Connecting Data Spaces and Data Marketplaces and the Progress Toward the European Single Digital Market with Open-Source Software

Achille Zappa, Chi-Hung Le, Martín Serrano, and Edward Curry

Abstract In this book chapter, recent advances in the development and implementation of open-source software technologies and information management systems to support the progression of the data economy by means of data operations and data offering descriptions are introduced. The management of controlled registries, mapping of information using metadata aggregation, interfaces among components, links of data and actors, discovery and retrieval of data, compiling smart contracts, and other core operations are introduced. This chapter contributes to the state of the art by providing the definition, creation, and collection of data-driven marketplaces that, by design, look at sharing and exchanging data using a common description framework called i3-MARKET. i3-MARKET's main design objectives are to support the sharing data assets, execute operations, and provide API services and generally all the security-related functionalities relying on data details, credentials, contracts, and pricing. i3-MARKET also uses a sharing semantic model to facilitate the work with people in improving and maintaining the models for the present and future. The i3-MARKET described in the chapter introduces the concept of a backplane architecture as a support tool that aims to innovate the data market industry providing solutions and support in developing building blocks to overcome the barriers to interoperable and integrative data using trusted, federated, and decentralized software components.

A. Zappa · M. Serrano (✉)
Insight SFI Research Centre for Data Analytics, University of Galway, Galway, Ireland
e-mail: achille.zappa@nuigalway.ie; martin.serrano@nuigalway.ie

C.-H. Le
Insight SFI Research Centre for Data Analytics, Data Science Institute, University of Galway, Galway, Ireland
e-mail: chihung.le@nuigalway.ie

E. Curry
Insight SFI Research Centre for Data Analytics, University of Galway, Galway, Ireland
e-mail: edward.curry@nuigalway.ie

E. Curry et al. (eds.), *Data Spaces*, https://doi.org/10.1007/978-3-030-98636-0_7

Keywords Data marketplace · Data offering · Semantic vocabulary · Digital economy

1 Introduction

There is a high demand for advancing and promoting the European data market economy by innovating Data Spaces and data marketplace platforms following single digital market strategies and demonstrating with industrial implementations that the growth of data economy is possible [1]. There is a growing need for solutions that provide technologies for trustworthy (secure and reliable), data-driven collaboration and federation of existing and new future data marketplace platforms, and those with special attention on large industrial data [2]. It is well known that despite various research and innovation attempts working on Big Data management, of personal and or industrial data integration and security, there is no broadly accepted trusted and secure data marketplace [3]. The H2020 i3-MARKET project aims to promote data market economy by providing support tools and avoiding to create another new marketplace but implementing a solution in the form of a backplane set of tools introduced as a framework of solutions that allow other data marketplaces and Data Spaces to expand their market functions, facilitating the registration and discovery of data assets and supporting the trading and sharing of data assets among providers, consumers, and owners for a better data sharing and trading processes. The i3-MARKET platform described in this chapter is designed to enable secure and privacy-preserving data sharing across Data Spaces and marketplaces by deploying a backplane across operational data marketplaces. The i3-MARKET Backplane, on the one hand, can be seen as a set of tools that can be deployed and integrated as backend technologies in current running marketplaces facilitating and allowing to add the missing functionalities that current marketplaces lack, and, on the other hand, i3-MARKET acts as baseline technologies for stand-alone reference implementation(s) that facilitates the starting point for a modern data sharing economy. In other words, the i3-MARKET Backplane provides the tools for setting up the foundations of a data marketplace ecosystem.

This book chapter reviews the progression of the data economy through data operations and data offering descriptions. It introduces the most recent advances in supporting, developing, and implementing open-source software technologies and information management systems [4]. As part of the design description, the management of controlled registries, mapping of information using metadata aggregation, interfaces among components, links of data and actors, discovery and retrieval of data, compiling of smart contracts, and other core operations are described [5]. This chapter contributes to the state of the art, providing the definition, creation, and collection of data-driven marketplaces that by design look at sharing and exchanging data using a common description framework called i3-MARKET. The i3-MARKET's main design objectives are to support the sharing data assets, execute operations, and provide API services and generally all the security-related functionalities relying on data details, credentials, contracts, and pricing.

This chapter analyzes the basis of data marketplace design and reviews the best practices on implementation and deployment for developing lacking technologies and solutions for a trusted (secure, self-governing, consensus-based, and auditable), interoperable (semantic-driven), and decentralized (scalability) data marketplace infrastructure [6, 7]. This chapter introduces and explains the principles for enabling federation and semantic data interoperability of the existing and future emerging Data Spaces and marketplaces. Finally, this chapter describes the principles of data monetization being added to formerly closed systems to offer and share data in the form of intelligent data economy services (smart contracts) and lowering the market entry barriers for stakeholders—especially SMEs—to trade their data assets to ignite a flourishing data economy that fosters innovation and business in Europe.

This chapter focuses on explaining the high demand for the design and implementation of technologies for enabling privacy and confidentiality levels that allow data marketplaces to support both legal and user-desired control and at the same time enable transparency for sharing data among data marketplaces. This chapter also focuses on reviewing the current demands on regulatory aspects around sensitive data assets and the more stringent demands on privacy and security using legal frameworks implementing the required security and access control measures that enable secure trading of data, including support for automated contracting and real-time exchange of data.

The organization of this chapter is as follows: Sect. 2 presents challenges in the data marketplace design and data economy in terms of best practices. Section 3 reviews the current state-of-the-art situation and introduces best practices for data exchange approach in three streams, i.e., security, privacy, and trust. Section 4 presents the i3-MARKET's innovations for the data economy that acts as a baseline supporting the information interoperability approach to the current state of the art and describes the features for a federated data marketplace and data space ecosystem. Section 5 introduces i3-MARKET Backplane architecture at a glance, including the reference data flow for Data Spaces and marketplaces. Section 6 describes industrial innovations as necessary features and addresses their benefits in industrial marketplace platforms. Finally, Sect. 7 presents the conclusions.

2 Challenges in Data Marketplace Design and Data Economy

The current state-of-the-art analysis reveals barriers for data marketplaces that require attention on security, data privacy, and trust [8, 9]. Persistent challenges blocking progress in data marketplace design and deployment are the following.

2.1 Data Marketplace Openness and Fairness

Data marketplaces are traditionally large, closed ecosystems in the hands of a few established lead players or a consortium that decides on the rules, policies, etc. This approach limits the number of data offers that can be included and, at the same time, creates barriers to a more open data economy. For example, the business interest of

data marketplace established members' interests often conflict with those from new applicants. Thus, the request from those who want to join an ecosystem might be denied. This is a significant barrier for growing a competitive data economy, where all stakeholders can freely participate under fair conditions.

In addition, the rights for using the data are often defined in contractual agreements among the involved parties. Therefore, companies with a stronger negotiating position usually obtain preferred rights to use the data. Unfortunately, this often results in smaller companies being excluded from gaining access to the data. This legal disadvantage is particularly detrimental to small- and medium-sized enterprises (SMEs) in a weaker negotiating position in such negotiations [3]. Yet, the main barrier of the European data economy is the fact that current Data Spaces and marketplaces are "silos," without support for data exchange across their boundaries. These wall gardens significantly limit market competition and overall data economy growth [10].

2.2 High Demands on Security and Privacy

In a large data-driven economy, sharing sensitive personal or industrial data assets demands high-security standards. This demand is applicable for Data Spaces and marketplace platforms and especially necessary over those interfaces and special hooks developed for data owners to control with whom their data is exchanged. In addition, the new European privacy regulation (GDPR) requires an unprecedented level of transparency and control for end-users, which, by design, must be implemented before personal data can be exchanged. Moreover, Data Spaces and marketplaces also lack adequate legal frameworks that address questions like how the data source is identified and verified, which type of data reuse is appropriate, who is responsible if data are leaked, etc. Those legal barriers prevent all stakeholders (SMEs, large enterprises, and any other organization or individual) from fully exploiting the opportunities of the data economy [2].

2.3 Data Marketplace Interoperability

The lack of interoperability due to missing standards, common APIs, and data models makes it difficult for data consumers to discover relevant data assets, access the data, and uniformly integrate the data, especially when combined from multiple providers. This is even challenging among data providers and consumers participating in the same data space or marketplace. The lack of extended common data models typically requires developers of a consumer application or service to consult the data provider first to learn how to interpret and use the data. This is a very timely and cumbersome task and thus restricts the sharing of data assets and potential innovation significantly. In addition, the missing semantic interoperability

is an obstacle to providing solid, consistent, and objective models of data quality [11]. Thus, transparent pricing and quality assurance strategies are essential for successful data markets. However, the main barrier of today's data economy is that there is no trusted backbone for Data Spaces and marketplaces to share data assets across the "silos." The lack of a self-governing and transparent backbone thus hampers the growth of the data economy in Europe and beyond.

3 Advancing the State of the Art on Security, Privacy, and Trust

To address current data marketplace challenges and leverage the full potential of the data economy, there is a need for developments in security, privacy, and trust as they are analyzed as follows.

3.1 Security

Self-sovereign identities are a must, independently from a single/central provider, to support global-scale identity management and enable the ability to associate personal data with end-users in a trusted and traceable manner. This is also the basis for identity-based access control and user consent management.

Accessibility to deployed data services is necessary. Therefore, there is a need to develop secure access for data consumers to access sensitive personal or commercial data directly and be compliant with data provider services. The use of application programming interfaces (APIs) is widespread, and this feature has the advantage of enabling data services to be connected and exposed. At the same time, the data can remain on the provider infrastructure and does not need to be stored or passed through a central infrastructure. However, APIs require a well-documented approach and a fully specified and published method, allowing existing data marketplaces or providers to adopt this. Thus, the Open-API approach is the primary best practice, allowing multiple stakeholders to participate in the driven data economy.

Data wallets and data economy require the adoption of emergent digital technologies, and the provisioning of a novel smart wallet framework enables data owners (i.e., end-users in the case of personal data or companies in the case of industrial data) to directly interact with smart contracts related to their data to give or revoke their consent for the anticipated data exchange. Therefore, in conjunction with the novel type of smart contracts, smart wallets will be a key component toward addressing user privacy following the GDPR and thus promoting the data-driven economy.

3.2 Data Privacy

There is a need for decentralized storage and access to semantic descriptions of the offered as data assets to enable data discovery across today's data marketplace silos. This requires enabling federation among the individual Data Spaces and marketplaces, without the need for central control or coordination that has to be trusted by all parties in the federated data marketplace ecosystem.

Transparency in Data Spaces and marketplaces is a feature that requires policy commitments and technology. Cryptocurrency/token provides a transparent, cost-efficient, and fast payment solution for trading data assets among the participating Data Spaces and marketplaces. As a result, the cryptocurrency/token will incentivize data providers to offer their data assets and thus accelerate the European data economy. Furthermore, the solution will be designed so that the participating Data Spaces and marketplaces can also use the tokens as an internal payment medium.

There is a requirement when sharing data that needs to be secured, mainly if a federated ecosystem is designed. A Secure Semantic Data Model Repository is a feature that enables data consumers to efficiently discover and access data assets (due to precise semantic queries) and integrate the data into their applications/services (based on a common understanding of the meaning of the data). This allows completely independent data providers and consumers to exchange and use data in a meaningful way—without prior information exchange. The availability of common data models is a key enabler for establishing a scalable data economy.

3.3 Trust

Secure and trusted APIs are required to allow Data Spaces and marketplace providers to obtain identities, register data assets, fetch their semantic descriptions, create, and sign smart contracts, make payments, etc. This ensures complete openness, i.e., any data space or marketplace provider can connect its local ecosystem with the global data market ecosystem.

Immutable and auditable smart contracts are necessary to trade data assets across data space and marketplace boundaries. All stakeholders, namely, data providers (for confirmation of the offer and its conditions, e.g., license, price, and SLAs), data consumers (for agreement of the contract conditions), and data owners (for consent to the data exchange), must sign these contracts. In addition, individual marketplaces can also adopt this advanced solution for handling local contracts.

Legal frameworks are obstacles that need to be removed by designed and implemented following the requirements (e.g., contractual basis for smart contracts and crypto-token) and innovative business models for incentivizing the sharing and trading of data assets and the operation of the decentralized backplane by the marketplace providers.

4 The i3-MARKET Backplane Innovations for the Data Economy

The i3-MARKET Backplane is an initiative/project that addresses the growing demand for a single European data market economy by innovating marketplace platforms demonstrating industrial implementations of the data economy. I3-MARKET implements features and requirements in the form of backend tools. The i3-MARKET Backplane implements reference components that can be used under different Data Spaces and marketplaces to satisfy common needs. i3-MARKET provides technologies for trustworthy (secure and reliable), data-driven collaboration, and federation of existing and new future marketplace platforms; special attention on industrial data and particularly on sensitive commercial data assets from both SMEs to large industrial corporations is taken.

4.1 Privacy and Data Protection

The i3-MARKET framework implements a trusted and secured backplane offering privacy preservation and fine-grained access control using an identity access management system (IAM) for data owners and consumers. Also, based on new types of smart contracts and a secure data access/exchange API to enable sharing of sensitive personal data and commercial/industrial data, i3-MARKET will ensure transparency and control. The i3-MARKET project will allow data producers to register their data offers (with all the necessary metadata to describe the offer). Data consumers will use data APIs to discover data descriptions as available information in the marketplace and thus start commercializing relations in a secure and controlled manner. i3-MARKET's strong focus on trust and security has the potential to remove the fear of data owners, to start sharing and trading their sensitive data, which are kept close as of today.

4.2 Trust and Security Platform

The i3-MARKET platform main target is to develop the missing building blocks for building a trusted, interoperable, and decentralized European data market, as well as an integrated platform (the i3-MARKET Backplane) that allows the federation (via integration) of currently emerging but yet isolated Data Spaces and marketplaces.

Besides addressing the privacy concerns of data owners to share their data in a user-controlled and transparent manner and the security concerns of companies to trade-sensitive/non-sensitive industrial data, the i3-MARKET project focuses predominantly on developing technologies, best practices, and reference design approaches that create trust. Based on distributed ledger technologies and their

blockchain-based decentralization, consensus-based ruling, and auditability [12], the i3-MARKET Backplane aims to be a fully scalable and trusted reference platform to power the overall European data economy, where every stakeholder can participate under fair conditions.

4.3 Secure Sharing of Personal Data and Industrial Data

The i3-MARKET platform addresses the increasing need to share sensitive data (i.e., industrial data or personal). This is key to growing the European data economy beyond "open data" and leveraging the potential of data in commercial settings. For this, i3-MARKET has developed the missing building blocks for trusted data-driven collaboration (interoperability) and trading platforms (economy) for sensitive commercial data assets.

Concerning privacy risk and threat methods to protect industrial data assets, the i3-MARKET platform uses stochastic models/algorithms that have been tested in previous platforms like AGORA and VITAL-IoT, and the aim is to use them for the identification of privacy attacks promoting secure and scalable trading of proprietary/commercial data assets with support for automated detection. The method for securing data sharing will be smart contracts, including the required legal framework(s), and enabling data exchange. The focus of i3-MARKET is on industrial data; however, the provided data access and protection frameworks will guarantee protection for both personal and industrial data, enforce user-desired privacy levels, and allow end-users to control by consent who can access their data.

4.4 Large-Scale Federated Data Platform

The i3-MARKET Backplane and its APIs act as a reference design and implementation for existing and emerging Data Spaces and marketplaces to federate and trade data assets across the existing ecosystem boundaries. Moreover, i3-MARKET introduces the concept for cross-domain data sharing and, employing federated tools, incentivizes opening formerly closed systems and offers their data assets via the i3-MARKET Backplane and lowers the market entry barriers for stakeholders (especially SMEs) to ignite a common, federated data market in Europe. In particular, i3-MARKET will address the interoperability challenge for trading data assets across independent stakeholders through a common, standard data access API and a shared data model repository, allowing data providers to semantically describe their data assets (metadata) and data consumers to access and integrate them in a uniform and standard manner (based on the metadata).

4.5 Policy and Regulation for Data Marketplace Backplane

The i3-MARKET project will address not only the latest policy and regulatory requirements in terms of data protection and privacy, e.g., the need for flexible and easy-to-use controls for data access (GDPR), but also the lack of interoperable data access APIs and data monetization support to enable the data exchange and incentivize data economy.

The i3-MARKET data market backplane, with its Open APIs and easy-to-use SDKs for developers to integrate their Data Spaces and marketplaces, makes sharing and trading of data assets across the participating Data Spaces and marketplaces a straightforward task for developers. Thus, i3-MARKET reduces the lack of ICT and data skills needed to grow the European data economy and increases the capacity of Europe to respond to the digitalization challenges.

Through the project results and their dissemination and exploitation, i3-MARKET will also increase the number of human ICT capacities with the required skills and know-how for industry digitalization in general and the relevant European regulations in particular.

5 i3-MARKET Backplane at a Glance

The i3-MARKET project innovates industry solutions by developing building blocks to overcome the barriers discussed above. As depicted in Fig. 1, we integrate them into a trusted, interoperable, and decentralized data backplane. In the same way, other marketplaces can be integrated to enable secure privacy-preserving data sharing across Data Spaces and marketplaces.

5.1 i3-MARKET High-Level Architecture

To validate the solution, the i3-MARKET Backplane is a deployment that will work across operational data marketplaces. Firstly, Atos and SIEMENS operate two marketplaces for data, Bridge.IoT [13] and AGORA [14].

These marketplaces allow data providers and consumers to share or trade data in an open and fair (every organization can participate under equal conditions) and interoperable manner. First, the BIG IoT marketplace and APIs are being transferred to the open-source community by establishing a new project called Bridge.IoT [12] within the Eclipse Foundation, where all future extensions could be maintained. Secondly, Atos operates a data marketplace for the automotive industry sector in Spain. This full-scale data marketplace prototype, AGORA, runs on the trusted Linked Data platform called with the same name and developed and owned mainly by Atos.

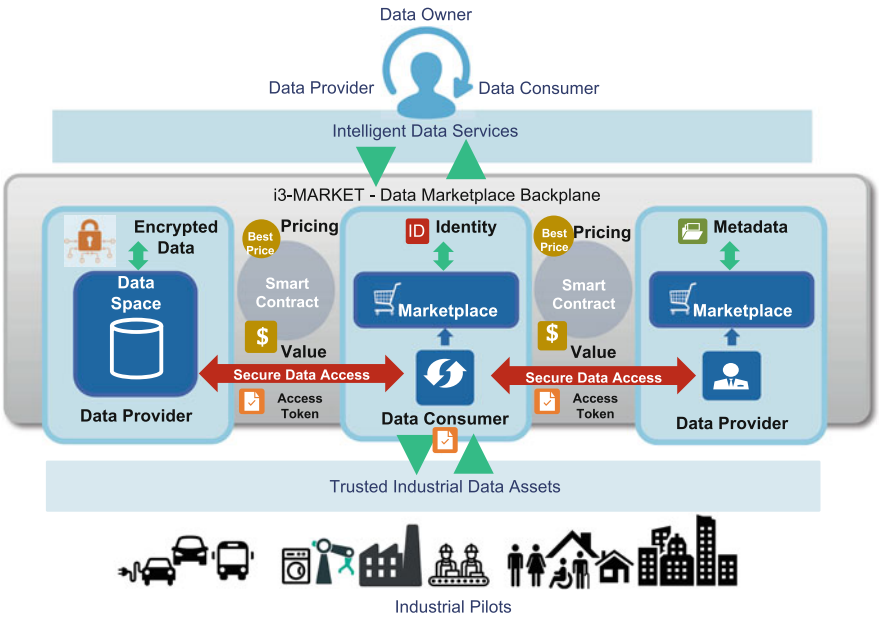

Fig. 1 The i3-MARKET Backplane for federated marketplace ecosystem

However, even though many use cases call for and would directly benefit from sharing or trading data across the different marketplace instances, there is still no scalable, trusted, and interoperable solution that enables sharing or trading data assets across individual marketplace instances. Moreover, today's data marketplace platforms, including Bridge.IoT or AGORA, still lack the capability for exchanging sensitive industrial data assets as the required levels of security and privacy (in accordance with the GDPR) are not yet supported—especially not across ecosystem boundaries. We consider those problems to be solved using blockchain-type technologies and part of the building blocks for the i3-MARKET Backplane. Furthermore, they will help the participating marketplace operators, who collectively run the consensus-based, self-governing, and decentralized backplane. As a result, the data owners, providers, and consumers trust the overall solution.

5.2 i3-MARKET Data Flow as Reference Implementation

The project's overall goal is to develop the i3-MARKET Backplane, defined as a software framework that provides the lacking technologies trusted, interoperable, and decentralized marketplaces for industrial data [15]. Figure 2 gives an overview of the i3-MARKET data flow to achieve that goal. The i3-MARKET Backplane

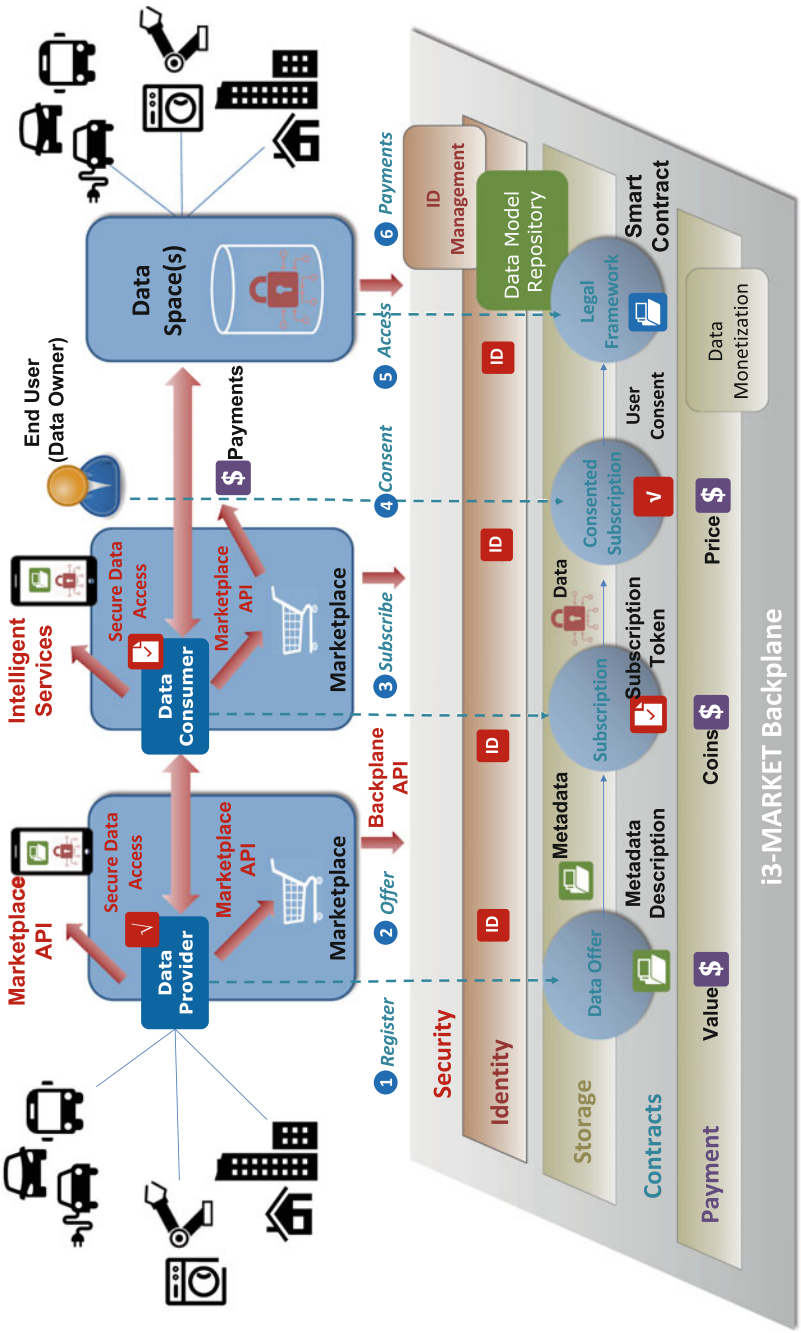

Fig. 2 i3-MARKET reference data flow

platform builds upon the state-of-the-art design principles [16–18] and the following assets:

1. Two data marketplace platforms: Bridge.IoT and AGORA. Both platforms will be operational during the project lifetime, allowing data providers and consumers to register and then sign up via subscription and secure access identification and offer or consume data in a protected manner. The Bridge.IoT platform has been developed by Atos, SIEMENS AG, NUIG, and UPC in the EU project BIG IoT [14] and is maintained in an Eclipse Foundation project. i3-MARKET aims to be extensible and integrative; thus, the solution can also be extended to other marketplaces, including other domains.
2. A secured data access API enables data providers secured registration and consumers verification to access and/or exchange data in a peer-to-peer fashion once the contracts and security mechanisms for identity management have been confirmed and executed. This improves scalability and avoids the need for data providers to share their data assets with intermediaries (e.g., a marketplace provider). This data access API also uses semantic data descriptions to access available types of data assets in the marketplace.
3. A marketplace APIs for all the communication between data providers and data consumers to the marketplace. Data providers use this API to register their data offers (with the necessary metadata to describe the offer). Data consumers use the APIs to register their demand and find the matching offerings they can then subscribe to.
4. A set of IoT-related vocabularies and data models to semantically describe data offers and demands. This is the key for enabling the trading of data assets across domains and stakeholder boundaries, without the need for developers of an application (data consumer) to learn about the meaning of the data from the data provider or through manual analysis or experimentation with the data and also for the owner of the data to consent access.
5. A set of intelligent services for data monetization is defined first by the pricing model the provider of the data assigned and second by the activity and interactions in the marketplace following dynamic pricing models .

Figure 2 gives an overview of the designed Data Spaces and marketplace data flow, including the architectural overview of the i3-MARKET Backplane approach as described above.

6 Industrial Innovation for a Data-Driven European Ecosystem

The ability to exchange or monetize data and gain rewards for offering data for various purposes while supporting data owners' privacy and security demands has great potential to incentivize and grow the European data economy and top the international competition in a socially acceptable manner [19].

The i3-MARKET Backplane aims to become one of the key enablers for embracing the latest European Commission Digital Single Market strategy, which mentioned according to a recent announcement that "it is time to make the EU's single market fit for the digital age—tearing down regulatory walls and moving from 28 national markets to a single one. This could contribute 415 billion euros per year to our economy and create hundreds of thousands of new jobs."

6.1 Data Sharing/Brokerage/Trading Build on Existing Computing Platforms

Despite various research and innovation projects working on Big Data management and large amounts of data integration and security, there is no broadly accepted trusted and secure data marketplace. At the core of the i3-MARKET is the definition and implementation of a data market backplane able to facilitate trusted and secure sharing and trading operations of proprietary/commercial data assets in a secure way and at the same time be capable of unifying data access across heterogeneous platforms (i.e., different types of Data Spaces and marketplaces).

Significant limitations and challenges when managing industrial data enable and facilitate trusted and secure sharing and trading mechanisms of the data assets. In i3-MARKET, we address those challenges by aggregating a backplane with security tools that will automatically establish robust and scalable controls of data protection over the activity occurring in the marketplace(s) and with legal compliance when data assets are to be discovered, shared, and then exchanged as part of a commercial transaction (brokerage or trading). Furthermore, we follow an innovative lifecycle that ensures that the security controls are compliant with the legal right and fair remuneration to the data owners.

We also acknowledge that several industrial applications require cross-domain use cases involving both large amounts of industrial data (Big Data), and based on those facts, our approach called i3-MARKET is also looking at scalability and efficiency levels concerning time response to preserve utility metrics for data analysis enabling intelligent services from the data and the marketplace to be easy to understand for the owner of the data and other stakeholders and at the same time contribute back the value in the form of data monetization.

6.2 Data Privacy in Industrial Data Marketplace Platforms

The i3-MARKET identity access management (IAM) approach is based on self-sovereign identities and new types of smart contracts to exchange and trade data in a privacy-preserving manner (in accordance with the GDPR) and with the desired level of control by the data owners. The blockchain-based decentralized backplane, with its support for smart contracts and crypto-tokens, is the basis for incentivizing data owners to share their assets. Based on the i3-MARKET crypto-token, we will incentivize especially early adopters of the i3-MARKET technology to overcome the common challenge of data markets, namely, to reach the initial liquidity level needed to achieve the network effect of marketplaces. Furthermore, addressing the aspects of data confidentiality and privacy is fundamental to i3-MARKET, as the project targets use case scenarios where personal and industrial data are shared or traded among the involved stakeholders. We will use self-sovereign identities and new smart contracts, which the data providers and consumers must sign and the data owners (e.g., end-users or corporations) to ensure that all parties consent to the data exchange. i3-MARKET will also support data encryption on data access interface to ensure that only the involved parties can see the data.

6.3 Industrial Data Marketplace Platforms

Three i3-MARKET use cases are implemented in the form of industrial pilots. The three are selected based on the involvement of multiple stakeholders (e.g., manufacturers, suppliers, as well as leasing and financial companies) and also from a cross-domain nature (e.g., manufacturing (Industry 4.0) and human-centric, as well as automotive sector) to demonstrate i3-MARKET's capability of integrating heterogeneous data platforms, solving the interoperability and integrative challenge, and providing the backbone for a single European data market. i3-MARKET builds on proven deployed and functional platforms toward extending them by providing publicly accessible and extensible services for secure and protected data assets.

7 Conclusions

This chapter addresses best practices for data space and data marketplace design and their implementation identified from the state-of-the-art analysis. These challenges are tested and validated in the context of an H2020 European Data Ecosystem called i3-MARKET. The best practices leverage the full potential of Big Data, IoT, and AI applications in data marketplaces and identify a need for further improvements in other streams supporting scaling-up applications.

The main objective of the i3-MARKET Backplane is to overcome hurdles in the current and new design Data Spaces and marketplace approaches by developing the

lacking building blocks (in the form of a software framework called i3-MARKET Backplane) for data providers and consumers, and thus incentivize and enable the creation of a more trusted European data market economy.

The i3-MARKET Backplane software platform addresses the interoperability and integration challenges for trading data assets across independent stakeholders using secured transactions based on data annotation (semantics) as well as a trusted data trading platform and will provide a network of decentralized and economy-driven and scalable data repositories that can be extensible for enabling the deployment of intelligent industrial data services fostering innovation and business opportunities.

The i3-MARKET Backplane aims at enabling the federation of data markets and targets to become a key enabler for embracing the latest European Commission Digital Single Market strategy, incentivizing the industrial data market economy. The impact of the exploitation of the i3-MARKET will be tackled, overall and individually, by exploitation and business models that will benefit all stakeholders in the data economy and take into account the information societies in Europe.

This book chapter analyzed the basis of data space design and data marketplaces discussing the best practices for data privacy, data protection, and data sharing/exchange alike, introduced concepts for data economy, and illustrated the i3-MARKET Backplane tools to enable semantic interoperability of the metadata using an open-source reference architecture and following an agile methodological innovative approach.

Acknowledgments This work has been partially supported by the H2020 i3-MARKET Project—Intelligent, Interoperable, Integrative, and deployable open source MARKETplace backplane with trusted and secure software tools for incentivising the industry data economy (www.i3-market.eu)—which is co-funded by the European Commission under H2020 framework program, contract number H2020-ICT-2020-871754-i3-MARKET. It is also partially supported by Science Foundation Ireland under grant number SFI/12/RC/2289_2.

References

1. *European Initiative on Digital Single Market*. Accessible online October 2021, from https://eufordigital.eu/discover-eu/eu-digital-single-market/
2. *A European Strategy for Data*. Accessible online October 2021, from https://digital-strategy.ec.europa.eu/en/policies/strategy-data
3. https://www.digitalsme.eu/data-economy-open-data-market-unleashing-untapped-potential-smes/
4. Brynjolfsson, E., & Mcafee, R. The business of artificial intelligence. *Harvard Business Review (HBR)*, July 17.
5. Fernandez, R. C., Migliavacca, M., Kalyvianaki, E., & Pietzuch, P. (2014). Making state explicit for imperative big data processing. In *USENIX ATC*.
6. Serrano, J. M., Serrat, J., & Strassner, J. Ontology-based reasoning for supporting context-aware services on autonomic networks. 2007 IEEE/ICC International Conference on Communications, 24–28 June 2007, Glasgow, Scotland.

7. Muan Sang, G., Xu, L., & De Vrieze, P. (2016). *A reference architecture for big data systems* (pp. 370–375). doi:https://doi.org/10.1109/SKIMA.2016.7916249.
8. Serrano, M., Strassner, J., & ÓFoghlú, M. A formal approach for the inference plane supporting integrated management tasks in the future internet. *1st IFIP/IEEE ManFI International Workshop, In conjunction with*11th IFIP/IEEEIM2009, 1–5 June 2009, at Long Island, NY.
9. Zillner, S., Curry, E., Metzger, A., Auer, S., & Seidl, R. (Eds.). (2017). *European big data value strategic research & innovation agenda*. Big Data Value Association. Retrieved from http://www.edwardcurry.org/publications/BDVA_SRIA_v4_Ed1.1.pdf
10. Curry, E., Metzger, A., Zillner, S., Pazzaglia, J.-C., & García Robles, A. (2021). *The elements of big data value*. Springer International Publishing. https://doi.org/10.1007/978-3-030-68176-0
11. Curry, E. (2020). *Real-time linked dataspaces*. Springer International Publishing. https://doi.org/10.1007/978-3-030-29665-0
12. Carson, B., Romanelli, G., Walsh, P., & Zhumaev, A. *Blockchain beyond the hype: What is the strategic business value?*", June 2018.
13. https://projects.eclipse.org/proposals/eclipse-bridge.iot
14. http://big-iot.eu and http://www.automat-project.eu/
15. Pääkkönen, P., & Pakkala, D. (2015). *Reference architecture and classification of technologies, products and services for big data systems*. Big Data Res. 2, 4 (December 2015) (pp. 166–186). doi:https://doi.org/10.1016/j.bdr.2015.01.001.
16. Le-Phuoc, D., Nguyen-Mau, H. Q., Parreira, J. X., & Hauswirth, M. (2012). A middleware framework for scalable management of linked streams. *Journal of Web Semantics, 16*(November 2012), 42–51.
17. Neumeyer, L., Robbins, B., Nair, A., & Kesari, A. (2010). *S4: Distributed stream computing platform*. In *2010 IEEE International Conference on Data Mining Workshops* (pp. 170–177).
18. Serrano, J. M. (2012). *Applied ontology engineering in cloud services, networks and management systems*, March 2012. Springer. Hardcover, 222 pages, ISBN-10: 1461422353, ISBN-13: 978-1461422358.
19. Zillner, S., Bisset, D., Milano, M., Curry, E., Hahn, T., Lafrenz, R., et al. (2020). *Strategic research, innovation and deployment agenda - AI, data and robotics partnership. Third Release* (Third). Brussels: BDVA, euRobotics, ELLIS, EurAI and CLAIRE.