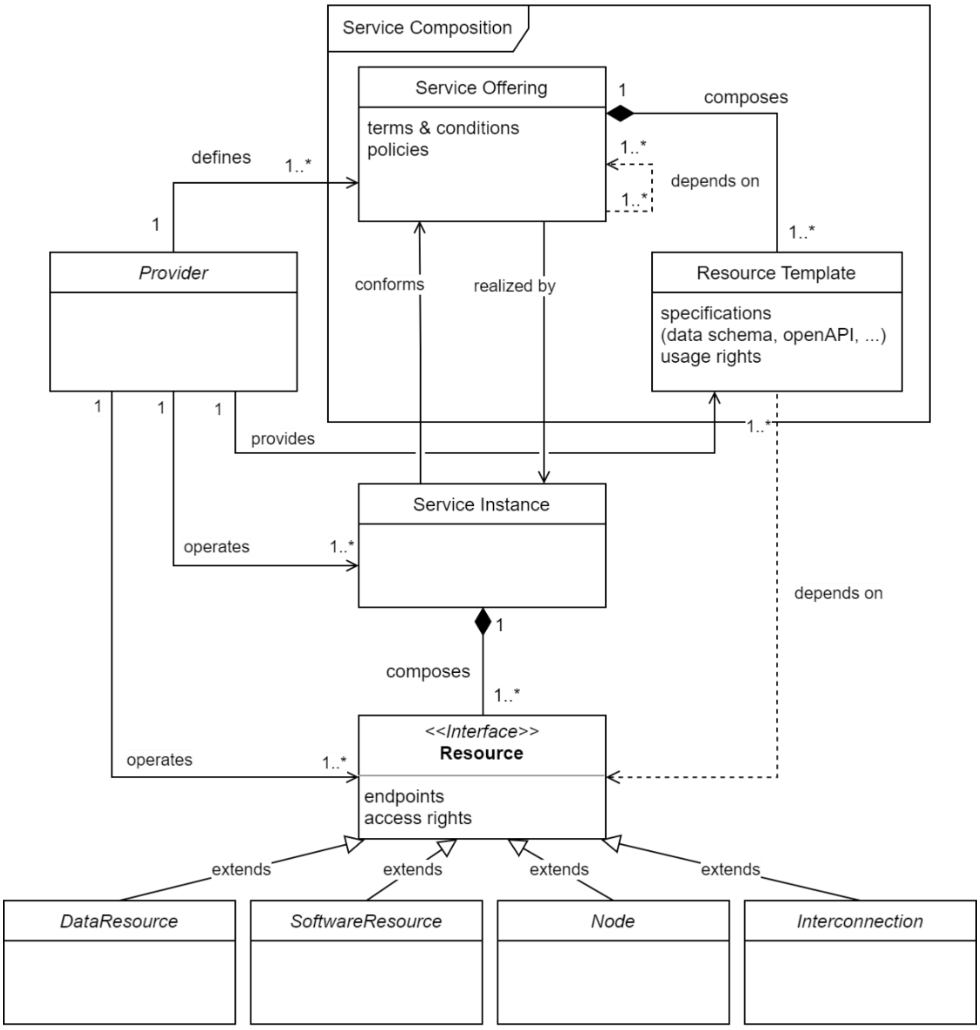


Figure 3 Relevant extract from the conceptual model of the AD detailing the multi-provider compositions

In the following sections we denote each resource by the icons defined in Figure 4. These four types of resources form the basis to describe the different perspectives on modularity and later on the different types of switching scenarios.

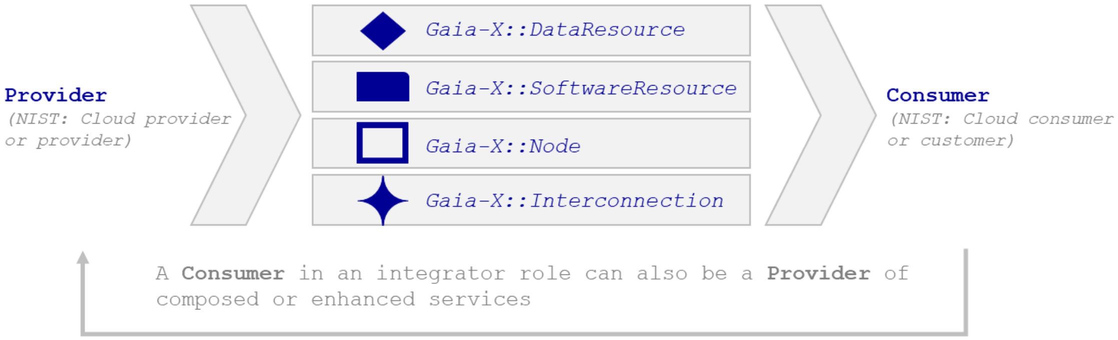


Figure 4 Legend for conceptual elements of Gaia-X used by this document – visualized in the provider-consumer value chain. The Provider and Consumer synonyms are taken from the NIST glossary[14].

[14] Provider and consumer definitions taken from https://csrc.nist.gov/glossary

Modularity and unbundling

In software architectures, modularity is an essential design technique to simplify the ability to replace individual elements. The shift from monolithic architectures to microservice-oriented architectures improved **MODULARITY WITHIN THE DESIGN PHASE** of software applications. Beyond the design and implementation phase of cloud and edge applications, there is a need to have a sufficient level of modularity in the post-deployment phase. In this phase the application is operational and in use. Nowadays it is common that many of the service offerings in the cloud landscape are bundled compositions of services that are all provided by a single provider. Figure 5, Figure 6, and Figure 7 use the resource elements of the conceptual model to describe three different perspectives of unbundling. The objective of these three projections is to enable the ability to express the **OPERATIONAL MODULARITY** within future Gaia-X ecosystems. Describing the operational modularity by means of the proposed projections enables federators to define rules so that the two-fold definition of *federated* given in Citation 1 in the introduction can be accomplished. The first angle of the definition requires an appropriate level of vertical unbundling, while the second angle addresses the need for horizontal unbundling at the data exchange layer. These unbundled viewpoints are being used later on in this paper to describe switching scenarios.

The first unbundling-projection is the **DECOUPLING BETWEEN SOFTWARE RESOURCES AND THE NODES** within the ecosystem, as shown in Figure 5. For a long time, this perspective has been studied at various levels ranging from the portability of programming languages, the POSIX-level standards, and at virtualization level by formats like OVF, and with also the recent OCI Distribution Specification for containers. Nevertheless, modern cloud native application architectures and applications that consist of cloud platform-level integrations face new practical challenges that limit the ability to transfer the operational workloads. Also, higher in the stack, new types of AI workloads demand a similar level interoperability and portability at the level of AI-models that goes beyond the classic compute workloads. In this area new open standards like ONNX emerge that aim to improve the interoperability between frameworks and cognitive service platforms.

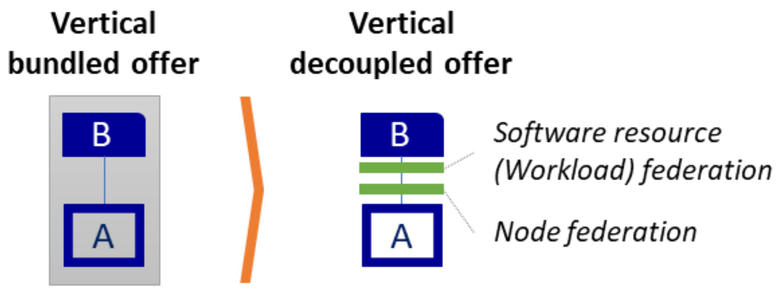


Figure 5 Vertical unbundling – level 1: From integrated services to decoupled software and node offerings.

The second level of vertical unbundling is shown in Figure 6, this viewpoint **UNBUNDLES THE INTERCONNECTIONS FROM THE NODES** within the ecosystem. For data centers this comprises the physical carrier level, it allows the users of the nodes to switch between the various carriers of the data centers without the need to make changes at node or software resource level. For the mobile and IoT domain, ever evolving standards enforce a natural decoupling between various network carriers for telecom, business, and home networks.

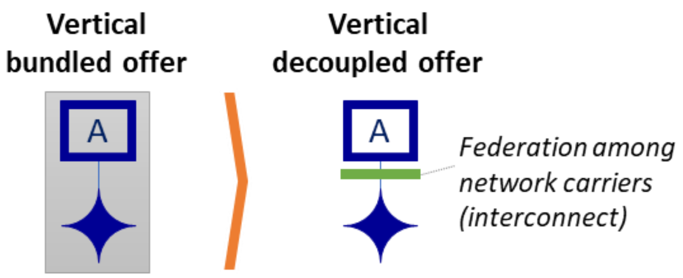


Figure 6 Vertical unbundling – level 2: From interconnected nodes being part of bundled offers to decoupling between interconnect and node provider (in switchable or multi-carrier scenarios).

The last level of unbundling is depicted in Figure 7. This perspective **DECOUPLES INDIVIDUAL SOFTWARE ASSETS** from each other. This enables providers of individual software modules or entire application suites to make seamless integrations with software assets delivered by other providers. This viewpoint involves both integrating software modules within a hosted application as well as constructing data pipelines across applications hosted by different organizations. In this the main objective of organizations is to get the most value out of the available data assets by enabling the creation of data integrations that go beyond closed data silos. Furthermore, it improves the replaceability of individual software resources and fosters the competition between software providers to create the best service implementations possible, ensuring that the maximal value can be extracted from the available data.

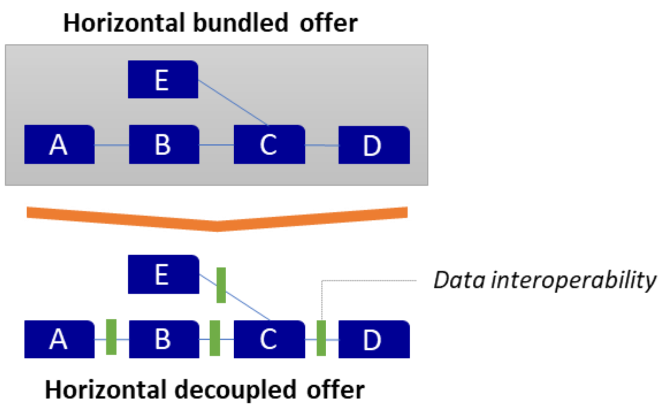


Figure 7 Horizontal unbundling: From integrated software assets to decoupled service offerings.

Effect of service granularity on market dynamics

In a sustainable digital market, consumers of services should have the ability to create and enhance service compositions that are offered by multiple providers. However, the combination of economies of scale, **NETWORK EFFECTS** and **VERTICAL INTEGRATION BY LARGE OPERATORS** result in **ENTRY BARRIERS** in the current cloud market[15]. These three negative characteristics limit the open choice of consumers. Figure 8 shows how improved – or even regulated - operational modularity can have a positive impact on the three presented characteristics in the current market.

[15] ACM Market study into cloud services, section 5 Market characteristics: "[..] the main economic characteristics that affect the market dynamics: [..] economies of scale, network effects, and integration. [..] Together these characteristics result in barriers to entry." Source: https://www.acm.nl/en/publications/market-study-cloud-services

Market characteristic	*Relevance of operational modularity to mitigate the negative effects*
Network effects	- Reduces technical impact of using a specific service from another provider, i.e. by means of having interoperability between the individual modular elements enabling multi-provider service compositions. - Interoperable (switchable) modular elements can eliminate the network effects coming from vendor-specific marketplaces for digital services.
Vertical integration by large operators	- An enforced (*regulated*) form of modularity can enforce the unbundling of providers within the market. The draft Data Act proposes standardization activities in this area. - Enforced (*regulated*) separation(s) based on independent (modular) responsibilities can reduce the current conglomerate effects.
Barriers to entry	- Providers can easier start new (innovative) businesses for an individual puzzle piece instead of producing entire puzzle.

Source: TNO

Figure 8 Relevance of operational modularity to mitigate the negative effects in the current cloud market. The characteristic 'economy of scale' is left out as it is not a direct technical relation with operational modularity.

Having modular services that are interoperable and/or exchangeable does not lead to a different market dynamic in all cases. To enable fair compositions at the level of individual services, the granularity of the service offerings will be an important factor that determines the position of the individual players within a market or specific ecosystem. Therefore, it is important that the granularity of *individual service*-offerings and *composed service*-offerings will be transparent among all participants in the ecosystem. The **DESIRED LEVEL OF GRANULARITY OF INDIVIDUAL SERVICES** is a subjective matter. Especially at the level of Nodes and Software Resources it is important to make a good balance of individual service elements. From the perspective of modularity, a fine-grained approach might look optimal as it might be easy to replace individual services. On the other hand, a course-grained approach is likely to improve the developer-friendliness and therefore simplifies the adoption. Trade-offs in this area are very similar with the software design decisions in which architects aim to find the perfect size of a microservice within enterprise software architectures. Similar principles apply to the modularity of Data Resources: the broader the domain of a dataset is, the more complex it will be to shift to another data provider. In contrast, with a fine-grained approach in which the scope of an individual dataset is very tailored, the ability to switch data providers might be improved. However, this increases both the administrative and technical overhead for each service within the ecosystem, and thereby it would affect the usability and adoptability of the technology in a negative way.

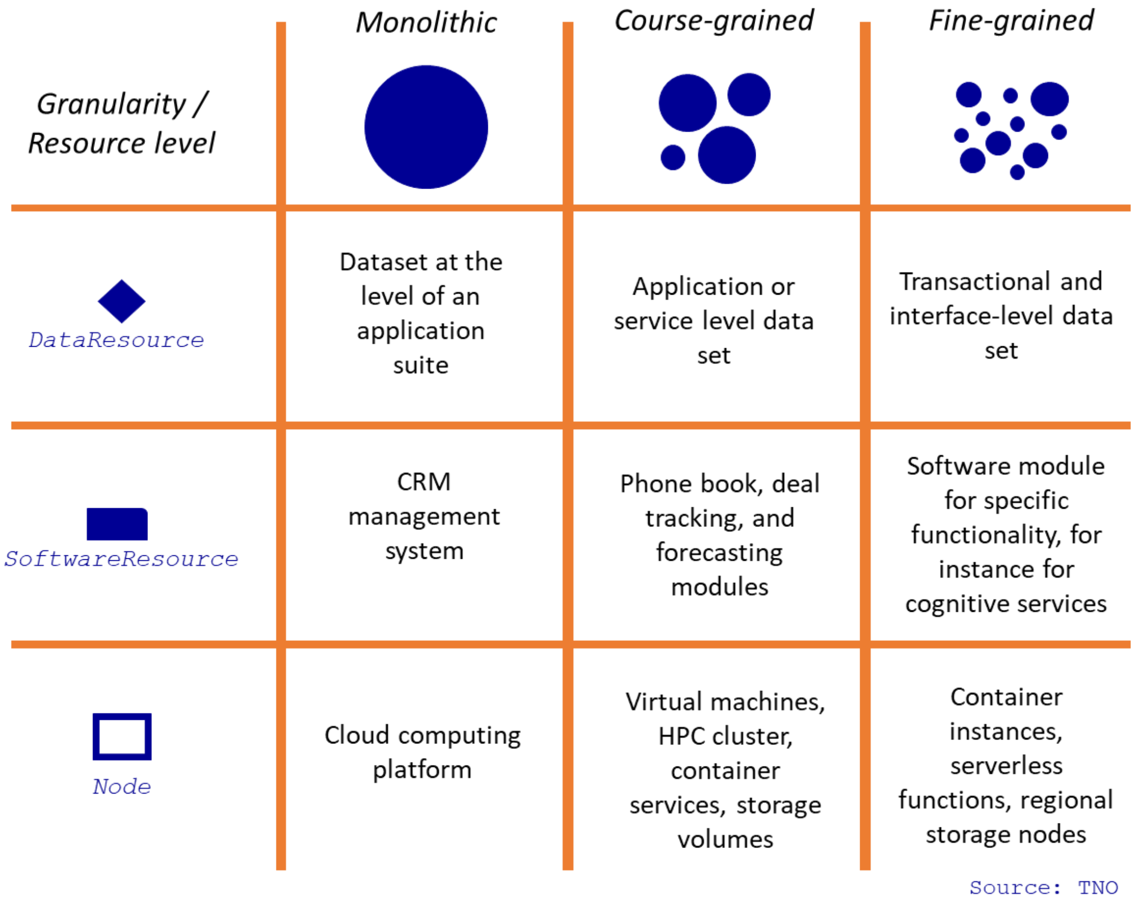


Figure 9 Examples of data resources, software resources and nodes for each level of service granularity.

Figure 9 provides indicative examples for three different levels of granularity for the resource types DataResource, SoftwareResource, and Node. In this diagram the size of the circles reflects the size of the functionality that is modular across providers. This does not relate to the size of the organization that provides the functionality within the ecosystem. On the left, in the monolithic scenario, services within the ecosystem are large and all-encompassing, complicating the replaceability of the concerned service. The complexity of switching between providers, as well the inability to construct compositions among multiple providers, results in low economic traffic between providers. This is depicted on the left side of the diagram in Figure 10. In contrast, the fine-grained approach enables modularity at micro-level, but at the same time it might result in an overshoot in which overengineering results in a lower market adoption as depicted by the right pane of Figure 10. In the middle area there is a **SUSTAINABLE BALANCE BETWEEN THE MODULARITY OF INDIVIDUAL SERVICES**, while the increased complexity introduced by service management within the federated ecosystem is still acceptable. Furthermore, in this area new challengers can enter the market, because their added value of the new or competing service is high enough to acquire a profitable position as a new player. In the right pane the fine-grained service elements might become too fragmented such that new competitors are not capable of constructing a business case of an appropriate size.

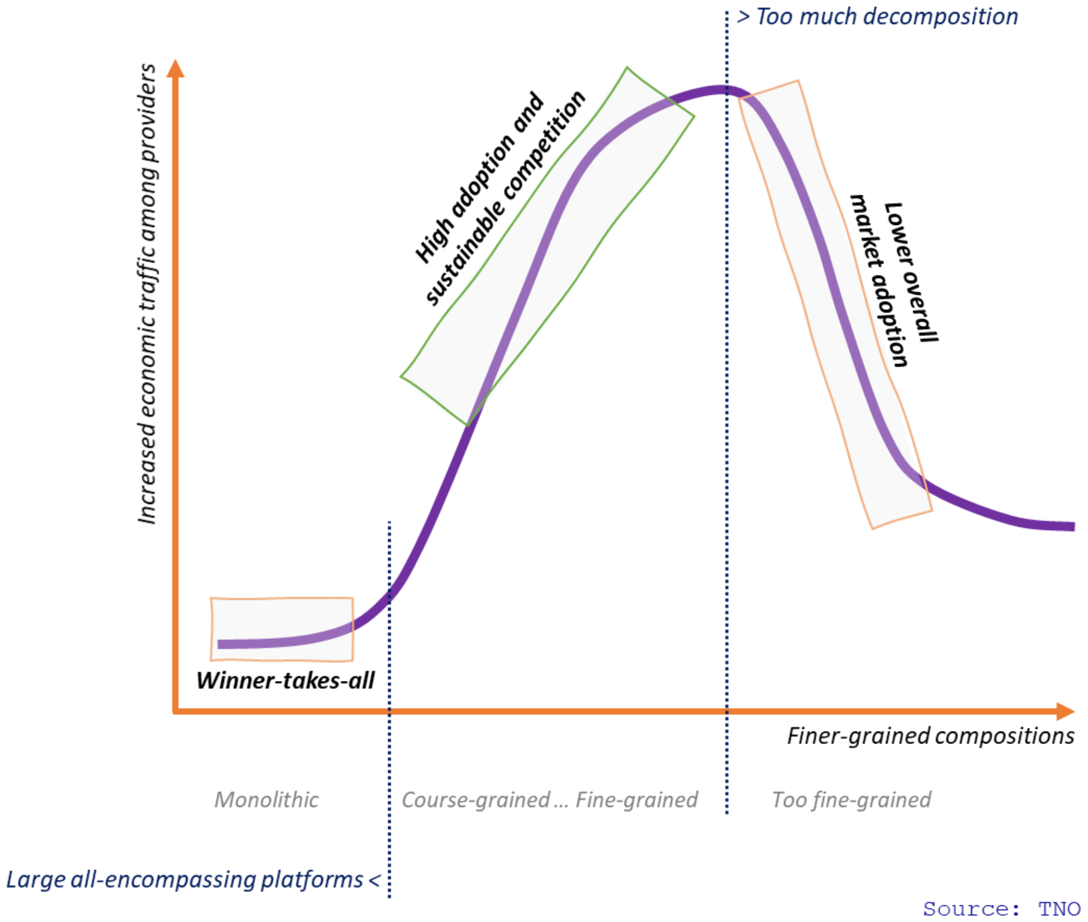


Figure 10 Expected influence of the granularity of the service-compositions on the market dynamics of the digital economy.

Cloud switching scenarios for unbundled service offerings

The previous two sections describe respectively the concepts of unbundling and operational modularity, and the relation of these concepts with the actual and targeted market dynamics. On top of these described concepts it possible look to the actual switching scenarios within such unbundled service offerings. These switching scenario's describe the technical ability of a service consumer to switch provider of a certain modular element, and at the same time it also implicitly defines the ability for newcomers to obtain a position within an ecosystem of existing service offerings.

From a regulatory perspective, the cloud switching scenarios could implement a (part of) the proposed regulations within **ARTICLE 26 OF THE DATA ACT**[16]. This draft regulation aims to make the shift from one provider to another possible without making any significant changes to software

[16] Chapter VI, Switching between Data Processing, Article 26 Technical aspects of switching, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:68:FIN

and/or configurations. It also states that after the completion of a transfer, the customer must receive functional equivalence. The Act poses that functional equivalence is required for data processing **SERVICES OF THE SAME SERVICE-TYPE**. Given the conceptual model of Gaia-X it is possible to map the definition of the same service-type for the three elements: Software Resources, Nodes, and Interconnections. Table 1 provides a possible interpretation on what the characteristics are of a service of the same service-type for each resource perspective.

Resource	*Characteristics of resources of the same Service-Type*
DataResource	Undefined by the Act as it only defines service types in relation to data processing services, not datasets or data elements itself.
SoftwareResource	Software modules or applications that provide functionality with the same primary objective.
Node	Node with the same primary objective (e.g., storage lake, VM-level processing, container/cluster, graphical/AI processing nodes).
Interconnection	Interconnection that can deliver connectivity between the same nodes or group of nodes.

Table 1 Interpretation of the meaning of Service-Type within the conceptual model.

For the above resource types the following sub sections describe the possible scenarios for switching service – possibly between providers.

Switching Software Provider

The first scenario concerns switching a SoftwareResource built and/or maintained by one provider to another of the same-service type. We can distinguish between stateful services (where a provided service must retain some data between use) and stateless services (where each use is independent). A switch between providers for a stateless service is shown in Figure 11. Here the SoftwareResource B is swapped for B’. Since there is no state, this switch will be straightforward. An example of such a switch could be for a weather data API, where service A requests the weather at a specific location, which both B and B’ can provide.

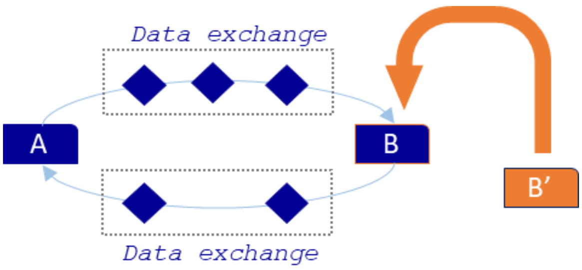


Figure 11 Switching software provider B to B’ in a stateless relation.

A switch between providers for a stateful service is shown in Figure 12. Before the switch from B to B’ can be made, the state of B’ must be brought up to date. Otherwise B’ would not be able to provide the same functionality as B (either due to data loss or lower quality results). This synchronization could be done from A to B’ or from B to B’ directly. As an example, B and B’ could provide appointment booking functionality. If B’ is not made aware of appointments previously booked through B, double bookings can occur.

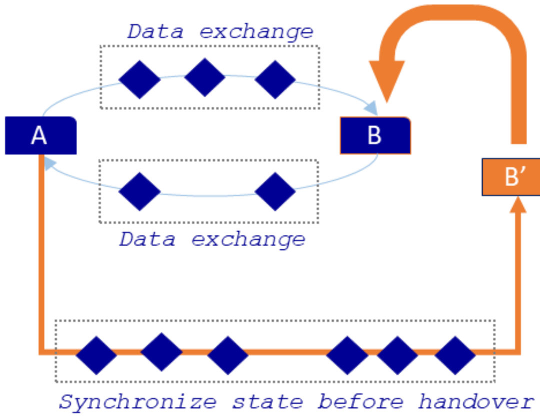


Figure 12 Switching software provider B to B' in a stateful relation.

Switching Node Provider

The next category is switching to another Node provider. This is again more straightforward for stateless services. Figure 13 shows a stateless SoftwareResource on top of node A, which is then switched to node A'. In the physical deployment it is of course not the Node that is switched from under the software, but the software is started at the new node, and stopped at the old node. As an example, a containerized software could be running on a (proprietary) Kubernetes cluster of one cloud provider in which this will be transferred to a Kubernetes cluster of another cloud provider.

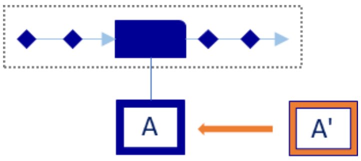


Figure 13 Switching node provider for a stateless software asset.

For a stateful service as shown in Figure 14, some internal state of the SoftwareResource must be transferred from node A to node A' before the handover can be performed. For instance, this can be a virtual storage volume attached to a virtual machine or container. In more complex scenarios in which the processing Node is more deeply integrated within the cloud platform of A, it could be needed to transfer additional higher level storage assets as well (e.g., object storage, data lake / business intelligence storage, or SQL/NoSQL databases). Next to these functional aspects of such additional storage facility, also the non-functional aspects (e.g., QoS and availability for the storage classes used) need be considered before a transfer can happen.

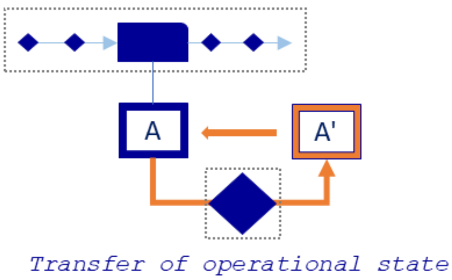


Figure 14 Switching node provider for a stateful software asset.

The Gaia-X AD is agnostic to the type of node – switching scenarios can involve a cloud-to-cloud transfer, a cloud to edge transfer or vice versa. In this, the definition of edge can refer to general purpose processing and storage capacities within an IoT device, or on an on-prem situated cloud, or on a telecom operator providing processing or storage capacities within the telecom infrastructure, up to a regional data center.

Switching Interconnection provider

Finally, it must also be possible to switch to Interconnections of a different provider. Mechanisms for this switch already exist in many cases: Datacenters already connect to multiple physical backbones and exchanges, and they can simply be described as Gaia-X Interconnections. This can often be done seamlessly (e.g. by changing routing rules), although the physical network connections must of course be available. In the context of digital services and the integration with IoT-edges, another practical switching scenario could entail swapping a physical SIM card, or simply provisioning a new eSIM.

In contrast to the previous scenarios, no significant amounts of stateful data needs to be transferred. Configuration data is of course still required, e.g. settings concerning software defined networking, firewall or security groups, and the subscriptions details.

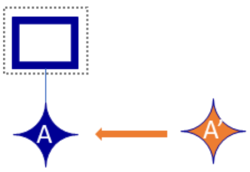


Figure 15 Switching interconnection provider for an operational node instance.

Role of the ecosystem federator in cloud switching

Besides **OFFERING TRANSPARENCY ON POSSIBLE SWITCHING OPTIONS TO SERVICE CONSUMERS**, the cloud providers might face challenges in providing evidence on their conformity with future regulations as proposed by the Data Act. In this, **THE FEDERATOR CONCEPT OF GAIA-X CAN SIMPLIFY THE PROCESSES FOR INDIVIDUAL CLOUD SERVICE PROVIDERS** by adopting a set of new rules and labelling criteria. By delegating the specific conformity rules to the federator within the ecosystem, each provider has proven conformity by completing the onboarding process for the concerned ecosystem. The trust model of Gaia-X ensures that the evidence that proves the conformity is made available to all future service consumers, reducing the overhead for providers when new service delivery contracts are accomplished.

Schematically the role of Gaia-X and the ecosystem Federator is shown in Figure 16. The right side of this figure shows how the publication of a regulation like the Data Act could influence the operational phase of the federator. From top to bottom, the diagram starts with the EC who introduces new proposed obligations on cloud switching. In step 2 the objective is to map the conceptual model of the Gaia-X Architecture unambiguously onto the concepts and items as described within the Act. The 3rd step aims to embed the switching conditions into the policy and rules, labelling framework, and labelling criteria. The joint outcome of step 2 and 3 creates the possibility that an ecosystem federator – possibly being the Gaia-X AISBL – can be used by individual providers to prove conformity on the new switching obligations. As a result, in step 5 it helps providers within the ecosystem to provide evidence on conforming to the new regulations in a simplified way. Moreover, a positive effect of the scenario in which the federator guards the standardized approach on the switching regulations can reduce the risks of unwanted complaints towards individual service providers. Lastly, in this phase, the service consumers benefit from simplified processes for defining and maintaining the desired exit and transfer strategies for all kinds of digital assets that are being adopted by Gaia-X.

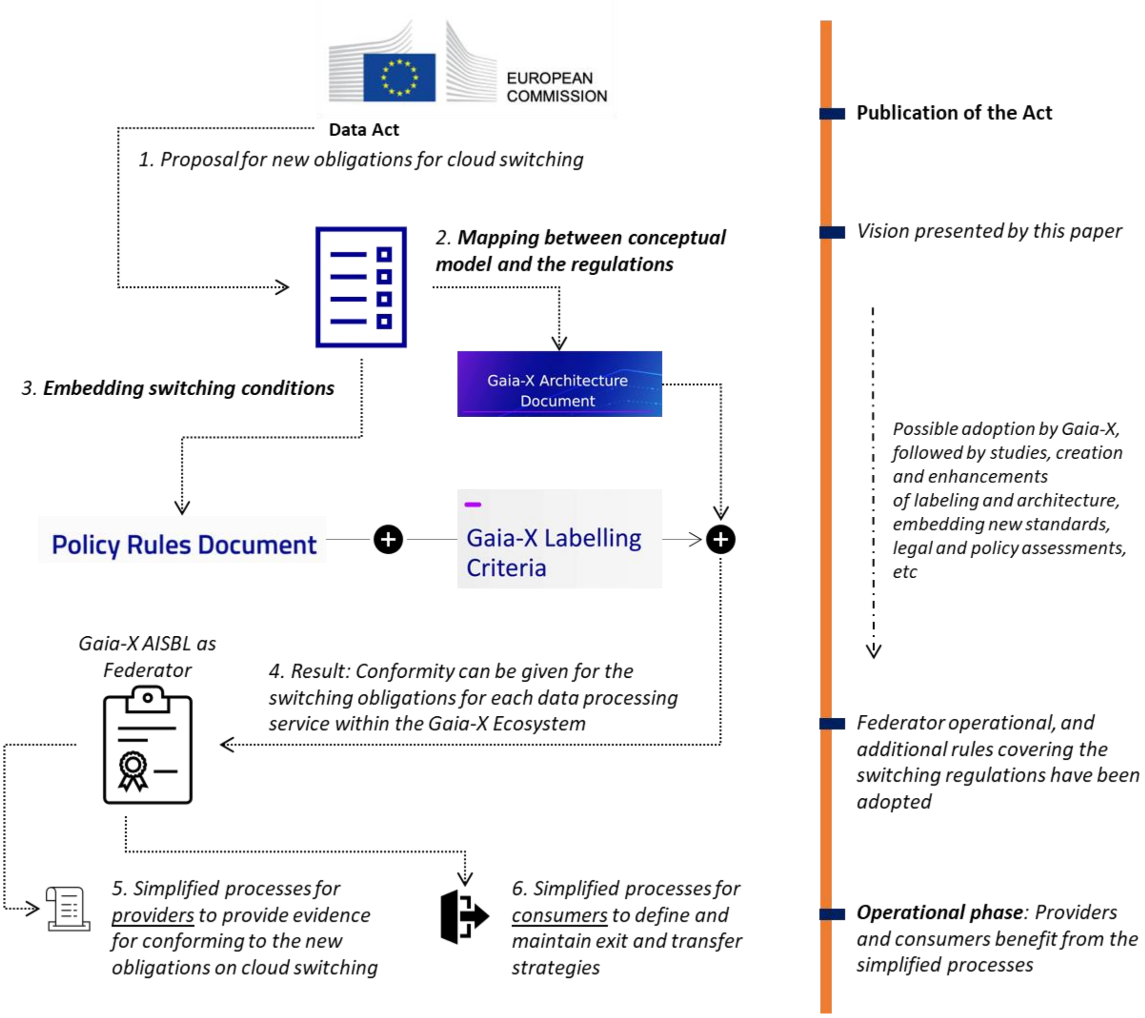


Figure 16 Example on how the Gaia-X AISBL can simplify the process to conform to the future switching regulations for all providers if the ecosystem federator adopts the right labeling criteria and the corresponding conceptual model. From top to bottom the diagram presents an indicative timeline (right) and the corresponding processes (left) that need to be taken.

Switchability within the labelling framework

The previous section describes the relevance of the labelling criteria document. By specifying the appropriate labelling criteria, providers can delegate a part of the responsibility of the bilateral conformity challenges (that concern individual service delivery contracts) to the federator within the ecosystem. In the version of the labelling document that we analyzed[17] we identified three labels that relate to cloud switching or service portability aspects:

Criterion 42:“Portability and interoperability: enable the ability to access the cloud service via other cloud services or IT systems of the cloud customers, to obtain the stored data at the end of the contractual relationship and to securely delete it from the cloud service provider.”

[17] Gaia-X Labelling Criteria, published the 21st of April 2022, source: https://gaia-x.eu/wp-content/uploads/2022/05/Gaia-X-labelling-criteria-v22.04_Final.pdf

Criterion 52: "The provider shall implement practices for facilitating the switching of providers and the porting of data in a structured, commonly used, and machine-readable format including open standard formats where required or requested by the provider receiving the data."

Criterion 53: "The provider shall ensure pre-contractual information exists, with sufficiently detailed, clear, and transparent information regarding the processes of data portability, technical requirements, timeframes, and charges that apply in case a professional user wants to switch to another provider or port data back to its own IT systems "

For Criterion 52 and 53, the labelling criteria document states that the SWIPO.EU Codes of Conduct are accepted standards to provide conformity. However, as described in the initial sections of this paper, the Data Act states that it will replace the self-regulatory approach. Within the security section criterion 42 originates from the European Cybersecurity Certification Scheme for Cloud Services (EUCS) defined by ENISA[18]. For this criterion the document lists C5, TISAX, SOC2, SecNumCloud, ISO 27xx, CSA, and as soon as available the ENISA EUCS itself as accepted standards. In this case, like Criterion 52 and 53, it partly addresses the future obligations defined by the act, but from our viewpoint it does not sufficiently address actual transfer processes itself. Moreover, the contents of the criterions are not specific enough to enable transparency among the ecosystem participants on modularity and switchability. In the following section we propose a direction how the switching process itself can become a transparent service property within future digital ecosystems.

Proposed transferability levels

The framework and policies developed by Gaia-X can help the participants within the ecosystem by giving them unambiguous transparency on the actual ability to switch services between providers. The more software and services shift towards a full **as-a-Service* model, the more critical it becomes to distinguish custom engineered services from the cloud commodity elements. From service procurement perspectives it is acceptable to establish a long-standing relation with a single service provider in the former situation, in the latter the ability to switch provider is key to benefit from the best offerings (e.g., based on new features, lower costs, higher quality of service, or better support). In the modern cloud landscape, the ability to switch provider is commonly subject of the cloud exit strategy, a complex set of documents that describe various scenarios to extract the digital assets from the platform of the provider, and possibly migrating these to another provider. Only in rare cases exit strategies are tested on a regular basis, causing an operational risk in case one of the exit scenarios really needs to be executed.

The market dynamics and regulations like the Data Act require re-thinking the traditional approach of having and maintaining an exit strategy. The combination with the vision of a federated data infrastructure and corresponding objective to establish a fair and sustainable digital economy creates a momentum for Gaia-X to set the new public norm on the transferability of digital assets. On the one hand transferability needs to be seen from the consuming perspective such it can be a selection property within the procurement phase. At the same time, the technical aspects concerning a service transfer need to be understandable for software engineers, data scientists and the operators involved. In Table 2 we suggest four different levels that describe the ability to transfer a service to another of the same service-type, ranging from not defined (level 1, None) to a fully seamless transfer without any service interruption (level 4, Seamless). All levels are defined in such a way that these are applicable to all three transferability scenarios described in the previous section. We deliberately define the first level in which no transferability information is described for the

[18] https://www.enisa.europa.eu/publications/eucs-cloud-service-scheme

specific services, but the decision within an ecosystem could be to minimally require the second level (Manual).

TRANSFERABILITY LEVEL	DESCRIPTION
NONE	Transferability is not known for the specific service.
MANUAL	Service is transferable but manual intervention is needed (engineering and/or operations).
AUTOMATED	Service is transferable, and no manual intervention is needed, except that the service consumer needs to initiate the transfer.
SEAMLESS	Providing the same functionality as level AUTOMATED, but in this case *service availability* is guaranteed during the transfer period *for the overall ServiceOffering (composition)* that is being consumed*.*

Table 2 Proposal for a set of transferability levels that participants within the Gaia-X ecosystem can use to simply determine the ability to switch a certain service including its technical and operational impact.

In the current set of deliverables of the Gaia-X project such transferability levels could be defined through the Policy and Rules Document (PRD), through the label framework and its corresponding criteria, or directly as property within the self-descriptions. In Figure 17 we propose a structure in which the levels itself are adopted by the self-descriptions. This way, the level can be set for each specific service within the ecosystem. Thereafter, the policy and rules and labeling criteria together set the baseline of the specific level that is minimally acceptable within the ecosystem. The latter also defines if the ecosystem by default conforms to the obligations of the data act or that providers within the ecosystem must take additional measures to conform.

Besides the transferability level, the self-descriptions also describe the service-type and several post-transfer conditions. The service-type property can be used by participants to discover services that provide similar or equivalent functionality. The post-transfer conditions describe guarantees or potential side-effects (and its mitigations) concerning the end-to-end transfer process.

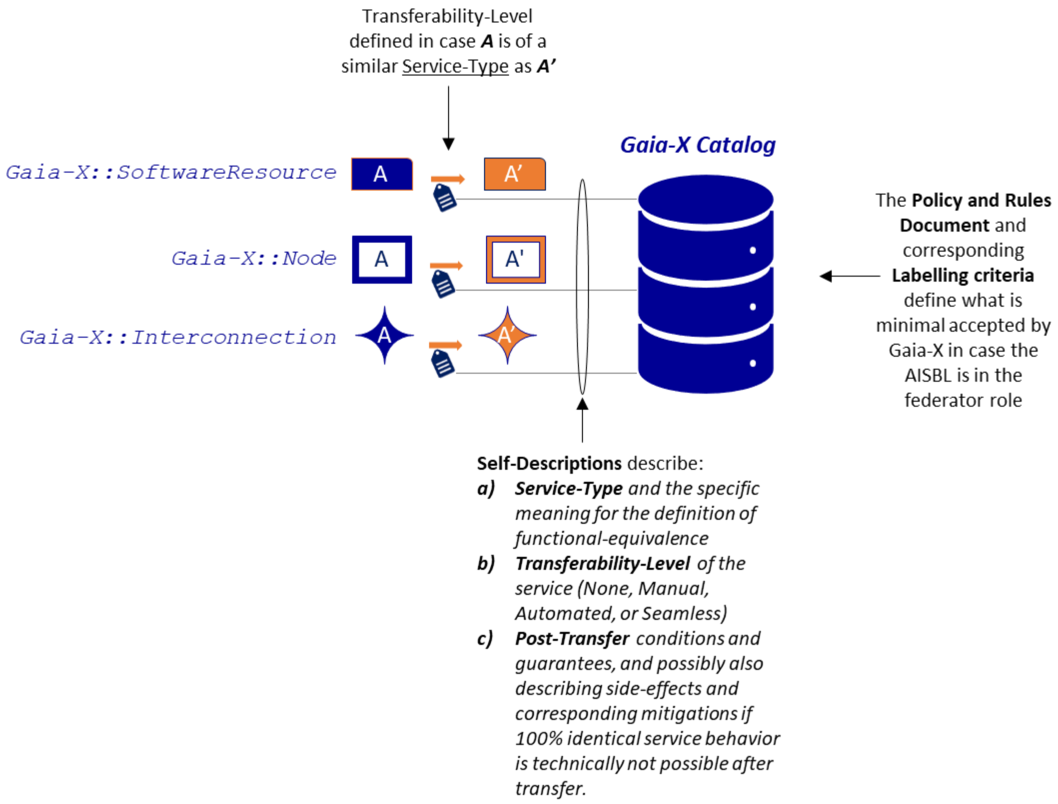


Figure 17 The envisioned relation between the services, the proposed transferability level, and the Self-Descriptions and Catalog concepts of Gaia-X.

Conclusions

Discussions in the market and expected future interventions by means of European regulations ask for a solution that gives the **MAXIMAL OPEN CHOICE TO SERVICE CONSUMERS**, and at the same time **A LOW ENTRY BARRIER FOR NEW SERVICE PROVIDERS** at all possible levels for service offerings. Gaia-X is the initiative within Europe that has the momentum and scope in the area of **DIGITAL SOVEREIGNTY** to shift the market dynamics in the current cloud market. From a technical perspective Gaia-X has the vision and the high level concepts that could be extended such that the aspects *unbundling, composability and switchability* will become important comparable characteristics of future digital offerings. However, the existing two-fold definition of the federation concept – that is part of the Gaia-X mission – involves technical design challenges to actually implement and effectuate the next generation federated data infrastructure. In order to achieve the targeted level of federation it is needed to technically enable service compositions that *join up infrastructures* and – at the same time - deliver *safe, secure and trustworthy data sharing* to the end users. From the modularity perspective of future digital ecosystems we can conclude that Gaia-X can:

- Have an important role in making the ability to switch from one provider to another visible to the consumers within the ecosystems. In this paper we describe **SWITCHING SCENARIOS** that could be used to facilitate and streamline discussions on the operational modularity within – and among – different service offerings. The conceptual model of Gaia-X that is used within the AD 21.12 and earlier gives a solid basis to describe the switching scenarios based on available resource sub types, while version 22.04 and 22.09 are too abstract for this purpose. Therefore we suggest to reintroduce the four resource subtypes of DataResource, SoftwareResource, Node and Interconnection, in order to increase the unbundling capabilities of Gaia-X.

Each of the three described unbundling perspectives have particular challenges. Challenges at the level of horizontal unbundling are being tackled by the sector-specific common European Data Spaces as well as well as inter-data spaces approaches. From the perspective of vertical unbundling, new developments need to be started to actually develop new approaches to operationally decouple SoftwareResources from their Infrastructure (Nodes and Interconnection) elements.

- Fill the gap between future switching regulation and the portability definitions from the current Code of Conducts within the SWIPO.eu initiatives. In the current version of the labelling criteria the portability aspects within are very high level. Gaia-X could make the “ability to switch” visible at the level of individual service offerings. We propose 4 **Transferability-Levels** that could be adopted as a property within the Self-Descriptions.
- Use its trust model with the federator concept to reduce overhead and simplify the process for individual providers to provide **evidence on the switchability of individual services** within delivery contracts.

Future work

Within Gaia-X the **Lighthouse project Structura-X** is targeting promising showcases in which applications and services can run on an integrated infrastructure provided by multiple cloud service providers and internet exchanges. Such developments that demonstrate the technical capabilities to place or move workloads to a selected provider help to establish the future infrastructure that is capable of hosting the common European Data Spaces. Moreover, the seamless switching and the transferability levels mentioned in this document also require technological advancements. Here, initiatives such as the **IPCEI Cloud Infrastructure and Services** are essential to kickstart and speed up the developments.

This document makes a number of references to **proposed cloud switching regulations in the draft Data Act** and how it aims to impact the cloud market. We therefore believe that a full analysis of the Data Act and how it relates to unbundling and switchability in Gaia-X should be done in the future.

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Gaia-X Hub The Netherlands

The Dutch Gaia-X hub is responsible for organizing the Dutch Gaia-X ecosystem, connecting this ecosystem to the international developments bidirectionally and initiating and supporting relevant usecases. This way data can be used more intelligently and the opportunities of an international cloud- and data infrastructure based on European values are being clarified.

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