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Domain Logistics Position paper 2023

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Content

1. Introduction and Motivation

The logistics industry is undergoing a digital transformation, marked by advancements in robotics, autonomous systems, data-driven (smart) services, and the Internet of Things (IoT) that characterise *Industry 4.0*. Furthermore, supply chains are increasingly driven by data to achieve resilient logistics operations and efficient flow of materials and goods. Thus, data exchanges play a crucial role in the logistics domain enabling, for instance, enhanced end-to-end visibility, workflow optimization, automation, and new forms of collaborations across the entire logistics ecosystem. While the exchange of data within the ecosystem in a sovereign and trusted manner is of increasing importance, data spaces emerge as an innovative technical framework to generate business value. These data spaces rely on decentralized infrastructures and federated software components through which data providers, data consumers, and service providers can interact in a co-created and self-determined manner. Furthermore, data spaces facilitate seamless integration, interoperability, and trust among various stakeholders, ensuring the confidentiality, integrity, and availability of data and service provisions. Due to their open and interoperable character, data spaces allow for a uniform interface management between information systems, thereby increasing the access to data-assets and services for each actor in a supply chain. The data and service offerings to be provided and consumed across business domains allows organisations to expand their digital portfolio, to manage legally compliant operations, to explore new ways for sustainable business, and to foster a competitive market position. In essence, emerging data spaces pave the way for participants that operate within multi-stakeholder networks to maintain their digital sovereignty as well as enabling data-driven innovations.

Overall, we believe that the establishment of data spaces in the logistics domain has the potential to tackle the sectoral challenges, such as lack of visibility, last-mile delivery costs, balanced inventory management, or paper-based communication. This belief is based grounded on the current logistics situation where isolated data storage, the use of proprietary systems, multihoming of digital platform application, and the lack of trust among the actors to share data are hindering operational excellence. For data providers, data spaces are the future cornerstones on which new digital business models are developed, not only within a single industry domain but also in cooperation with organizations of other domains (e.g., mobility, smart city, health, insurance, banking). In addition, actors in the logistics sector that lack of capabilities and resources to make use of the data (e.g., geo-positions of freight transport assets in use) benefit from novel revenue mechanisms following from data sharing concepts (e.g., marketplaces). Overall, this paper contextualises the importance of data spaces for the logistics sector with a specific focus on the vision, the value propositions, and the technological deliverables of **Gaia-X**. We are convinced that forming a **Gaia-X logistics community** provides competitive impetus for both economy and society guiding the business domain toward a prospering European future. For this reason, this paper presents three initial use cases for the foundation of a Gaia-X Domain Logistics.

2. Vision

Gaia-X enables participating organisations to meet the level of security, transparency, reliability, and interoperability required for federated data exchange. Data spaces developed with Gaia-X enable the use of data based on agreed rules within a federated system that connects several participants with each other, aiming at new services and innovative products. Data and service offerings can be shared transparently in a self-determined way, while the raw data are left entirely at its point of origin. Participants are therefore provided with the control over their data. To achieve digital sovereignty in the logistics business, the vision of the Gaia-X domain logistics is to ensure the respect of fundamental principles and EU values that will determine the future of Europe and our civil society. The underlying paradigm shift follows a "sharing is caring" approach and calls for a logistics community that will take a leading role for promoting interconnected, resilient, compliant, and sustainable supply chain operations across business domains.

Gaia-X data spaces that build on interconnected data and infrastructure ecosystems engage participants to compete fairly in the digital economy with market incumbents. A Gaia-X Federation is operated by a set of 'federation services' that respond individually to the technological concepts and supply chain trends in the sector emphasized before. The aim of the Gaia-X Domain Logistics is to embark on a visionary path, where we propel Logistics 4.0 towards a Supply Chain Continuum. To understand this path, we briefly outline what Logistics 4.0 entails and how it differentiates from the concept of a Supply Chain Continuum. Logistics 4.0 refers to the integration of digital technologies, such as the IoT, Artificial Intelligence (AI), and big data analytics, into traditional logistics operations. This digitization enables real-time data exchange, automation, and optimization, leading to improved efficiency, visibility, and decision-making within the logistics domain. On the other hand, the concept of a Supply Chain Continuum takes Logistics 4.0 a step further. It involves the seamless integration and collaboration of all stakeholders across the entire supply chain, transcending organizational boundaries. The Supply Chain Continuum aims to achieve end-to-end visibility, synchronization, and optimization, enabling a holistic and connected approach to supply chain management. To make this vision a reality, Gaia-X represents the innovative space to leverage secure and standardized data exchange between different companies and systems in use. By using common standards and protocols, data can be seamlessly exchanged between In-house (vertically) and inter-company (horizontally), leading to a more efficient and transparent supply chain (see Figure 1).

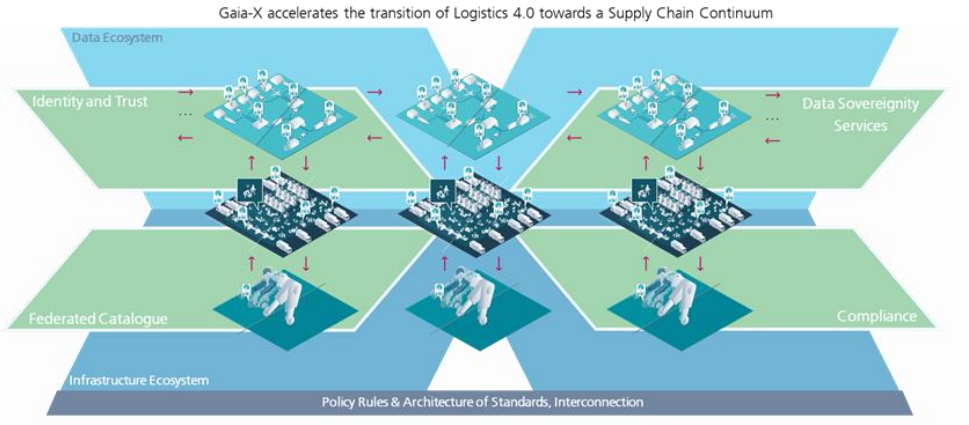

Figure 1: Gaia-X Logistics Data Spaces enabling a Supply Chain Continuum

3. Value Proposition of Gaia-X

Data exchanges are necessary for all types of logistics processes for the planning, management, and control of the flow of materials and goods. To allow for the exchange of data, logistics companies currently set up their own individualised and, therefore, costly interfaces often with the help of traditional centralized cloud providers. Against this background, **the key value proposition of Gaia-X is its provision of standardized and open-source data exchange mechanisms between geographically distributed infrastructures**. When applying Gaia-X, data exchange does take place in a trusted data ecosystem based on European rules and values. Generally, trusted data exchanges will allow for a faster, more cost-effective setup, and for value-adding information flows. This, in turn, can accelerate and improve the decision-making regarding logistics resources and processes (see example in section 4). We believe that the use of Gaia-X can lead to cheaper, faster, safer, and more sustainable deliveries of goods. To be more precise, Gaia-X addresses the major challenges of logistics in the following ways:

- **Lack of visibility:** Traditional supply chain processes often suffer from limited visibility, making it challenging to track goods, monitor inventory levels, and anticipate potential disruptions. Gaia-X can facilitate the fast integration of new data sources to enhance overall visibility.
- **Last-mile delivery:** The final route to the customer, especially in the e-commerce business, is known as last-mile delivery that is often the most challenging and expensive part of the transport chain. A dedicated Gaia-X data space enables the co-creation of last-mile delivery services by integrating resources from the crowd or public transport business. Beyond, last-mile operators could make use of interoperable data spaces to share fleet information for advanced customer experience, utilisation of transport assets, and reducing the traffic impact, particularly in urban areas with other business domains (e.g., smart living).

- **Inventory management:** Maintaining an optimal inventory level is critical for avoiding excess carrying costs or stockouts. By connecting an inventory management to new data sources within Gaia-X, innovative approaches for the forecasting of demand and crucial events can be achieved to balance inbound and outbound flows of both materials and goods.
- **Supply chain interaction:** Complex supply chains today often involve multiple partners, suppliers, and distribution centres, making coordination and collaboration a challenging task. The geographically dispersed actors in a supply chain network, from different companies, could be connected through Gaia-X. Hence, coordination and collaboration could be decentralized, while interactions between the participating actors could be intensified, allowing for a faster and more embedded decision-making, controlling, and automation.
- **Management of empty load carriers:** Managing the availability and the return of empty load carriers after the delivery of goods is challenging. Gaia-X could allow for an easier integration of each single load carrier by connecting a load carrier directly to other load carriers. Similar to a freight exchange, participants could create (digital) swarms of load carriers dynamically and consequently increase utilization of their freight assets. These swarms could identify needs for additional load carriers and consequently create transport orders autonomously for long-haul transports between the nodes in a supply chain leading to more balanced material and goods supply within networks.
- **Warehouse efficiency:** Inefficient warehouse operations can lead to delays and higher operational costs. Using Gaia-X, a warehouse could get more information from inbound and outbound truck operations including arrival or departure time. From this information, warehouse activities could be optimized so that resources and goods could be provided at gates just-in-time for outbound deliveries.

Environmental sustainability: The European Environment Agency reports for 2020 that 77% of greenhouse gas (GHG) emissions caused by the transport sector came from road transport.[1] Likewise, estimates indicate that commercial trucks account for 23% of the GHG emissions.[2] Gaia-X-can in practice lead to decarbonization in two ways: Frist, by providing more sources of information, data spaces can optimize the management of warehouses, empty load carriers, supply chains, and last-mile deliveries. Second, emission tracking opportunities along the transport chains across transport modes connected to the data space can minimise GHG emissions. New emission insights along the supply chain can improve the decision-making for certain actors in a logistics system generated from other (logistics) companies involved in supply chains. **Gaia-X can provide companies with a new market for their GHG emission data or services leading to innovative business models.** Moreover, Gaia-X is aligned with the European Data Strategy which aims to create a federated infrastructure for building data and service markets.

By allowing for horizontal information flows between distributed nodes and thereby pushing the idea of decentralization, **Gaia-X can be seen as a key enabler for the concept *Logistics 4.0***

[1] https://www.eea.europa.eu/en/topics/in-depth/road-transport (Retrieved on 11 October 2023)
[2] https://www.transportenvironment.org/challenges/road-freight/ (Retrieved on 11 October 2023)

(likewise discussed as S*mart Logistics*) as well as for technological approaches like autonomous systems, compute-to-data, federated learning, smart services, and multi-agent systems. *Logistics 4.0* focuses on the automation and decentralization of decision processes in the logistics domain by using more robotics, increasing the connectivity of the actors (IoT), and adding to the single actors' data processing and decision-making capabilities (machine learning, big data). The concepts of *Logistics 4.0* and *Supply Chain Continuum* are coupled with the field of autonomous systems that tries to build robots or software equipped with a certain amount of intelligence and that are directly embedded in their environment. To embed systems in their environment, horizontal information flows within data spaces are necessary. Using Gaia-X, autonomous systems could gather the data in their environment and compute a solution using their own processing capabilities. This can be seen as a so-called compute-to-data approach, which is the opposite to a centralized solver for several actors. Due to more horizontal information flows, Gaia-X can not only decentralize the decision-making but also the machine learning in logistics systems, thus, backing the so-called federated learning approaches. In the end, Gaia-X could support the creation of several autonomous systems collaborating with each other and could, thereby, support the emergence of new types of multi-agent systems within and across company networks.

4. The Gaia-X deliverables

In Gaia-X, distributed infrastructures that want to exchange data form so-called federations and the services that ensure standardized and trusted data exchanges between the data infrastructures are called federation services. These federation services are provided on an open-source basis and allow for the self-description of data providers, the management of identities and access, the actual data exchange, the adherence to general policies during the data exchange, and the searching for data providers. More specifically, the service for **inter-catalogue synchronisation** ensures that data providers can describe their offerings by self-descriptions to enable their discovery within and across available federations. The service for **identity and access management** covers identification, authentication, authorization, credential management, decentralized identity management, and verification of credentials. The **data exchange** service realizes the actual data exchange between two data infrastructures and enforces the individual agreements between data provider and data consumer, including the usage constraints expressed by the provider in the self-description. The **Gaia-X Trust Framework** service enforces the general rules regarding security, privacy, transparency, and interoperability during onboarding and data exchanges. The service **Portals and APIs** is necessary to realize the onboarding and management of participants in federations as well as to support the discovery of offerings. Examples for already existing federations are found in **Catena-X**[3] and the **Mobility Data Space**[4]. Catena-X is the first collaborative, open data space for the automotive industry. It connects global players to form end-to-end value chains and attempts to improve the competitiveness of all participating companies. Use cases for digital,

[3] https://catena-x.net (Retrieved 7 August 2023)
[4] https://mobility-dataspace.eu/de (Retrieved 7 August 2023)

end-to-end supply chains with secure, sovereign, and standardized data exchange have already been implemented. It is stipulated that the participation in Catena-X is rewarded with above-average resilience, innovative strength, and earnings opportunities. The Mobility Data Space is a specialized data space dedicated to the mobility sector. It aims to provide a trusted platform for various mobility-related stakeholders, such as mobility service providers, cities, and data analytics companies, to share and access data collaboratively. It represents a data marketplace where data from the mobility sector can be exchanged by providing the meta data to consumers ensuring data sovereignty.

5. Federation ramp-up and use case proposals

In this section, initial logistics use cases are proposed to present innovative ideas for conceptualizing Gaia-X data spaces following the conceptual approaches of Catena-X or the Mobility Data Space. The use cases are neither complete nor comprehensive but provide an initial scope of research initiatives addressing applicable solutions for problem solving in practice. It is important to note that other data space concepts exist that may likewise contribute to the emergence of the intended logistics data ecosystem to be developed with Gaia-X (e.g., International Data Spaces).

5.1 The Intelligent Pallet

The primary goal of this use case is to expand the automation of processes related to *uniform loadings aid* used in the logistics industry, particularly for fast moving consumer goods. Standardized pallets provided by a pallet manufacturer are circulating within logistics systems requiring a careful planning, real-time positioning, and coordination of individual pallet flows. By equipping pallet with Internet of Things (IoT) technologies, novel software agents allow realizing growth and cost reduction for various stakeholders (i.e., pallet users, pallet providers, producers, retailers, transport and warehouse service providers, in-house logistics, insurance companies) operating within the same logistics network. Sensor data and geo-positions will be gathered following a compute-to-data approach to facilitate automated decision-making for the stakeholders in certain business areas. Autonomous systems are leveraged based on software agents leading to automated optimization, collaboration, learning, and communication processes between the actors involved. Gaia-X will be used for creating a common data space between all the stakeholders and actors that are necessary for the pallet automation along the processes allowing manufacturers to offer software agents “as a service” or data gathered within transport networks.

A Gaia-X-enabled automation of the pallet activities (see Figure 2) are based on the following processes:

- the warehouse registration of intelligent pallets for inbound transport operations,
- the maintenance management of circulating intelligent pallets,
- the warehouse replenishment management of intelligent pallets,
- the performance monitoring of intelligent pallet during transportation,
- the load integrity monitoring when multiple intelligent pallets are forwarded, and
- the transport order management of intelligent pallets.

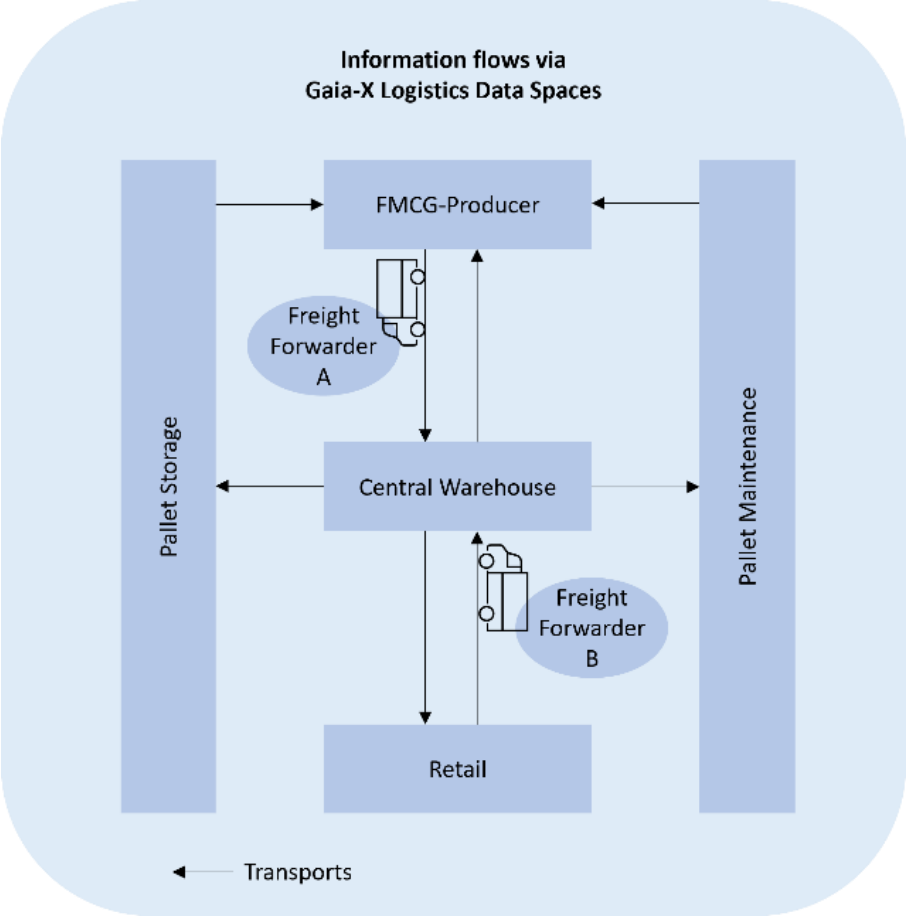

Figure 2: Intelligent Pallet Concept

5.2 Simulation-based Real Time Collaboration

A more generic and cross-company use case is a simulation-based real time collaboration. All entities of a supply chain send a real-time status via interoperable apps on a rolling basis to a decentralized data chain, which triggers a material flow simulation model or a different type of collaborative decision-making application. A data space is utilized to enable real-time collaboration and simulation via a digital supply chain twin for resilient planning and risk mitigation, considering potential (short-term) disruptions, supply chain vulnerabilities, and contingency strategies (see Figure 3). This concept of data-driven real time decision-making within data spaces enables stakeholders to make informed decisions based on shared insights, leading to optimized capacity plans, improved operational efficiency, and better resource allocation. Data spaces facilitate collaboration among logistics stakeholders to assess and simulate various risk scenarios, allowing for a comprehensive evaluation of potential disruptions and their impact on the supply chain. Furthermore, the benefits of the use case are that it helps companies to develop dynamic contingency plans, including alternative sourcing options, rerouting strategies, and inventory buffers, to mitigate the impact of disruptions or spontaneous bottlenecks and ensure business continuity. In addition, this transparency can also be used to address aspects of supply chain finance. Rather than stopping at reverse factoring, the use case could also address, for example, inventory-oriented financing schemes or supplier led schemes.

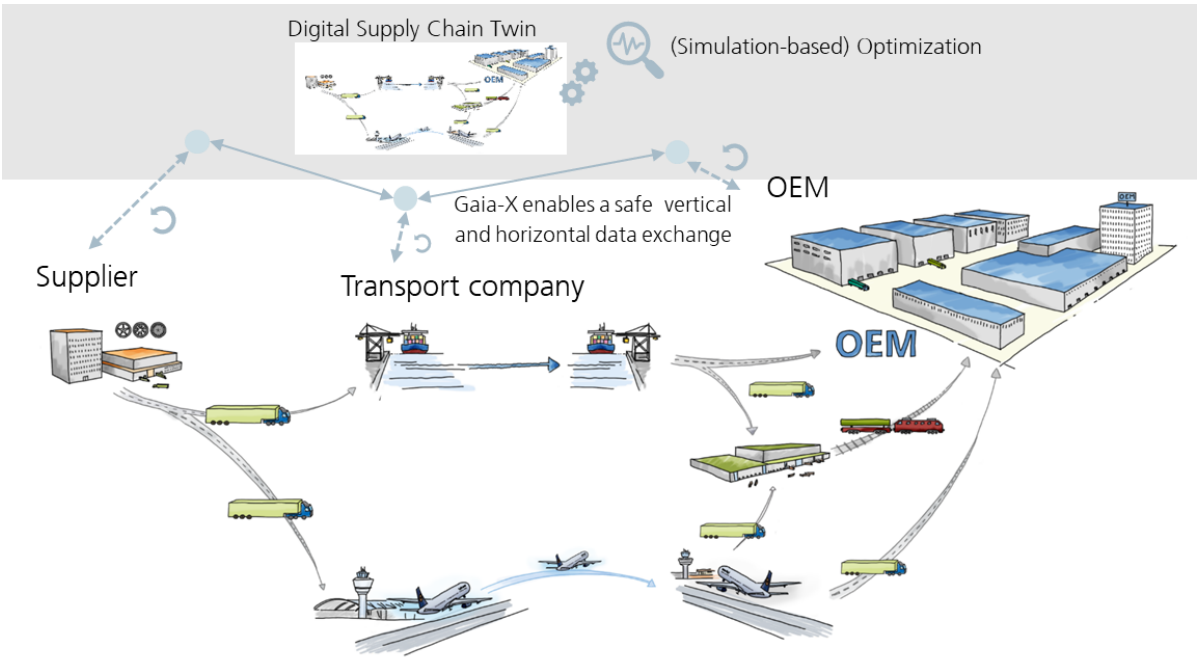

Figure 3: Gaia-X-enabled Real Time Collaboration Network

5.3 Co-bility Hub

Urban transportation is increasingly faced with challenges associated with a growing population and the rapid growth of e-commerce and thus, driving data-driven innovations for more sustainable mobility services. Consequently, shared mobility consequently emerges as a promising city transport concept, while combined service opportunities between public transport, crowd mobility, and last-mile logistics are scarcely investigated. The co-creation of urban mobility services within federated ecosystems focusing on a transshipment hub leads to a novel approach called “co-bility” and facilitates the conceptualization of a co-bility hub with relevance for smart cities. The concept strengthens the co-created mobility in urban ecosystems by combining transport resources from different areas resulting in transaction-based services comprising capacity utilization, advanced service levels, and social interactions. A Gaia-X-enabled co-bility hub data space (see Figure 4) can be achieved by (a) a federated ecosystem orchestrating mobility services and resources, (b) municipalities ensuring coherent platform governance, and (c) eclectic incentives to make co-bility successful. Overall, the designed product leads to a mobility hub for passengers, crowd, and freight incorporating shared service opportunities to achieve an interoperable and sovereign urban ecosystem.

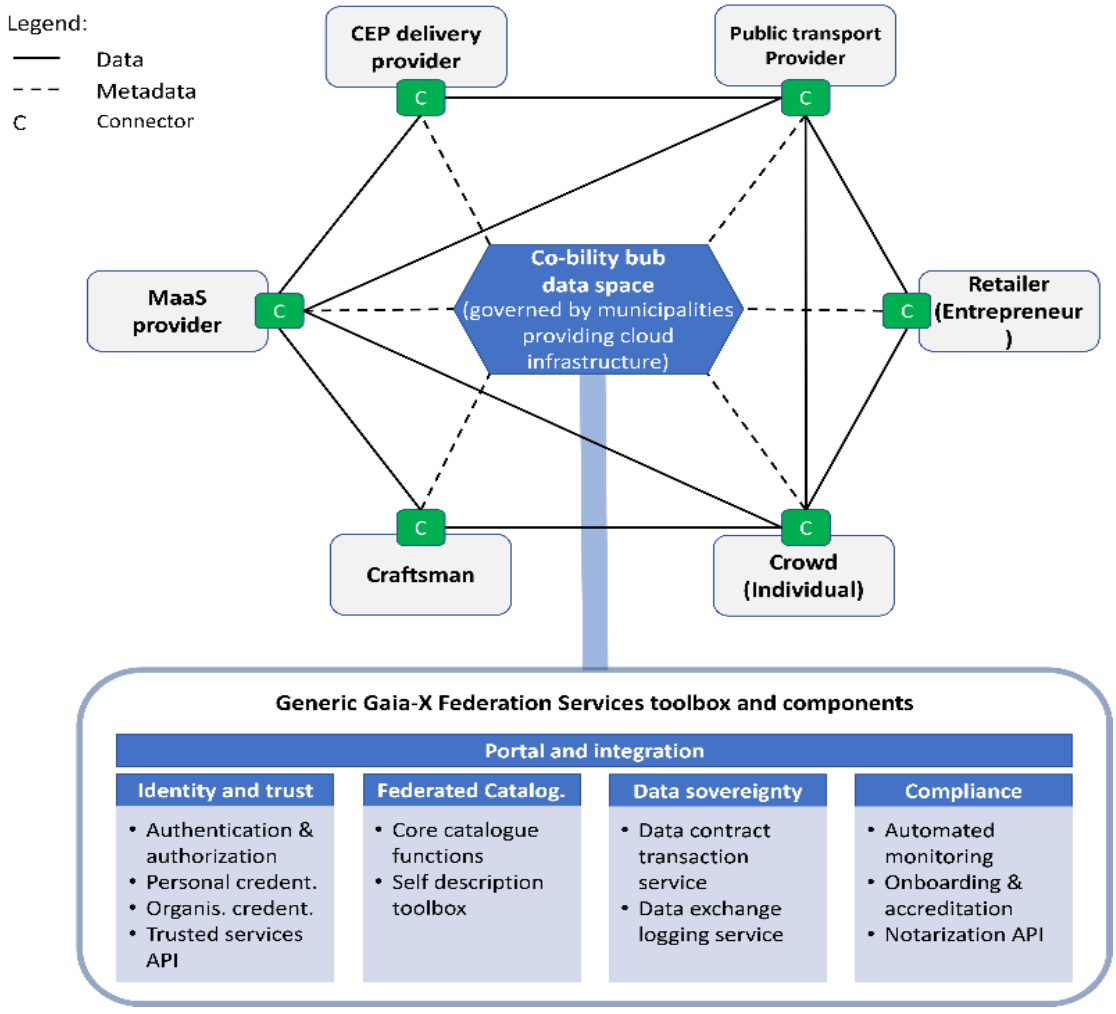

Figure 4: Conceptualized Co-bility Hub Data Space

A Gaia-X-enabled decentralized logistics system for parcel deliveries in the ongoing project Gaia-X 4 ROMS

In the project **Gaia-X 4 ROMS** (Remote Operation of Automated and Connected Mobility Services) the use case “Smart Managed Freight Fleet” is currently focussing on the development of an automated parcel delivery system across fleet resources in use, therefore, representing an initial logistics contribution. The transport system consists of several autonomous systems forming a multi-agent system. Each autonomous system represents one actor in the intermodal transport chain between parcel consignor and parcel consignee (senders, receivers, operators, vehicles, depots, maintenance stations) and makes decisions independently on behalf of this actor. To achieve the most optimal decision, each autonomous system is continuously connected with its environment and those autonomous systems representing the other actors in the transport chain. For example, a parcel delivery robot optimizes its own tour in an urban area with the status information of the consignor and consignee of parcels, of inbound and outbound trucks, of other robots and vehicles in the same area, and of the ongoing depot processes. The involved robots and software agents in this scenario run within data infrastructures that are owned decentral by different companies. The use of Gaia-X enables for the easy setup of horizontal and trusted information flows between these data infrastructures. In the ROMS-data space, status information of inbound trucks will then easily be accessible for the optimization of parcel delivery robots’ tours. Overall, if an inbound truck would indeed be delayed, this status update would be made available via a Gaia-X-based data space, and the parcel delivery robot could meanwhile add a stop to its delivery tour.