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Regulating data space connectors as an essential gateway to data spaces

The European Electronic Communications Code as a suitable choice for addressing a lack of interoperability and harmonisation?

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Abstract

Data Spaces are highly interconnected data sharing ecosystems that represent a new array of collaborative data-sharing forms. In this context, data space connectors play a vital role as gateways for integrating existing systems and their respective data into Data Spaces. However, the lack of reusable and interoperable core components for data space connectors has resulted in divergent implementations and a lack of a shared understanding of data space connectors as mere bridging software. Absent harmonised components of connectors and a unified definition of the primary function of data space connectors, there is a concern that these connectors may impede, rather than facilitate, seamless access to Data Spaces. The hypothesis of the paper is that regulation should be considered as a means of addressing the current heterogeneous landscape and achieving the objective of enabling data sharing through Data Spaces. The paper therefore concludes with a hypothesis regarding the regulation of data space connectors as electronic communication services under the European Electronic Communications Code, and a call for further detailed research into the potential for implementing this hypothesis in practice.

1. Introduction

The European Union has articulated a vision for the future internal market that encompasses the establishment of collaborative and highly interconnected data sharing environments or data spaces.[1] The establishment of such highly interconnected data sharing environments is, in essence, the objective of the European Union for the next decade.[2] In such environments, the sharing of data should be facilitated, thereby enabling the development of new, innovative services through the further use of a range of data within existing data infrastructures. These infrastructures have historically been shaped by heterogeneous formats and diversity, which has hindered the reusability of data.[3] The concept of data spaces thus emerged as a response to the legal and technical limitations inherent in conventional data management practices.[4] In the context of these practices, datasets were previously overseen within a singular database or data silo. Consequently, organisations continued to encounter challenges in terms of flexibility within their own data infrastructures.[5] In contrast to the establishment of a novel physical infrastructure and silo on the European level, a solution of coexistence and thus data spaces has been proposed.[6] Within the proposed data spaces, which are intended as a method of sharing and governing data within the EU, the existing data infrastructures of the various involved parties will be interconnected. The objective of this interconnectedness is the creation of a strategy for data coexistence, with the aim of facilitating the discovery, retrieval, and accessibility of data.[7]

The primary concern of data spaces in facilitating a strategy of coexistence is thus the integration of existing data sources and infrastructure into a more extensive federated structure.[8] In this regard, so-called data space connectors have been identified as playing a pivotal role in achieving the envisioned coexistence and establishing highly interconnected data sharing environments via the connection of participants' existing data infrastructures. The function of data space connectors is to serve as the necessary bridges to facilitate the connection of future participants and their existing data infrastructures into a broader federated network that eventually constitutes a data space. Access to the various datasets, functionalities and services provided within the data space is only granted to data space participants via these connectors.[9]

The definition of data space connectors as outlined in this paper is as follows: these are pieces of software that facilitate secure and controlled data sharing between different systems, platforms and organisations by acting as a bridge to the broader data space ecosystem. The definition is based on the concept of data space connectors as defined by the International Data Spaces Association (IDSA).[10] The International Data Spaces Association (IDSA) has been instrumental in establishing and promoting standards for data spaces, which are regarded as the foundation for a fair data economy. The organisation has also been pivotal in setting rules for trusted data sharing, a key component in the implementation of the EU Data Strategy

1. Commission (EC), 'Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee And The Committee Of The Regions' (A European strategy for data) COM/2020/66 final, 19 February 2020.
2. Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030, OJ L 323, 19 December 2022, 4.
3. Johannes Theissen-Lipp and others, 'Semantics in Dataspaces: Origin and Future Directions', ACM Web Conference 2023 - Companion of the World Wide Web Conference, Austin, TX, USA, 2023) https://doi.org/10.1145/3543873.3587689 accessed 29 October 2025.
4. Inês Machado, Carlos Costa and Maribel Yasmina Santos, 'Data-Driven Information Systems: The Data Mesh Paradigm Shift' (2021) Proceedings of the International Conference on Information Systems Development (ISD) https://aisel.aisnet.org/isd2014/proceedings2021/currenttopics/9 accessed 29 October 2025.
5. Jerzy Stefanowski, Krzysztof Krawiec and Robert Wrembel, 'Exploring Complex and Big Data' (2017) 27(4) International Journal of Applied Mathematics and Computer Science https://doi.org/10.1515/amcs-2017-0046 accessed 29 October 2025.
6. Commission (EC), 'How to master Europe's digital infrastructure needs' (White Paper) COM/2024/81 final, 21 February 2024, 20-24.
7. Commission (EC), 'Connectivity' (*European Commission Fact Pages,* 26 June 2025) https://digital-strategy.ec.europa.eu/nl/factpages/connectivity accessed 29 October 2025.
8. Antonio Kung, Ray Walshe and Rigo Wenning, 'Data sharing spaces and interoperability' (*Big Data Value Association,* 22 February 2024) https://bdva.eu/news/bdvas-position-paper-on-data-sharing-spaces-and-interoperability/ accessed 29 October 2025.
9. Heinrich Pettenpohl, Markus Spiekermann and Jan Ruben Both, 'International Data Spaces in a Nutshell' in Boris Otto, Michael Ten Hompel, Stefan Wrongel (eds), *Designing Data Spaces* (Springer 2022), 32-33.
10. Giulia Giussani and Sebastian Steinbuss, 'Data Connector Report' (*International Data Spaces,* 2024), 8-9, https://internationaldataspaces.org/data-connector-report/ accessed 29 October 2025.

and the Data Spaces objectives of the EU.[11] In accordance with the stipulated bridging functionality, the IDSA further asserts that this software should operate across diverse organisational domains on a non-competitive basis.[12]

Connectors can be regarded as logical access points to data spaces that are integrated into each participant's infrastructure and communicate with each other.[13] However, the present paper is concerned with the absence of a cohesive strategy for developing and regulating this essential access point to data spaces, which are envisaged as the way forward to achieve the objectives of the EU Data Strategy. These objectives are to share more qualitative data between Member States to further develop innovative services in the internal market. Data space connectors are currently very heterogeneous in terms of maturity and methodology.[14] There is currently a discrepancy between the conceptualisation of connectors as mere bridging software with limited additional functionalities in accordance with interoperable international data standards and their current implementation in practice. The absence of a shared application of reusable and interoperable core components is observed, and this absence consequently gives rise to a common misunderstanding of the minimal functionality required of connectors. While a significant proportion of connectors are derived from the standard open-source software provided by Eclipse as part of their EDC connector, a substantial number of context-specific adaptations are made.[15] In addition, standardisation efforts are not always uniform across different levels. Divergent implementations and technological readiness levels of core components, such as usage policies and brokering functionalities across various contexts, have the potential to result in incompatibility issues.[16] This, in turn, could lead to complications in the process of constructing an ecosystem encompassing multiple connectors. However, the implementation of Data Spaces is premised on the availability of connectors that are distinguished by a shared understanding, comprehensive documentation and a high level of technological readiness.[17] In addition, recent connector implementation reports underscore the heterogeneity of features, wherein data space connectors provide supplementary services beyond those offered by software, or alternatively offer a platform as a service, with connector functionality implemented. Despite the efforts of international organisations such as the IDSA and European organisations such as the Data Spaces Support Centre (DSSC) to promote the adherence of connectors to common data space protocols and standards for data sovereignty, security and trust, connectors and their exact composition of components appear to differ in practice and risks of incompatibility arise.[18] The necessity for organisations to prioritise certain factors over others is determined by their individual requirements for flexibility, control, and commercial interests.[19]

Absent harmonised fundamental components of connectors and a unified definition of the primary function of data space connectors, a concern emerges that these connectors may impede, rather than facilitate, seamless access to highly interconnected data sharing environments, such as data spaces, within the internal market. The capacity of connectors to operate in a manner that is both interoperable and harmonised regarding the core components of connectors is considered to facilitate participants' access to the data space and the convenient display of their available datasets, according to the IDSA and the vision for highly interconnected data sharing environments in the EU Data Strategy. However, at present, connector

11. 'Implementing the European Strategy on Data. Role of the International Data Spaces (IDS)' (*International Data Spaces Association*, April 2020) https://internationaldataspaces.org/wp-content/uploads/IDSA-Position-Paper-Implementing-European-Data-Strategy-Role-of-IDS1.pdf/ accessed 29 October 2025.
12. Giulia Giussani and Sebastian Steinbuss (n 10) 5.
13. Tobias Dam and others, 'A Survey of Dataspace Connector Implementations' (2023) Proceedings of the 2nd Italian Conference on Big Data and Data Science https://doi.org/10.48550/arXiv.2309.11282 accessed 29 October 2025.
14. As revealed by a thorough analysis of Giulia Giussani and Sebastian Steinbuss (n 10) 15-112.
15. See for more information, 'Contract Negotiation Protocol' (*Dataspace Protocol 2025-1-RC4* 2 July 2025) https://eclipse-dataspace-protocol-base.github.io/DataspaceProtocol/2025-1-RC4/#negotiation-protocol/ accessed 29 October 2025.
16. Danniar Reza Firdausy, Patrício de Alencar Silva, Marten van Sinderen and Maria-Eugenia Iacob, 'A Data Connector Store for International Data Spaces' in Mohamed Sellami, Maria-Esther Vidal, Boudewijn van Dongen, Walid Gaaloul and Hervé Panetto (eds), *Cooperative Information Systems*, CoopIS 2022, Lecture Notes in Computer Science, vol 13591 (Springer, 2022) https://doi.org/10.1007/978-3-031-17834-4_14 accessed 29 October 2025.
17. Tobias Dam and others (n 13).
18. Tobias Dam and others (n 13).
19. Giulia Giussani and Sebastian Steinbuss (n 10) 115.

functionalities are being integrated into proprietary platforms as supplementary services. Consequently, they are neither interoperable nor open source, thus deviating from the initial conception of connectors as mere bridging software.[20]

The present paper posits and builds upon the hypothesis that the current practice of not regulating data space connectors is unsuccessful and that regulation should be considered to tackle the heterogeneous landscape and achieve the EU Data Strategy objective of enabling the creation of innovative services in the internal market by establishing highly interconnected environments of data sharing. The paper proposes a renewed consideration of connectors as mere bridging software within regulation, in close alignment with the original conception of the IDSA. The paper goes on to investigate if the heterogeneity of such connectors can be tackled already through recent legislative instruments that relate to the facilitation of the digital single market or establishment of highly interconnected environments of data sharing, in particular, through the broad regulation of data intermediaries within the Data Governance Act (DGA).[21] However, the ambiguous scope of the DGA, when considered alongside the unclarity surrounding the provision of additional data-related services or tools by data intermediaries, in comparison to the original conception of data space connectors as more generic bridging software, suggests that the DGA may not be the optimal instrument for regulating data space connectors.

The paper concludes with a hypothesis regarding the regulation of data space connectors as electronic communication service under the Electronic Communications Code (EECC) in the future, and a call for further detailed research into the potential for implementing this hypothesis.[22] The paper presents the argument that this hypothesis is more closely aligned with the original conception of a data space connector as a mere bridging software solution. This, in turn, has the potential to provide clarity within the current heterogeneous landscape, facilitating an efficient connection to data spaces, a convenient manner of displaying datasets in the federated network, and an increased reuse of data space connector implementations and their core components. The potential benefits of the EECC are then further delineated, and further arguments that substantiate the hypothesis are outlined via a concise historical comparative perspective on the regulation of telecommunication services.

2. Methodology & objective

The significance and relevance of the subject matter under discussion in this paper are delineated in Section 3, which provides a context for the subsequent discussion. Firstly, the relevance of data spaces will be highlighted in the initial part of Section 3, using a descriptive approach. Secondly, the role of data space connectors as pivotal bridges or gateways for accessing and using datasets within data spaces will be demonstrated using a descriptive approach. The technical process of how a connector precisely works is thereby demonstrated, and the specific components, according to the IDSA definition of a connector wielded by this paper, are explained in more detail.

In the third part of Section 3, an analysis and evaluation are conducted of the difference between the initial conceptualisation of connectors by IDSA and the heterogeneous and fragmented implementation and development in practice. This third part of Section 3 constitutes the issue that is the focus of this paper. In instances where connectors and their core components are not fully interoperable, the achievement of highly interconnected environments is rendered more difficult. This is due to the pivotal function connectors have in connecting existing data infrastructures into a new federated network. Consequently, connectors are technically unable to communicate with each other and to display all relevant data sets within the federated network, or they are unable to connect participants without difficulties or additional adjustments to a particular data space.

20. As revealed by a thorough analysis of Giulia Giussani and Sebastian Steinbuss (n 10) 15-112.

21. Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act), OJ 2022 L 152/1.

22. Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast) (EECC), OJ 2018 L 321/36.

The present paper puts forward the hypothesis that regulation is needed to ensure that data space connectors function as effective bridging software, facilitating seamless interoperability and effortless integration of existing datasets into a federated network of datasets. This would, in turn, foster seamless connectivity with the data spaces, as envisaged by the EU in its EU Data Strategy. In this regard, the fourth and final part of Section 3 provides a preliminary and concise analysis of two recent regulatory instruments (Data Act and Data Governance Act) of the EU Data Strategy, and their capacity to regulate connectors. This is motivated by the fact that the regulations under discussion were established in the context of establishing a digital single market with future data spaces, and the Data Act even explicitly refers to data spaces, albeit not directly to data space connectors. The DGA is then proposed as the more promising instrument for the regulation of connectors as data intermediaries at first sight. A more thorough analysis and evaluation of data space connectors within its scope is presented in Section 4.

Section 4 then goes on to demonstrate the shortcomings of the DGA in providing a consistent regulatory approach towards data space connectors, due to its ambiguous scope of data intermediaries and unclear possibilities to provide additional services as a data intermediary. Furthermore, the DGA's shortcomings in ensuring the harmonisation of data space connectors' functionalities and core components, and in facilitating their interoperability within the federated network, are highlighted.

In Section 5, a normative proposal in the form of a hypothesis is subsequently advanced regarding the fragmentation of data space connectors in practice. On initial consideration, no recent legislation related to the facilitation or establishment of Data Spaces is directly relevant in addressing this fragmentation. The purpose of this proposed hypothesis is to establish a foundation for subsequent research in this domain, building further on the concrete achievability of such a hypothesis in practice. In consideration of the initial conceptualisation of data space connectors as a bridge between existing data infrastructure and an essential element for establishing a new federated network, and the need for interoperability and harmonisation of core components and functionalities of data space connectors, it is hypothesised and thus normatively suggested that the regulation of data space connectors under the scope of the EECC could provide beneficial outcomes. This hypothesis is not without foundation, as demonstrated by a historical comparative approach to the regulation of electronic communication services.

3. Establishing the context of data spaces and identifying the specific issue with connectors

3.1 Relevancy: the EU's ambitious plans regarding data spaces

Common European Data Spaces are legally referred to as purpose- or sector-specific, or cross-sectoral interoperable frameworks for common standards and practices to share or jointly process data for a range of purposes, including the development of new products and services, scientific research, and civil society initiatives in the Data Act (hereinafter 'Data Spaces').[23] It is technically possible to define such systems as federated environments, consisting of multiple data infrastructures that are governed in a more distributed way than is typical of a fully decentralised system. This objective is realised through the implementation of specific design principles and the integration of advanced technical infrastructure. Data spaces are defined as environments that facilitate secure and reliable data transactions between participating organisations. There is no universally accepted form of a Data Space, as it can exist as a stand-alone space or as part of a larger network. The concept itself is ambiguous, which engenders difficulties in delineating its boundaries.[24] Accordingly, there is a broad reference to Data Spaces as interoperable frameworks for the purpose of facilitating the exchange of data, as outlined in the Data Act. The objective is to accommodate all possible forms of Data Spaces in practice.

23. Article 33 Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act), OJ 2023 L 2854.
24. Commission (EC), 'Commission Staff Working Document on Common European Data Spaces' SWD(2022) 45 final, 14 February 2022.

The concept of data spaces proposes a strategy of coexistence of existing data infrastructures, wherein each party holding data connects to the Data Space with their own data infrastructure. The eventual objective is to establish a collaborative and dynamic space that will facilitate a variety of data analysis services and functionalities.[25] The process of browsing a Data Space should be as efficient and expeditious as executing a search on the internet via a search engine such as Google. The EU envisions a genuine single market for data, wherein participants have ready access to an extensive array of high-quality personal and non-personal data, thereby stimulating growth and generating value.[26] In the proposed scenario, Data Spaces are proposed as a new way of data governance to enable participants to locate and access all the necessary information in a straightforward and efficient manner, akin to the ease with which one conducts a basic internet search. In a manner analogous to the automatic retrieval of relevant data by search engines, the objective of Data Spaces is to achieve a similar outcome for a designated query. In the event of a Data Space participant encountering a particular query, the relevant datasets should be able to be located and accessed immediately. Moreover, the participant should be able to access a compiled or aggregated summary of the relevant datasets.[27]

The European Union's dedication to the success of data spaces is substantiated by the considerable financial investment allocated to projects and infrastructure related to data spaces. For instance, a significant investment of at least 2 billion was allocated to a European High Impact Project, with the aim of developing data processing infrastructures, data sharing tools, architectures and governance mechanisms to facilitate effective data sharing. The project concentrated on European data spaces and the federation of energy-efficient and trustworthy cloud infrastructures and associated services. [28] In addition, a considerable financial investment was made in the establishment of a data spaces support centre and in sector-specific follow-up projects.[29] Furthermore, several national member states, including Germany, have made substantial investments in consortia in the infrastructure sector, such as Gaia-X.[30]

3.2 Initial conceptualisation of a data space connector

The purpose of a data space connector is to facilitate the integration of the current data infrastructures of participants, such as data holders and data users, within the data space itself. Through a strategy of coexistence, each participant connects to the Data Space with their own datasets and data infrastructure.[31] The terms of data holder and data user are defined under the DGA. A data holder can be any natural or legal person that either has the right or obligations according to applicable Union or national law to process the data in question (i.e. data that is held). This includes anyone with the technical capability to make the data available through the control of the technical design of a product or service. Conversely, the data user is legally entitled to access the data in question.[32]

The software that serves as a conduit between data space participants and the federated network, otherwise known as the Data Space, is designated as the connector. The primary function of the connector is to enable the integration of existing data sources with a novel federated network of data infrastructures. This facilitates trustworthy data sharing in highly interconnected environments that are known as Data Spaces. To ensure clarity throughout this paper, a concise explanation of the operational mechanics is provided in the following section.

25. Boris Otto, 'The Evolution of Data Spaces' in Boris Otto, Michael Ten Hompel, Stefan Wrongel (eds), *Designing Data Spaces* (Springer 2022).
26. A European strategy for data (n 1) 4.
27. Luis Serrano, 'What is Semantic Search', (*Co:here*, 27 February 2023) https://txt.cohere.ai/what-is-semantic-search/ accessed 29 October 2025.
28. A European strategy for data (n 1) 19.
29. Commission (EC), 'Data Spaces Support Centre' (*EU F&T Portal*, 1 October 2022) https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/projects-details/43152860/101083412/DIGITAL accessed 29 October 2025.
30. 'Funding Competition: German Government Puts 200 Million into GAIA-X' (*International Data Spaces Association*, 6 Aril 2021) https://internationaldataspaces.org/funding-competition-german-government-puts-200-million-into-gaia-x/ accessed 29 October 2025.
31. J-P. Soininen et al., 'Data Spaces' synergies', (*Data Spaces Support* Centre, October 2024) https://dssc.eu/space/DSSE/758350768 accessed 29 October 2025.
32. See Article 2 (8) & (9) Data Governance Act (n 20).

The foundational component of the data space connector is the reliance on application programming interfaces (APIs).[33] Furthermore, in order to establish a connection to the federated network of existing data infrastructure, it is also necessary to implement a mechanism that can catalogue, display or make available datasets, discoverable and respond to queries in an effective and efficient manner, while also displaying the relevant datasets for that query.[34] This phenomenon can be implemented through two distinct mechanisms. Firstly, it is notable that a connector may be contingent upon the presence of another essential component within the Data Space, namely a metadata broker, to be able to browse existing datasets and display the datasets held by that participant in the federated network via the connector. This metadata broker component facilitates the publication of datasets within a federated network by maintaining persistent communication with all available connectors within the network. A metadata broker is a system that has been developed to systematically extract all available datasets and data infrastructures within a federated network via a connector.[35] Consequently, it is instrumental in ensuring the findability of the dataset by connected data users. The role of the data broker is to aggregate all available information regarding datasets connected to the network via that connector. Secondly, it should be noted that a connector may also implement a cache node, the function of which is to cache available datasets connected to the network via the connector. In essence, caching is a process that involves the storage of multiple copies of data or files in a temporary storage location (cache), with the objective of facilitating faster access to them. This cache node then facilitates the dissemination of data offers to other Data Space participants. A secondary cache crawler perpetually requests the network to cache all available data offerings by crawling other data space connectors and their cache nodes.[36]

Consequently, the effective findability, searchability, access, retrieval and reuse of valuable datasets of participants is made available within Data Spaces through reliance on another component, namely the metadata broker, or implementing a similar component within the connector itself via the technique of caching.[37] Moreover, following the initial conceptualisation of data space connectors, the establishment of usage policies for datasets connected to the federated network via connectors should be a mandatory component of connectors prior to their integration of the datasets into the federated network. The definition of usage policies is as follows: these are defined as permissions and obligations that are associated with a specific data set. The whole idea is that they should be put into a machine-readable language that is both interoperable and comprehensible throughout the entire Data Space.[38] This signifies that the connector hosting the dataset assumes the role of the sole source of truth, while the participant is empowered to modify the restrictions on dataset usage at any given moment.[39]

3.3 A heterogeneous landscape of connectors with several non-reusable and non-interoperable components in practice

Connectors represent a core area of the IDSA expertise, providing the means to integrate and access a wide variety of diverging data infrastructures. Instead of developing and promoting their own data space connectors, the IDSA has opted to create and implement common protocols and standards, leaving

33. Giulia Giussani and Sebastian Steinbuss (n 10) 12-14.
34. Manlio Bacco and others, 'What Are Data Spaces? Systematic Survey and Future Outlook' (2024) 57 Data in Brief 110969 https://doi.org/10.1016/j.dib.2024.110969 accessed 29 October 2025.
35. See e.g. for more technical details, 'IDS Meta Data Broker' (*International Data Spaces Global (IDS-G) Github* 11 July 2022) https://github.com/International-Data-Spaces-Association/IDS-G/blob/main/Components/MetaDataBroker/GeneralOverview.md accessed 29 October 2025.
36. '3.5.4 Metadata Broker | IDS Knowledge Base' (*International Data Spaces,* 27 February 2023) https://docs.internationaldataspaces.org/ids-knowledgebase/ids-ram-4/layers-of-the-reference-architecture-model/3-layers-of-the-reference-architecture-model/3_5_0_system_layer/3_5_4_metadata_broker accessed 29 October 2025.
37. 'Data Spaces Blueprint v2.0. Building Block Overview. Data Interoperability. Data Models', (*Data Spaces Support Centre,* 7 March 2025, https://dssc.eu/space/BVE2/1071255252/Data+Models accessed 29 October 2025.
38. Data Spaces Blueprint v2.0. Building Block Overview. Data Sovereignty and Trust. Access & Usage Policies Enforcement', (*Data Spaces Support Centre,* 7 March 2025, https://dssc.eu/space/BVE2/1071256095/Access+&+Usage+Policies+Enforcement accessed 29 October 2025.
39. '3.4.2 Data Offering | IDS Knowledge Base' (*International Data Spaces,* 27 February 2023) https://docs.internationaldataspaces.org/ids-knowledgebase/ids-ram-4/layers-of-the-reference-architecture-model/3-layers-of-the-reference-architecture-model/3_4_process_layer/3_4_2_data_offering accessed 29 October 2025.

the concrete implementation in practice to others, such as the Eclipse Foundations. Adherence to these protocols is said to guarantee data sovereignty, security and trust.[40] DIN SPEC 27070, a German formalised standard of the reference architecture model of data spaces that IDSA puts forward (IDS-RAM), is an example of such a standardisation effort being already formalised in a national Member State.[41] This standard is predicated on the establishment of common design principles, with the objective of refining the reference architecture model into a specific protocol. It is claimed that concrete implementations of the IDS RAM, and thus the DIN SPEC 27070, are interoperable with other connector initiatives such as the Eclipse Data Space Connector.[42]

The role of the IDSA in the development of standards and protocols for data space connectors, in combination with the development of data spaces and connectors in the EU following those standards, suggests that data space connectors are bridging software with some additional functionalities that are interoperable with other data space connectors and do not need further regulation since they follow established IDSA standards. Furthermore, the imposition of additional interoperability obligations would not be necessary to ensure the capacity of different data space connectors to connect to the same federated network and to read and apply the usage policies of different datasets connected via different connectors to the federated network.

However, a recent market study demonstrated that the practical implementation of connectors cannot currently be identified as mere bridging software. In practice, there is considerable heterogeneity in terms of methodology and maturity of connectors.[43] Firstly, attention must be drawn to the fact that there is a considerable amount of closed-source software available, in contrast to the open-source software recommended by the IDSA and built in practice by the Eclipse Foundation. Although the software on which context-specific implementations are built is often that of the Eclipse Foundation, the incremental nature of Data Spaces results in the release of newer versions of that software, and thus incompatibility of context-specific adaptations built on older software versions. Furthermore, the implementation of core components, such as policy enforcement engines, has been observed to vary among different parties due to the adoption of divergent approaches in the establishment of such policies within connector implementations.[44] In principle, data connectors should rely on established and interoperable machine-readable languages to articulate usage policies regarding datasets, such as the Open Digital Rights Language (ODRL).[45] Consequently, this facilitates the comprehension of usage policies by other connectors. However, a significant number of these systems do not consider established vocabularies or the potential for defining usage policies in accordance with interoperable and known standards. In some cases, the onus is even placed on the software developer to specify data usage preferences through their proprietary choices. Thirdly, some of the connector functionalities are offered as software-as-a-service, while others are integrated as part of a larger platform functionality and thus are provided all together in the form of platform as a service.[46] Fourthly, the presence of additional supplementary functionalities in extant datasets is subject to variation, with the incorporation of such elements being contingent on the specific nature of the connector employed.[47] Automated data de-identification software is an example of software that can be used to enable the automatic pseudonymisation

40. '3.5.2 IDS Connector| IDS Knowledge Base' (*International Data Spaces,* 27 February 2023) https://docs.internationaldataspaces.org/ids-knowledgebase/ids-ram-4/layers-of-the-reference-architecture-model/3-layers-of-the-reference-architecture-model/3_5_0_system_layer/3_5_2_ids_connector#ids-connector accessed 29 October 2025.
41. 'DIN SPEC 27070:2020-03' (*DIN Media,* 2020) https://www.dinmedia.de/de/technische-regel/din-spec-27070/319111044 accessed 29 October 2025.
42. 'Eclipse Documentation' (*Eclipse Foundation EDC Github* 3 December 2024) https://eclipse-edc.github.io/documentation/ accessed 29 October 2025.
43. Giulia Giussani and Sebastian Steinbuss (n 10) 6-7.
44. Tobias Dam and others (n 13).
45. See for more information, 'ODRL Profile: Data Spaces' (*W3C Community Group Draft Report* 11 October 2025) https://w3c.github.io/odrl/profile-dataspaces/ accessed 29 October 2025.
46. See in this regard e.g., the Data Space Integration by SAP, embedded into SAP Integration Suite (platform), Giulia Giussani and Sebastian Steinbuss (n 10) 33-34.
47. See, e.g., Jason Steinmetz, Dolores Ordóñez and others (DSFT and DATES Consortium), 'Blueprint and Roadmap for Deploying the European Tourism Data Space', (*Tourism Data Space,* 31 October 2023) 41-43 https://www.tourismdataspace-csa.eu/wp-content/uploads/2024/01/DRAFT-BLUEPRINT-Tourism-Data-Space-v3.3 final.pdf accessed 29 October 2025.

or anonymisation of data prior to its transmission into the federated network.[48] Finally, the EU itself has encouraged the development of software that bears resemblance to a data space connector by acting as a bridge between existing data infrastructures and a federated network under the name SIMPL.[49] However, the EU's SIMPL initiative has the potential to facilitate access to a range of additional data space functionalities, thereby rendering the similarities with a connector even more ambiguous and dependent on the context. SIMPL software facilitates the integration of additional cloud infrastructure components, such as storage, on top of a connector, thus bridging functionality.

The establishment of an extensive federated network of current data infrastructures (termed the 'data space') is dependent on connectors that facilitate seamless access and connectivity. The establishment of a Data Space is premised on the interoperability of connectors themselves and other services within the Data Space, as well as interoperability between core components, such as policy enforcement engines building on languages like ODRL. However, this objective has yet to be realised in practice. At present, supply of interoperable bridging software does not adhere to IDSA standards and pilot projects encounter numerous challenges when attempting to implement and reuse data space connector components or implementations from existing providers of connector software.[50] The EU Data Strategy has outlined objectives to achieve more qualitative data sharing and to develop more innovative services via the new way of data sharing that is Data Space. However, this is not a reality at present because the connectors as logical access points are not facilitating ease of access in practice and are not connecting data to the federated network as easily as would be desired.

In view of the prevailing heterogeneity in maturity and methodology, and in order to circumvent the challenges of fragmentation and achieving optimal scale, this paper takes as a starting point the regulation of data space connectors as a means to achieve the implementation of highly interconnected data sharing environments. The hypothesis is made that regulation may act as a catalyst for progress within the prevailing fragmented context, with the objective of achieving the development of more innovative services and the advancement of the internal market, in accordance with the EU's strategic vision.

3.4 Recent regulatory frameworks in the context of a digital single market facilitating data sharing through Data Spaces

Following the formulation of the EU Data Strategy, a variety of new legislative instruments have been issued to facilitate or impact the establishment of a digital single market, with Data Spaces being proposed as a means of sharing data.[51] Firstly, the Data Act (DA) has been established as a legislative instrument, with a pronounced emphasis on the release of IoT data and the fair access to and use of such data, for example within Data Spaces. Moreover, Chapter VIII of the Data Act explicitly delineates the concept of common European data spaces and imposes a series of essential requirements on participants regarding the interoperability of data, data sharing mechanisms and services provided within the Data Space. However, a more detailed analysis reveals that these obligations pertain to the interoperability of dataset structures and formats, as well as to tools that automate the execution of data sharing agreements, such as smart contracts, and technical means to access the data, such as APIs.[52] The absence of any reference to data space connectors is notable. These are pieces of software that rely on APIs, yet they possess equally significant functionality within the ecosystem of Data Spaces. Furthermore, the overarching objective of the Data Act is to foster a more competitive and interoperable European cloud market by imposing various interoperability obligations on so-called data processing services.[53] The Data Act defines them as digital services provided

48. 'Anonymization / Pseudonymization' (*Prometheus-X,* 2023) https://dataspace.prometheus-x.org/building-blocks/anonymization-pseudonymization accessed 29 October 2025.
49. Commission (EC), 'Simpl: Cloud-to-edge federations empowering EU data spaces. Preparatory Study. Architecture Vision. Preparatory work in view of the procurement of an open source cloud-to-edge middleware platform. Architecture Vision Document V4.00' (*Digital Strategy EC*¸ 11 October 2024) 21-22 https://digital-strategy.ec.europa.eu/en/policies/simpl accessed 29 October 2025.
50. See e.g., Departement Zorg, 'Vlaamse Health Data Space project. Eindrapport' (*Flemish Government,* February 2025) 178-179 https://www.vlaanderen.be/publicaties/vlaamse-health-data-space-project-eindrapport accessed 29 October 2025.
51. A European strategy for data (n 1) 1-6.
52. See Article 33 (1) (a)-(d) Data Act (n 22).
53. See Article 35 (1) & (2) Data Act (n 22).

to a customer that enable ubiquitous and on-demand network access to a shared pool of configurable, scalable and elastic computing resources of a centralised, distributed or highly distributed nature. The provision and release of these resources can be accomplished in a rapid manner, with minimal management effort or service provider interaction.[54] When considering the definition of data space connectors provided by the IDSA, which is limited to the role of bridging software, it is challenging to interpret connectors as falling within the scope of the Data Act. However, as demonstrated in Section 3.3, connector functionalities can be embedded within data processing services, such as cloud infrastructures, in practice. However, it is noteworthy that the principal emphasis of these Data Act provisions for data processing services is on functionalities such as portability of digital assets, thereby facilitating the transition of customers between various cloud service providers within the domestic market. Interoperability is understood to be the capacity for two cloud systems to communicate with one another. Data portability is the capability for customers to transfer data between cloud systems. Application portability pertains to the ability to transfer executable software between cloud systems and ensure its proper operation.[55] This would imply that connector software integrated within one cloud service should be capable of running on another cloud service as well. However, this does not address the interoperability between connector software itself, nor does it mandate the inclusion of specific core components as part of connector software. The primary focus of the Data Act does not pertain to the integration of existing cloud infrastructures within a novel federated network, a goal that is precisely the aim of data space connectors. Consequently, the Data Act is inappropriate for addressing the issues delineated in Section 3.3 concerning connectors and will not be discussed in more detail.

Secondly, the Digital Markets Act (DMA) establishes the foundations for a fair and more contestable data economy and a future digital single market. In this respect, the DMA aims to open up existing data silos by imposing several interoperability obligations on the parties within its scope, thereby paving the way for the establishment of highly interconnected data-sharing environments.[56] Indeed, the DMA establishes supplementary provisions solely for a select number of companies, presumed to be gatekeepers upon meeting specific quantifiable thresholds, with the objective of reducing barriers to entry in the internal market.[57] For instance, these gatekeepers are prohibited from engaging in practices such as the bundling of certain core platform services with other services. Furthermore, the core platform services of said gatekeepers are bound by obligations regarding interoperability.[58] Several online marketplaces, search engines, social networks, and operating systems have already been designated as core platform services by the European Commision.[59] In this regard, certain web browsers have also been designated as core platform services at the access level. It could be argued that these web browsers, in a manner analogous to the function of data space connectors, facilitate access to datasets and provide a bridge between an entity hosting data on a web server and a user of a web browser searching for particular information via a query. Nonetheless, it is challenging to conceptualise a connector as a core platform service at this moment in time, in accordance with the IDSA definition of mere bridging software. Given the current fragmentation of the landscape of connectors, it appears improbable that a connector will be designated as a gatekeeper with a core platform service in the foreseeable future and reach the quantifiable thresholds of the DMA for gatekeepers. To be precise, it is further assumed that an annual turnover of €7.5 billion, a market capitalisation of €75 billion, or a large user base of 45 million or more monthly active EU end-users will not be attained soon.[60]

The Data Governance Act (DGA) was established with the purpose of addressing the current lack of trust in data sharing within the internal market. Trust is ensured by the establishment of transparent, neutral or impartial data intermediaries among the parties engaged in data sharing.[61] This was regarded as a key

54. See article 2 (8) Data Act (n 22).
55. See Article 35 (2) Data Act (n 22).
56. See e.g., regarding the scope of the DMA, Rupprecht Podszun, *Digital Markets Act: Article-by-Article Commentary* (1st edn, Bloomsbury Publishing 2024) 17-66.
57. Article 3 Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (Digital Markets Act), OJ 2022 L 265/1.
58. See article 6 (7) Digital Markets Act (n 56).
59. Article 5 and 6 Digital Markets Act (n 56).
60. Article 3 (2) (a) & (b) Digital Markets Act (n 56).
61. See recital 5, 23, 24, 32, 38, 43, 47 and 52 Data Governance Act (n 20).

component in the development of Data Spaces.[62] As such, these data intermediaries, as defined under the DGA, encompass a wide range of services and are subject to a variety of specific conditions to ensure their neutrality and trustworthy function within Data Spaces. In this regard, several authors have advanced the argument that the scope of the DGA can be interpreted in a broad manner, due to a general definition of data intermediation services that leaves a lot of room for ambiguity. Consequently, a significant number of services could be classified as data intermediation services.[63] In this regard, the DGA is selected as the regulatory instrument to analyse more thoroughly its potential application to data space connectors. The definition of data intermediary and scope of the DGA is therefore analysed and evaluated in Section 4, along with the implications of the obligations stipulated under the DGA.[64]

4. Data Governance Act

4.1 Broad and ambiguous definition of data intermediation services under the DGA

The DGA provides coverage of a wide range of data intermediation services. These services are categorised under a general definition in article 2, as well as under three specific categories that are listed explicitly in article 10.[65] Firstly, a general definition and thus general category of intermediation services are delineated as 'services that aims to establish a commercial relationship for the purpose of data sharing between an undetermined number of data subjects and data holders on the one hand and data users on the other through technical, legal or other means'.[66] This definition incorporates extensive and somewhat ambiguous legal terminology. First, it is necessary to consider the generic concept of "services" as set out in the relevant EU legislation, given that the DGA does not offer a particular definition.[67] The classification of specific activities as services is determined on a case-by-case basis.[68] Secondly, in a similar manner, the term 'commercial' does not receive further clarification throughout the DGA. However, this term refers broadly to the nature of the interaction between parties in the data ecosystem, and is distinct from their capacity, which can be either commercial or non-commercial.[69] Thirdly, the 'aim' of entering commercial relationships, as previously defined, concerns the design of a data intermediary business model and the specific business decisions that need to be made in advance to establish such relationships for the purpose of data sharing. Fourthly, to qualify as a data intermediary, it is essential that a service does not consist of one which is exclusively dedicated to facilitating interactions for specific parties. Rather, it should function as a universally accessible service within the recently established data ecosystem.[70] Lastly, the modalities of intermediation – including the selection of technology – are irrelevant.[71]

In addition to this general definition, the scope of the DGA is further delineated by listing three additional categories of intermediation services. These include data cooperatives, personal information management

62. See recital 27 and 28 Data Governance Act (n 20).
63. Heiko Richter, 'Looking at the Data Governance Act and Beyond: How to Better Integrate Data Intermediaries in the Market Order for Data Sharing' (2023) 72(5) GRUR International 458 https://doi.org/10.1093/grurint/ikad014 accessed 21 October 2025; Gabriele Carovano and Michèle Finck, 'Regulating Data Intermediaries: The Impact of the Data Governance Act on the EU's Data Economy' (2023) 50 Computer Law & Security Review 105830 https://doi.org/10.1016/j.clsr.2023.105830 accessed 21 October 2025; Lukas von Ditfurth and Gregor Lienemann, 'The Data Governance Act: – Promoting or Restricting Data Intermediaries?' (2022) 23(4) Competition and Regulation in Network Industries 270 https://doi.org/10.1177/17835917221141324 accessed 29 October 2025.
64. See for the definition of a data intermediary, article 2 (11) Data Governance Act (n 20).
65. von Ditfurth and Lienemann (n 62).
66. See Article 2 (11) Data Governance Act (n 20).
67. Art. 57 Consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union Consolidated version of the Treaty on European Union Consolidated version of the Treaty on the Functioning of the European Union Protocols Annexes to the Treaty on the Functioning of the European Union Declarations annexed to the Final Act of the Intergovernmental Conference which adopted the Treaty of Lisbon, signed on 13 December 2007 Tables of equivalences, OJ 2016 C 202/1; Article 4 (1) Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market, OJ 2006 L 376/36.
68. Tobias Mc Fadden v Sony Music Entertainment Germany GmbH, Case C-484/14, [2016] (ECLI:EU:C:2016:170), at para. 43
69. Richter (n 62) 458.
70. Tervel Bobev and others, 'White Paper on the Definition of Data Intermediation Services' (*Social Science Research Network*, 2 October 2023), 33-36, https://papers.ssrn.com/abstract=4589987 accessed 29 October 2025.
71. See Article 2 (11) Data Governance Act (n 20).

systems and intermediation services between data holders and users. The latter includes the provision of technical means to enable such intermediation services. Accordingly, the provision of intermediation services may be considered to encompass the provision of technical resources such as the creation of platforms or databases, or the development of other infrastructure designed to facilitate connections between data holders and users.[72]

The broad general definition and the specific category that explicitly refers to the provision of technical resources have the potential to encompass a wide variety of services, provided in the context of Data Spaces.[73] In this context, it is challenging to determine whether services are or are not subject to the stringent and diverse obligations of the DGA. A broad reading of the DGA could lead to encompassing almost all data intermediation services in the broad sense.[74] However, the recitals furnish supplementary context, thus enabling the exclusions of various services from the scope and facilitating a more comprehensive understanding of the DGA's rationale. For instance, the phrase 'aim to' in the general definitions implies that intermediation services should not comprise generic services that could incidentally also be used to support relationships between data holders and data users. However, the DGA does not specify a de minimis threshold below which services would not be considered generic and would therefore fall outside the scope of the DGA.[75] Generic services or technical tools that do not fall within the scope of the DGA are those that do not aim to establish a commercial relationship between data holders and data users, nor allow the data intermediation service provider to acquire information on such relationships for the purposes of data sharing. Examples of such services include cloud storage, data sharing software and web browsers, as listed in the recitals of the DGA.[76] However, the scope of services that should not be considered data intermediaries may evolve with continual technological development.[77] In that regard, data space connectors are merely conceived as bridging software that is generic to any data space or participant and follows generic standards. Therefore, they would not fall under the scope of the DGA.

However, in practice, the landscape is heterogeneous, with data space connectors containing different core components or building blocks or being provided as part of another service or platform. Depending on the case in question, the current heterogeneous landscape of data space connector software is sometimes integrated into a platform-as-a-service offering or incorporated into a larger software as a service package or offering that provides additional functionalities for data sharing compared to connectors as mere bridging software. The potential for these software components and platform services to extend beyond the provision of generic services, thereby also facilitating commercial relationships between data holders and users, is a point that merits consideration. Consequently, they could be classified as data intermediaries within the broader definition outlined in the DGA. From a theoretical perspective, it is intriguing to examine the regulatory obligations imposed on data intermediaries under the DGA. The objective of this analysis is to determine whether a regulatory framework exists that could govern data space connectors as mere bridging software. The present paper sets out the argument that the purpose of the bridging software is to possess a set of interoperable and harmonised core components to facilitate seamless connectivity for all participants to a Data Space in a functionally equivalent manner. This is to achieve the objectives outlined in the EU's Data Strategy and make Data Spaces work in practice.

4.2 Strict requirements DGA fall short in governing heterogeneous data space connectors

The DGA imposes diverse regulatory obligations on data intermediation services. The question must be posed as to whether all categories of intermediaries should be subject to all stipulated data intermediaries' obligations without distinction, which are highly diverse (e.g. across various legal branches).[78] Firstly, data intermediaries must unbundle their intermediation services from any other services they provide, including generic services such as cloud storage, web browsers and connector software. This practice originates from

72. See Article 10 Data Governance Act (n 20).
73. Bobev and others (n 69) 36-46.
74. See in that regard, e.g., Richter; Carovano and Finck; von Ditfurth and Lienemann (n 62).
75. Bobev and others (n 69) 42
76. Recital 28 Data Governance Act (n 20).
77. Bobev and others (n 69) 31.
78. Bobev and others (n 69) 59-62.

the EU's goal of avoiding network-related industries susceptible to anti-competitive practices within the context of Data Spaces. Here, vertically integrated companies engage in discriminatory behaviour towards competitors regarding access to their platform or infrastructure.[79] Furthermore, data intermediaries are obligated to adhere to what is termed 'neutrality obligations', which stipulate the provision of fair, transparent, and non-discriminatory access to their services.[80] In that regard, commercial terms, including pricing, shall not be contingent upon the use of other services provided by the same data intermediary. Furthermore, data intermediaries are also subject to interoperability obligations within and across sectors, with a view to decreasing the effort required for data sharing.[81]

In this regard, the DGA incorporates stringent provisions pertaining to the potential offer of additional services in combination with the intermediation service itself. As was the case in the discussion on the exclusion of generic services, additional tools are only considered to form part of intermediation services if they are used exclusively for the purpose of establishing commercial relationships between data holders and users. Consequently, they fall under the scope of the DGA. As demonstrated in the preceding section, the implementation of this criterion in practical contexts is challenging.[82] Notwithstanding the careful examination of the relevant recitals set out in the DGA, a certain ambiguity remains.[83] However, the present paper operates under the hypothesis that additional tools cannot be connector services, as their purpose is not exclusively to establish commercial relationships. In practice, this means that when some platform-as-a-service offerings or larger software package offerings fall within the scope of the DGA, the data intermediation service obligations would require the intermediation service itself to be strictly separated from other generic services, such as connector functionality or bridging software. Consequently, the intermediation service itself would be subject to regulation, while the connector functionality and bridging software would be excluded from the scope of regulation.

In the event of connector functionalities within a software or platform as a service package being regarded as an additional tool and thus provided alongside intermediation services as an inherent component thereof, essential for the establishment of commercial relationships, the DGA's interoperability and other obligations would not address the interoperability and lack of harmonisation of core components concerns highlighted in Section 3.3. Firstly, in accordance with the DGA, it is necessary to convert data into specific formats to enhance interoperability within and across sectors.[84] Secondly, data intermediaries are obliged to implement appropriate measures to ensure interoperability with other data intermediation services.[85] However, in order to facilitate interoperability between data space connectors and existing data infrastructures from participants, a more comprehensive approach to interoperability is required than merely converting data formats. The objective would be to establish the necessary mechanisms to ensure the interoperability of software and protocols at the infrastructure level, as well as at the data intermediation service level. Furthermore, the requirement in the DGA for data intermediation services to be interoperable with each other, as discussed in Section 3.4 concerning the interoperability of cloud services, can only indirectly address data space connectors and their bridging functionality. The underlying objective and rationale of these obligations in the DGA is to ensure the interoperability (open standards use) of 'matchmakers' as data intermediation services between each other within the Data Space and the specific sector in which they operate. This is not to ensure via those intermediaries that participants can access the Data Space and display and grant access to their datasets in a functionally equivalent and straightforward manner.

79. See e.g., Tilman Michael Dralle, *Ownership Unbundling and Related Measures in the EU Energy Sector: Foundations, the Impact of WTO Law and Investment Protection* (1st edn 2018 Springer Nature eBook) https://lawcat.berkeley.edu/record/480990 accessed 29 October 2025.
80. See article 12 (f) Data Governance Act (n 20).
81. See article 12 (i) Data Governance Act (n 20).
82. Bobev and others (n 69) 43-46.
83. Recitals 32 and 33 are for example not in alignment with recital 28 Data Governance Act (n 20).
84. See article 12 (d) Data Governance Act (n 20).
85. See article 12 (i) Data Governance Act (n 20).

4.3 DGA not suitable to regulate heterogeneous landscape of connectors with several non-reusable and non-interoperable components

As demonstrated in Section 4.1, the definition of a general category of data intermediation services employed by the DGA is broad in nature, resulting in an ambiguous scope. Furthermore, the three specific categories of intermediation services listed alongside the general definition did not clarify the scope to a greater extent regarding data space connectors. A more teleological interpretation of the definition of a data intermediary, one which follows the initial goal and rationale of the DGA as shown in its recitals, points towards the essence of the matchmaking function between two parties. The purpose of intermediation services is to establish relationships between the parties involved, rather than focusing on the specific nature of the service provided (e.g. the selection of means or particular technology).[86] The paper thus argues that generic services or technical tools that fall outside the scope of the DGA encompass not only cloud storage and web browsers, but also mere bridging software that functions as a data space connector. However, as demonstrated in Section 3.3, in practice, a connector is not often offered as mere bridging software, but rather as part of a platform service or a more extensive software as a service package. Consequently, and once more, given the extensive scope of the DGA, the services in question could be classified as data intermediation services. The obligations to which they are subject were examined in Section 4.2.

Section 4.2 provides a detailed exposition of the diverging obligations for data intermediaries. Regarding the obligation of unbundling and structural separation of the intermediation service with other services, it was highlighted that, in theory, additional tools such as data conversion or anonymisation tools can be regarded as inherently part of the intermediation service and therefore not need to be unbundled. Nevertheless, uncertainty persists in this respect because there are no objective criteria available to qualify supplementary tools that can be provided in combination with the intermediation service. As with the arguments presented in Section 4.1, the paper then advanced the hypothesis that it would be difficult to consider connector functionalities or a piece of bridging software as inherently part of the intermediation service and thus aiming to establish commercial relationships between data holders and data users. In practice, this results in the requirement for the provision of connector functionalities or pieces of bridging software to be strictly separated from the data intermediation service. Therefore, this functionality falls further outside the scope of the DGA and is left unregulated. In circumstances where the functionality of such connectors is regarded as an intrinsic component of the data intermediation service provided as a platform as a service or a software as a services package and is deemed essential for the establishment of commercial relationships, the DGA's obligations do not address the issues as delineated in Section 3.3.

5. The hypothesis of regulating connectors under the European Electronic Communications Code

In practice, there appears to be a lack of clarity regarding the boundaries between the core components of data space connectors. At present, connectors are frequently part of or incorporated within other services, such as platform or broader software package services, and offer connector functionalities in this context rather than being purely bridging software. Consequently, a heterogeneous connector landscape exists in practice regarding methodology and maturity. Furthermore, it appears that the connectors are not interoperable with each other. Consequently, they are unable to establish interconnected data sharing environments or Data Spaces that are easily accessible to participants and where participants can display and provide access to their datasets in a convenient manner.

The present paper is founded on the hypothesis, as outlined in Section 3, that the function of data space connectors should be limited to that of a mere bridging software solution, incorporating a restricted array of interoperable functionalities or core components between each other. In accordance with the definition stipulated by the IDSA, where data space connectors are effectively regarded as a mere bridging functionality, the paper normatively suggests the hypothesis of regulating data space connectors under the Electronic Communications Code (EECC) to data space connectors and concludes with a call for further exploration

86. Bobev and others (n 69) 36-46.

of this hypothesis.[87] The EECC has established itself as a technologically neutral legislative framework that addresses the harmonisation of electronic transfer of information, data, or messages using digital means in a forward-looking manner.[88] In Section 5.1, drawing upon a range of historical illustrations, a detailed argument is presented in support of the hypothesis that data space connectors, regarded as mere bridging software, might also be construed as software that facilitates the transfer of information and data under the EECC. This is predicated on the EECC's forward-looking and technologically neutral character. Secondly, Section 5.2 will provide a detailed exposition of the potential benefits of this hypothesis by demonstrating how the application of the diverse interoperability obligations, end-user protection guarantees and long-standing tradition of licensing and spectrum coordination set out in the EECC could prove to be useful instruments to address the issues with data space connectors currently identified in practice, as described in Section 3.3, hindering the implementation of Data Spaces.

5.1 The evolving interpretation of electronic communication services in the context of technological neutrality

In order to develop an argumentation and rationale for the application of the EECC to data space connectors, it is necessary to briefly refer to the historical developments and evolutive interpretation of electronic communications services as they relate to the adoption of the EECC.[89] This will allow the reader to understand how data space connectors could be seen as functionally equivalent to current electronic communication services.

Prior to the establishment of the European Electronic Communications Code (EECC), the regulatory framework governing electronic communication services was comprised of several directives, including the Universal Service Directive[90], Framework Directive[91], Access Directive[92] and Authorisation Directive[93]. This regulatory framework has its origins in the fact that the conventional value chain underwent a series of transformations, thus necessitating a new regulatory framework governing the telecommunications sector. Firstly, the transition from traditional voice-oriented telephone networks to broadband-based networks offering internet-based services has had several consequences for the regulation of electronic communications. In the past, the transmission of information via traditional telephone cable networks was limited to SMS (short message service) due to the capacity constraints of these networks. However, the advent of network developments and enhancements of existing cable networks resulted in higher data or information carrying capacity and so-called broadband networks. These broadband networks facilitated high-speed broadband, enabling activities such as web browsing and file downloading. Consequently, reliance on SMS for the transmission of information became redundant, as the transmission of a greater volume of data and information over these networks became possible.[94] The delivery of new data and information, which was previously made available through service providers relying on voice-oriented telephone cable networks, was subsequently made available through service providers relying on evolved broadband cable networks. As such, it was necessary to regulate the providers of those services in a functionally equivalent manner. In this regard, technological advances have resulted in the development of increasingly rapid networks with substantial data transmission capabilities. Consequently, following the advent of broadband networks, mobile broadband networks emerged, thereby enabling service providers to deliver streaming

87. European Electronic Communications Code (n 21).
88. Mehmet Bilal Unver, 'End(s) of the Harmonization in the European Union: Centrifuging or Engineering?' (2021) 11 Journal of Information Policy 582, 604-632 https://doi.org/10.5325/jinfopoli.11.2021.0582 accessed 29 October 2025.
89. Ian Walden, 'European Union Communications Law' in Ian Walden and John Angel (eds), *Telecommunications Law and Regulation*, Second Edition (Oxford, 2005)
90. Directive 2002/22/EC of the European Parliament and of the Council of 7 March 2002 on universal service and users' rights relating to electronic communications networks and services (Universal Service Directive) OJ 2002 L 108/51.
91. Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive) OJ 2002 L 108/33.
92. Directive 2002/19/EC of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive) OJ 2002 L 108/7.
93. Directive 2002/20/EC of the European Parliament and of the Council of 7 March 2002 on the authorisation of electronic communications networks and services (Authorisation Directive) OJ 2002 L 108/21.
94. Theo Dunnewijk and Staffan Hultén, 'A brief history of mobile communication in Europe' (2007) 24(3) Telemat. Inf. 164, 164–179 https://doi.org/10.1016/j.tele.2007.01.013 accessed 29 October 2025.

media directly to consumers over the internet by leveraging the augmented investments in and capacities of existing networks.[95] This development has bypassed traditional equivalent services offered through cable voice-oriented telephone or broadband networks. Consequently, these service providers were designated over-the-top (OTT) service providers, a term that encompasses prominent examples such as WhatsApp.[96] The subsequent regulatory expansion, in the form of a new EECC, was driven once more by advancements in the field of telecommunication networks. Consequently, the EECC encompassed new service providers, such as OTTs, incorporating interoperability, harmonisation, non-discrimination, and transparency obligations. These obligations bear a close resemblance to those previously imposed on traditional service providers on broadband networks.

The deployment and subsequent investments in existing cable networks have, in essence, been leveraged throughout history to facilitate the emergence of providers offering novel services in a functionally equivalent manner to previous service providers relying on the existing cable network. OTTs leveraged investments in existing cable and broadband networks to deliver new content and content of a similar nature via mobile broadband networks. Accordingly, OTT services serve as a substitute for conventional service providers relying on cable and broadband networks and were regulated in a functionally equivalent manner.[97] While the advent of novel services that are functionally equivalent to the preceding regulated services initially falls outside the scope of existing regulation, the preceding paragraphs demonstrate how the further development in the field of telecommunications has consistently been addressed with more forward-looking and technologically neutral regulation.[98]

Such historical developments, it can be argued, have provided a foundation for the adoption of the EECC as a broad and technologically neutral piece of legislation.[99] The EECC underscores the necessity for regular adaptation of definitions of telecommunication services to ensure alignment with technological advancements. In that regard, within the context of 5G networks – which represent yet another network evolution compared to mobile broadband networks due to their increased and accelerated data transmission capacities – the Body of European Regulators for Electronic Communications (BEREC) has highlighted that cloud software providers are converging with traditional providers covered by the EECC.[100] The advent of cloud software has the potential to virtualise services formerly offered through physical components in the context of 5G networks. Consequently, novel services can be offered in a functionally equivalent manner by reliance on investments in existing networks.[101] To illustrate this point with greater precision, consideration should be given to the function of physical components such as routers and network ports and switches. For instance, they facilitate access to internet services and the establishment of private networks for companies to store their data on. The advent of 5G networks has rendered these physical components capable of being offered in a fully digital capacity, through cloud software. This is due to the enhanced speeds and data transmission capabilities of 5G networks compared to mobile broadband. By leveraging the enhanced speed and data transfer capacity of these networks, cloud software has become capable of creating and setting up multiple virtual networks, or 'slices', tailored to specific use cases with unique requirements for

95. Wolfgang Briglauer, Klaus Gugler and Adhurim Haxhimusa, 'Facility- and Service-Based Competition and Investment in Fixed Broadband Networks: Lessons from a Decade of Access Regulations in the European Union Member States' (2016) 40 (8) Telecommunications Policy 729 https://doi.org/10.1016/j.telpol.2015.07.015 accessed 29 October 2025.
96. See for a more in-depth analysis, Markus Steingröver, Edgar B. Cardozo Larrea, Nikolay Zhelev, 'The Rise of OTT Players: What is the Appropriate Regulatory Response?' in Pter Krüssel (ed), Future Telco. Successful Positioning of Network Operators in the Digital Age (Springer 2018) 241-249.
97. Jürgen Kühling, Tobias Schall and Corinne Ruechardt, 'Are Gmail,WhatsApp, and Skype "Electronic Communications Services" within the Meaning of the Framework Directive?' (2016) 17 (5) Computer Law Review International 134 https://doi.org/10.9785/cri-2016-0503 accessed 29 October 2025.
98. Explanatory Memorandum Proposal for a Directive Of The European parliament And Of The Council establishing the European Electronic Communications Code (Recast) COM/2016/0590 final, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=comnat:COM_2016_0590_FIN accessed 29 October 2025.
99. Recital 14 European Electronic Communications Code (n 21).
100. 'BEREC Report on Cloud and Edge Computing Services' (*Body of European Regulators for Electronic Communications*, 7 March 2024) https://www.berec.europa.eu/system/files/2024-03/BoR%20%2824%29%2052_Draft_Cloud_Report.pdf accessed 29 October 2025.
101. Serge JH Gijrath, '(Re-)Defining Software Defined Networks under the European Electronic Communications Code' (2021) 40 Computer Law & Security Review 105492 https://doi.org/10.1016/j.clsr.2020.105492 accessed 29 October 2025.

performance, security, and other factors.[102] Cloud software has the capacity to establish a private network for specific, domain-specific operations within a company. This function was originally implemented by physical network switches or ports. The advent of cloud software has been instrumental in facilitating access to a plethora of new services that are functionally equivalent to traditional services. A similar phenomenon has been observed with OTT services.[103] In light of the emerging capacities of cloud software providers, which are reliant on the advancements in existing networks, BEREC has confirmed the potential application of the provisions of the EECC to cloud software service providers within the context of 5G.

When considering the historical developments in regulating telecommunications services as outlined in the first paragraph, and when considering recent advancements in the field of cloud software in the context of 5G, an argument can be made for the functional equivalence of data space connector services as functionally equivalent to traditional telecommunications services too. Data space connectors are conceptualised as bridging software. It can thus be argued that connectors facilitate access to and the potential display of a plethora of content (in this case, datasets) that traditionally have been offered by relying on cable, mobile broadband or even 5G networks. A data space connector facilitates access to functionalities and services for data sharing within and via a data space, without providing such content themselves. This practice is analogous to that of OTTs, as outlined in the preceding paragraphs. In the contemporary context, data is exchanged bilaterally between organisations that wish to engage in such exchange via cable or broadband networks. However, it is anticipated that, in the future, a federated network of datasets will emerge in the form of a data space, thereby serving as a novel means to deliver existing content in a different manner. The data space connector represents the foundational element in the establishment of connections between existing datasets, thereby facilitating the configuration of a federated network. The exchange of data is, in essence, functionally equivalent to previous data exchange practices. However, it encompasses new ways of delivering it and, as such, new services in the form of data space connectors.

The paper thus puts forward the hypothesis that the regulation of data space connectors under the EECC is a worthy hypothesis. Furthermore, the exploration of this hypothesis is pertinent, given that a reform of the EECC has been planned for some time within the legislation itself, with the objective of implementing it by the end of 2025.[104] The question of whether this reform will be a major, comprehensive review leading to a new piece of legislation, possibly the Digital Networks Act, or whether a minimal overhaul with additional clarifications will suffice is currently being debated.[105] The EU has previously outlined that the principle of technological neutrality should be sufficiently safeguarded during such a reform.[106] The issue of pan-European harmonisation of infrastructure access regimes is also a matter of significant concern.[107] In this regard, policymakers should consider the arguments presented in this Section 5.1 and regulate data space connectors under the EECC as the pivotal access point and thus infrastructure to connecting to Data Spaces and the content therein in the future.

5.2 Potential benefits of applying the EECC to data space connectors

Absent minimum requirements regarding the composition of core components for a connector, and thus absent harmonisation of said components, the establishment of connectors will remain fragmented and diverse in terms of methodology and maturity. In practice, establishing a connection to data spaces poses a significant challenge, primarily due to the incompatibility of numerous data space connector implementations, which renders them unable to be (re)used across different data spaces or contexts. The objective of establishing a novel approach to data sharing through the medium of Data Spaces, as

102. P. Rost et al., 'Network Slicing to Enable Scalability and Flexibility in 5G Mobile Networks' (2017) 55 (5) IEEE Communications Magazine 72, 72-79, https://doi:10.1109/MCOM.2017.1600920 accessed 29 October 2025.
103. 'BEREC Common Position on Mobile Infrastructure Sharing' (*Body of European Regulators for Electronic Communications*, 13 June 2019) https://www.berec.europa.eu/sites/default/files/files/document_register_store/2019/6/BoR_%2819%29_110_CP_Infrastructure_sharing.pdf accessed 29 October 2025.
104. Article 82 European Electronic Communications Code (n 21).
105. 'Five Pitfalls to Avoid in the Digital Networks Act' (*Euractiv*, 4 June 2025) https://www.euractiv.com/section/tech/opinion/five-pitfalls-to-avoid-in-the-digital-networks-act/ accessed 29 October 2025.
106. Commission (EC), 'Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee And The Committee Of The Regions' (Commission Work Programme 2025) COM(2025) 45 final, 11 February 2025.
107. How to master Europe's digital infrastructure needs (n 6).

delineated by the EU Data Strategy, is proving to be a challenging endeavour in this context. Furthermore, the interoperability of connectors between each other and with other services, such as a metadata broker service offered within a Data Space, is also of consideration in the current fragmented connector landscape. Consequently, this paper will elaborate on the potential to yield numerous advantages from the diverse interoperability obligations, end-user protection guarantees, and long-standing tradition of licensing and spectrum coordination set out in the EECC to address the issues with data space connectors currently identified in practice.

Firstly, it is important to note that the EECC's interoperability obligations have the potential to enhance interoperability between data space connectors and their core components (e.g. the attachment of usage policies to datasets) as well as between data space connectors and other services of importance within Data Spaces, such as metadata brokering (as explained under Section 3.2). Member States are obliged to encourage the use of the standards or specifications, technical interfaces or network functions, to the extent strictly necessary to ensure interoperability of services, end-to-end connectivity, facilitation of provider switching and to improve freedom of choice for users.[108] It is important to note that national regulatory authorities (NRAs) themselves can also mandate the implementation of specific standards by electronic communication service (ECS) providers. NRAs are characterised by a certain degree of flexibility, which enables them to select the remedies deemed most suitable for addressing potential market failures, according to the proportionality principle.[109] For instance, where commercial negotiation has proven unsuccessful and the provision of adequate access and interconnection of services is in the best interests of end-users.[110] This, in turn, ensures the provision and interoperability of services throughout the Union.[111] Further harmonisation requirements regarding the core components of data space connectors could also be imposed by the NRAs, should there be evidence to suggest that they have the potential to ensure the maintenance of a competitive market for data space connectors, whilst maintaining elevated standards and safeguards for end-users.[112] A detailed analysis of the EU or Member State market can be conducted to determine the validity of imposing (additional) regulatory and interoperability obligations.[113] Additionally, NRAs have a wide array of tools at their disposal for the purpose of ensuring interoperability, and are able to grant open access to technical interfaces, protocols and key technologies.[114] The purpose of the powers granted to NRAs is threefold: firstly, to promote efficiency, sustainable competition, efficient investment and innovation, and secondly, to ensure that the maximum benefit is given to end-users.[115]

Secondly, the EECC contains robust end-user protection guarantees. The term 'end-user' is understood to denote any user who does not provide public electronic communication networks or services. A user may thus be referred to as either a natural person or a legal person and encompasses data space participants, including data holders, data users and data subjects.[116] In the event of end-to-end connectivity between end-users being hindered due to a lack of interoperability between communications services (such as data space connectors and their core components in this case), obligations are imposed on relevant providers of such services to achieve a significant level of coverage and user uptake.[117] In a similar vein, in circumstances where circumstances significantly restrict competitive outcomes for end users, the NRA may be compelled to impose access obligations on fair and reasonable terms and conditions.[118] Moreover, the EECC encompasses price control and accounting obligations, with the aim of preventing price setting that would have a negative effect on end-users.[119]

108. Article 39 European Electronic Communications Code (n 21).
109. Unver (nr 87) 610-618.
110. Recital 144 European Electronic Communications Code (n 21).
111. Article 60 European Electronic Communications Code (n 21).
112. Article 101 European Electronic Communications Code (n 21).
113. Article 67 European Electronic Communications Code (n 21).
114. Article 73 European Electronic Communications Code (n 21).
115. Article 61 European Electronic Communications Code (n 21).
116. Article 2 (13) and (14) European Electronic Communications Code (n 21).
117. Article 61 (2) (c) European Electronic Communications Code (n 21).
118. Article 61 (3) European Electronic Communications Code (n 21).
119. Article 74 European Electronic Communications Code (n 21).

The EECC contains several broad interoperability obligations and gives NRAs the flexibility and possibility to also deploy a wide array of measures to ensure interoperability, efficient investment and innovation. Furthermore, the EECC can be implemented to ensure the protection of end-users by imposing fair and reasonable access obligations on data space connectors. In conclusion, this paper thus advances the hypothesis that a further exploration of this hypothesis is merited. In future research, a more detailed translation of EECC (interoperability) obligations, could for example be explored.

6. Conclusion

The European Union has a clearly defined objective of establishing collaborative and highly interconnected environments for data sharing in the form of Data Spaces. The EU anticipates that these environments will facilitate enhanced qualitative data exchange and the development of innovative services within the internal market. In the context of data infrastructures, which have historically been characterised by heterogeneity, for instance regarding data formats, the EU is now proposing a strategy of coexistence. Each extant data infrastructure is expected to connect to and disseminate datasets into a newly established federated network. Data space connectors are a foundational element in the establishment of federated networks. Connectors are software that facilitates the connection of existing data infrastructures to the federated network or the Data Spaces, thereby enabling the transmission of datasets within these environments. All participants in data spaces rely on connectors to facilitate straightforward access to datasets within data spaces and to seamlessly connect existing data infrastructures.

However, Section 3.3 outlined that in practice, data space connectors appear to be heterogeneous in both the maturity of their core components and readiness of use, and their precise methodology to establish connector software differs. Accordingly, the implementation in practice differs from the initial conceptualisation of connectors. The initial conceptualisation defined connectors as mere bridging software with a limited set of standard functionalities, such as the ability to attach policy or usage requirements to a dataset before connecting it to the Data Space. As is apparent from the extant reports and surveys, connector functionalities have been shown to be a component of larger software as a service offering, or an integral component of platform services. In order to construct a federated network of existing infrastructures in which data can be further shared and used as envisaged by the EU in its Data Strategy, the paper therefore advances the hypothesis that it is essential to provide connector services that are interoperable between each other and between other services provided in the Data Space and that these connector services are more harmonised regarding their core components. Consequently, regulation is deemed necessary to ensure that the connector software offered to Data Space participants remains in accordance with the original definition of the IDSA, namely that of mere bridging software.

A preliminary analysis of new regulatory frameworks in the context of establishing a digital single market with highly interconnected data sharing environments revealed that, among the available options, only the Data Governance Act, with its broad scope, had the potential to address the heterogeneity of data space connectors. However, as demonstrated in Section 4.1, it is challenging to categorise bridging software as a data intermediation service. Notwithstanding the potential qualification of platforms or large software packages with embedded connector functionalities as data intermediaries, Section 4.2 demonstrated that the obligations imposed by the DGA are ill-suited to address the heterogeneous connector landscape.

In view of the foregoing, the paper then put forward the hypothesis of regulating data space connectors under the framework of the EECC. A concise historical investigation into the regulation of electronic communication services was undertaken to establish the rationale of the hypothetical application of the EECC to data space connectors. The regulatory framework governing electronic communications has historically been adopted for new services that facilitate access to content in a new manner that is, in essence, functionally equivalent to prior or traditional telecommunication services. Section 5.1 advanced the argument that data space connectors provide functionally equivalent services to conventional communications services. The process of data sharing is being facilitated in a novel manner, namely via a federated network consisting of connectors that facilitate the integration of existing data infrastructures into the federated network. In

Section 5.2, the potential benefits of implementing the hypothesis of regulating data space connectors under the EECC in practice were highlighted. The presentation provided a comprehensive overview of the key advantages of the broad interoperability obligations and provisions in the EECC, highlighting the tools that NRAs possess in that regard. Furthermore, the EECC ensures the protection of end-users by imposing fair and reasonable access obligations on data space connectors.

The measures delineated above have the potential to address the current heterogeneity of data space connectors. Moreover, Section 5 and the hypothesis delineated therein are of relevance in the context of the planned revision of the EECC, which is anticipated by the end of 2025. Additionally, ongoing dialogue continues regarding the way data space connectors might be offered to ensure the sustainability of their business models. Finally, the arguments developed in Section 5 to regulate connectors under the EECC could also serve as an incentive or an example to further explore the concrete implementation of this hypothesis in practice. In subsequent research, a more detailed translation of EECC (interoperability) obligations could be explored, for example.

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