Trusted Data's Marketplace

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Abstract. This article presents a literature review and the discussion about the key concepts associated with data markets. Data markets have multiple centralized and decentralized approaches. The main problem is the trust and reliability of supplies, inflows, and suppliers. The proposed study object is the decentralized marketplace data supported by Blockchain technology to ensure confidence in the supply chain of data, in the actors involved in the market and the data sources. The application scenarios are proposed in a model with four levels, data provision, data delivery, rights management, and producer internal sources. That will be done with Blockchain technology, through contracting using smart contracts, the controlled delivery of data by the data producers, the management of flows of data, and access control to data.

Keywords: Data Marketplace · Blockchain · Open data · IoT data

1 Introduction

This work analyzes how data markets can increase the data value assigned to the supply chain by increasing the confidence of the sources and provided data.

The problem arises from a lack of recognition of the data providers or owners of the data and so on the data that can be exploited. There is a need for data owners wish to maintain some degree of control over their rights and restrictions on access and use.

The different approaches to create data markets may be to set the architecture (centralized or decentralized), the data dynamically (streams or sets of static data), the access to data (external or internal API, download or Blockchain), reliability (by user feedback or data integrity and data origin) and the opening (open or closed).

The most important features for participants in data markets pass by a data catalog with search functions, access control, tools to create appropriate arrangements, appropriate monetization for transactions, monitoring of compliance with the SLA and dispute resolution, and tools to assess the quality and reliability of data and its suppliers. Reliability is central to assessing the quality and trust of data and its suppliers. The security management, authentication and authorization identities, is integrated into market solutions.

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The data are essential and critical making it difficult to involve enterprises of different sizes, with different collection needs with their data and need to analyze them together with other sources static, dynamic and IoT [1].

The value that can be attributed to the data can come from different services and forms, which can be through filtered access to raw data, processing, and analysis of raw data, deriving business ideas through data mining and predictive modeling, and contexts that can trigger new business.

The quality and availability of data used to develop the commitment to better administration and governance. Technological developments open up new sources of information and analytical innovations [2].

Data delivery models and the underlying architectures rely mainly on the availability of resources, data security and privacy, and pricing.

The capabilities of a data market go through several characteristics, such as the description of the Data, categorization, definitions, tags, and forms of research, and the creation of metadata that facilitate the creation of data catalogs and business glossary.

From a different perspective, we have data security and privacy concerns that involve interfaces of various natures, file, service, SQL access, analytics, data insertion by the owner and the clients.

In the following sections we begin by reviewing the key concepts about the structure of the data markets, present the review of the literature that claims to give state of the art, the problem to be solved, the proposed solution, methodology and conceptual model support, and conclusions.

2 Key Concepts

In this section, we discuss the key concepts that we consider essential to understanding the data markets, seeking to present the various perspectives we consider appropriate for the analysis of this area.

2.1 The Data Delivery Chain

The data supply chain can be presented in a simplified manner (Fig. 1) by suppliers who deliver raw data by producers (Data Generation) that convert the data into products for data warehouses (Data Transformation) that store data for distribution centers that provide retailers (Data Processing) Data to deliver the user (User Analytics).

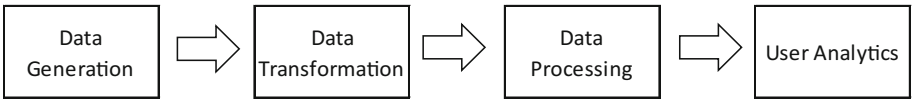

Fig. 1. Data supply chain

The data production process must be monitored, controlled and optimized through control dashboards, data flow control, and security mechanism, to improve the quality of the data supply chain [3].

2.2 Actors in Data Marketplaces

Figure 2 presents a model of IoTs data market system, with various actors in this market, the Data Owner (DO), the Data Broker (DB), the Value-Added Services Provider (VASP) and the User. The model is for each actor a set of activities, paper business, and interests.

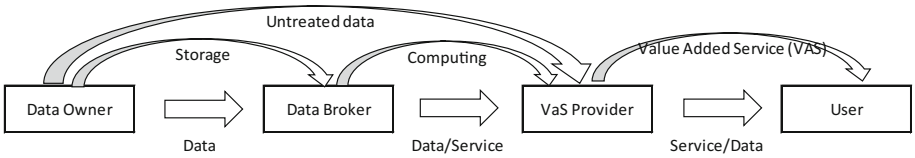

Fig. 2. Data market (Adapted from [1])

The DO of the activities deploy and operate the sensors, and update data. DB pass to store data, perform access control policies and provide computing power to the VASP. The VASP have as activities access to data, the implementation of the changes and provide value-added services. The user uses the value and services.

The business role for the DO refers to investment in infrastructure, the purchase storage services and intermediation, and data sale. The DB also invests in infrastructure, in selling storage services, computing and intermediation. The VASP purchase raw data, computing resources and sells value-added services. The user buys the value and services.

The DO specify access control policies according to its interests and to hide data from other parties. DB controls access rights to data and controls the scope of computable functions. The VASP seeks to maintain its secrecy computing logic, hide the result of your computer and receive significant results.

Stakeholders in data provisioning are referred to in [4] as Data Provider (People - individual/crowds/organization), software and stuff, Service Provider (Software and people), Data Consumer (people, software and Things), data aggregator/integrator (software people more software) and data evaluation (software and people).

The actors in the supply chain in the data market can have others functions, more granular, like the data producer, the data provider, the data distributor, the reseller data, the data amplifier, data buyer and data consumer.

2.3 Data Service

The conceptual data service unit presented in [4] states that as the service data model (consumption, property, provisioning, price) plus the concept of unit (essential

component, primary function, modeling, and description) make a data service unit, which can be used privately or publicly, and can be elastic or not.

The data service units in the cloud provide data resources instead of providing computing resources or software in business environments and e-science with a data combined with the analysis of data, combined with AI (Artificial Intelligence) imply the provision of data assets.

Service models in the context of Data-as-a-Service, go through middleware publication/data subscription as a service, the sensor-as-a-Service, Database-as-a-Service (consultation systems structured and unstructured) and storage-as-a-Service (essential functions of storage), deployed in IoT, Edge & Cloud Systems. [4]

Data as a service, according to the definition of the NIST[1], has the self-service demand characteristics in which resources request data to be provisioned at different granularities. The resource pool is with the various types of data, large, static or near real-time, raw data and high information one level, extensive access network, as it can be accessed from anywhere, rapid elasticity as it is easy to add or remove data sources, and the service measured as the assessment, monitoring and publication focused on data use.

The dichotomy of the roles of the different actors in the data market goes through a data market in which the company and the individual can be the seller or buyer.

The data market is a showcase where users can purchase data products, private data, and public data, whether internal and external users, provided they find the data of products that reflect the needs of users and users can develop their Data products to share with others.

The challenges inevitably pass through research and development, prioritizing the development of new data, data products, with the marketing and sale of data products with newly discovered data products, looking for those who pay or go, which implies proper sizing architecture and organization.

2.4 The Value of Data

The amount of data is the critical issue for the success of a data market and trust is central to the assigned value. In this section, we present a set of four points that determine the creation of the data value.

- **Point 1.** The role and potential of creating data of the market value of the company or participating data brokers are different depending on whether the market is in technical startup phase or reached full commercialization.
- **Point 2.** The market relates to the various licensing models to deal with data owners and suppliers to maintain specific information without access and do not share in the market.
- **Point 3.** The terms, the general market conditions, and the data categories are the technical configurations of the market phase, in which the data providers define the licensing conditions independently, and the platform provides references to the licensing conditions.

[1] https://www.nist.gov/.

- **Point 4.** Customers and Data market suppliers pass initially set by the market can be commercially viable. Customers include all types of data providers, and the market system should actively seek new types of data to be more attractive to customers.

2.5 The Application Scenarios of Blockchain Technology

As the application of Blockchain technology is taking an increasing importance in new areas of research, in addition to the crypto-currency applications, comes applied in IoT, with 28% in the financial sector, 14% in e-governance, 12% in intelligent contracts, with 10% in smart Cities and businesses with 9% and 5% health [5].

The Blockchain technology may eventually replace systems that rely on third parties by eliminating intermediaries, to confirm third-party transactions, to enhance the process of disintermediation, and the consensus mechanisms distributed and transmit the clear and safe value.

The data market can use the features and mechanisms of Blockchain like the elimination of intermediation, providing a direct link between consumers and data providers, with more confidence between the parties and the available data.

The application scenarios of Blockchain technology proposed in this work involve the use of Smart Contracts in Blockchain in hiring. Blockchain will support the market operations, and the external data flows between data providers for the various data markets and the internal flows within each one of the data providers to insure the origin and quality of data and its access by the participants.

3 Literature Review

The literature review shows a context of exponential increase in data volume and the increasing commercialization of data that thickens the interest to the data markets. The players in this market need to have access to vast amounts of data processed using Big Data concepts, with algorithms that are more sophisticated and use Artificial Intelligence (AI), which can turn the centralized approach to become unworkable [6].

The Blockchain [7] technology can act as a catalyst for growth and can provide a platform where innovative practices may create a truly global and collaborative economy, with common goals for the benefit of the community at large. Trust is at the heart of the EU economy and seeks to incorporate the transition to a single digital market. The Blockchain can simplify interactions between the various actors and provide opportunities for consumers and businesses.

Other fields of application in data markets implies the development of algorithmic solutions incorporating AI and Machine Learning, as work [8], which sought to apply algorithmic solutions to the data market, with a real-time mechanism to efficiently buy and sell data.

3.1 Analysis Applied to Data Markets

Article [9] continues to market research area and the study of data vendors and data markets area, revealing the following trends: the raw and unstructured data became less often available, with data enrichment services and the offer of processed data most

sought after, with the data available in more languages, and more amount of updated data offerings increased. Target customers spent focus on more or less relevant consumers and business customers. The fields of application have not changed much, and the sources of data are increasingly growing. Pay per use has increased, and at technical level, the technologies supported on the Web exceeded more traditional exchange formats.

3.2 Blockchain Applications

Blockchain technology is a decentralized technology that allows to perform transactions through shared network participants, supported by new forms of distributed software architectures. This technology improves the transparency of products, the management of the supply chain and more efficient data chain, better loyalty management system, improving customer profiles and preventing counterfeiting [10].

The Blockchain technology has the potential to be applied to supply chain management [11]. This text identifies four categories of questions to explore: How can physical products be tied to the digital diary? How can networks activate by Blockchain be linked to other foreign markets? How can the Blockchain be improved to meet the complicated structures of the supply chain? How can reserve enough space to store the amount of information required by the supply chain?

The management of the supply chain should be able to eliminate the need for third parties in its trading and adapt to the specific needs of supply chains, both concerning data requirements and terms of supply chains of complex structures [12].

In [13] a new Common Information Model Vehicle model is presented (CISG) for open and harmonized data markets, which allows aggregation and sets of generic data. The Automat European project has developed an open market by providing a single point of access for independent Data of the vehicle brand and model. The CISG prototype enables service providers and applications can access data for the vehicle through a single point of access to the weather forecast and monitoring of road quality.

3.3 Trust, Security and Privacy

The commodification of supported confidence in Blockchain technology is evaluated in [14] and suggests an opportunity for regulators and policymakers to shape the development and commercialization of disruptive innovation. Privacy and security are two of the questions that can be applied object of the more widespread use Blockchain technology.

The text [15] proposes a data protection framework based on distributed Blockchain technology to improve the data security of the cyber-attacks against the power system and to increase the robustness of the power systems. In this framework, it is evaluated from cyber-attacks efficiency point-of-view and shows that Blockchain can be considered as a solution to the data security of the power system. However, still wait developments in Blockchain based technology that improve the connection speed of the blocks, the acceleration of reliability and security, reducing the investment risk, and improving the consensus algorithm.

The Enigma [16] platform is a decentralized computing platform that guarantees privately, based on a peer-to-peer network allows different parts store together and that the calculations performed on data remain private. The computer model used is based on an optimized version of secure multiparty computation, secured by a verifiable secret through full verification and public nature of Blockchain.

Article [17] seek to apply the certification mechanisms following Art. 42 of the Data Protection Personal General Regulations. Although Blockchain not the main component of the proposed architecture considers that enables decentralized transactions, reliable among a crowd of pseudonymous participants, to adopt and implement the paradigm of "Privacy by Design".

3.4 Data Marketplaces

Article [18] analyzes the motivations and techniques for the exchange of scientific data and proposes the use of Data Marketplace service model to facilitate the exchange of data between producers and consumers. The service of a business model for the data appears in the commercial sector and can be adopted as a data-sharing platform for the scientific community.

The DataBright [19] prototype it is a system that transforms the creation of training examples and sharing of trusted computing, an investment mechanism that pays dividends whenever the hardware or contributions data is used in training a learning model machine. This system allows the data creators to retain ownership of their contribution and assigns measurable value. The amount of data is given by its utility in distributed computing later performed in the computing market.

The work [20] has a Marketplace decentralized data based on Blockchain (Datapace), where the data is your base and grows with new devices, sensors, and new technologies. Data may be perishable or durable, but with a common problem, how to draw an additional profit from these data. The TAS token will be used as a utility token of this system to allow a fair and functioning insurance system and allow the system. Also uses AI and Machine Learning algorithms to ensure that data streams can be unified in a format and prepared for easy consumption.

The value of an open Data Marketplaces is analyzed in the article [21] through a value proposition for open data users, in which five amounts received are identified, the less complicated the task, the greater access to knowledge, the most significant possibilities to influence, the lower risk and greater visibility. It was concluded that open data markets, through a central portal, could provide better access to associated data and support services and increase the transfer of knowledge within the ecosystem.

3.5 Decentralized Repositories

Article [6] has a market data based on decentralized data repositories data sharing in various scientific fields. The central portal provides access to multiple distributed repositories, with a reliable and consistent basis with standardized metadata and semantically enhanced.

The work [22] presents the demonstration of Sterling, a decentralized market of private data, which allows the distribution of privacy preservation and use of data by using Smart Contracts based on Blockchain. The focus goes through a mechanism of data providers control the use of their data.

A Blockchain-based Database is presented in [7] to ensure the integrity of data in cloud computing environments. In cloud computing environments, the data owners do not control the fundamental aspects of the data, such as the physical storage of data and management of access.

3.6 IoT Data Markets

This paper [23] summarizes the features that are available through a cloud-based platform to support the IoT and describes the federation of eleven Internet deployments of things in various application fields, including smart cities, the intelligent building in crowdsensing and the smart grid.

The work [24] shows the IoT market for smart communities (I3), with dynamic data and motion data, which allows data flows of different entities to be mixed and analyzed, processed, and to support a diverse range of applications. The Internet promotes scalability and interoperability in IP and I3 is a data exchange middleware layer above the transport layer.

Article [25] has a data IoT market supported Blockchain (IDMoB). The solutions of artificial intelligence (AI) and machine learning (ML) are being integrated into the various types of services, products with more "intelligent" in which the centerpiece is the data. A decentralized platform is applied to a data market as proof of concept, implemented in Ethereum platform for Smart Contracts and the Swarm as a storage system. It involves multiple parties, not data in real-time applications and non-critical IoT.

The work [26] shows the dynamic data market (MARSA) based on a cloud of human sensing data (IoT) in near real time for different stakeholders sell and buy these data. The Data Marketplace prototype presents techniques to select the types of data and management of data contracts based on different types of costs, quality of data, and the rights to the data. The text [27] intends to ensure data exchange in a market in the cloud, and provide an overall and practical encryption solution for Secure Data Exchange (SDE).

Article [28] proposed a three-level hierarchy consisting of multiple data sources, a service provider and customer. The Blockchain technology can be applied to create a decentralized structure with producers or consumers.

The [29] work presents the Wibson, a Blockchain based data market for individuals selling safe and anonymous way information in a trusted environment. Combines Smart Contracts and Blockchain to allow sellers and buyers data of personal information and transact directly maintaining anonymity as required.

4 Problem

The main problem is to get a solution that can ensure the confidence and reliability of the sources, flows, and suppliers. This issue is critical because it is to establish a reliable network a data supply chain.

Like any problem more complex, this problem has many challenges that require a structured and coherent solution to establish the various levels of trust dimensions systematically.

5 Solution

The proposed solution involves four levels of performance that go through contracting through smart contracts, the controlled delivery of data by the data producers, rights and access to data, and the management of data flows. The model proposed and represented in Fig. 3 aims to present the architecture of a decentralized data market supported by Blockchain technology to ensure confidence in the data supply chain, the actors involved in the market and the data sources.

5.1 Methodology

The literature review allowed characterize a wide range of applications of the data market and application possibilities of Blockchain technology in this field. This review revealed the growing importance of data, Data markets, and marketplace, some limitations of Blockchain technology, consensus mechanism, and scalability.

The approach is based on research Design Science Research (DSR) [30] with the use of research methodologies supported on conceptual models [31].

The implementation of this model will be the project TDMP - Trust Data Marketplace. This project will be a prototype based on a generic data market portal for ecosystems that make up a Smart Place, in the specific case, a Smart City.

5.2 The Supply and Delivery Model in the Data Marketplace

In this section, we present the model of supply and delivery in the data market, which summarizes the four Blockchain application levels needed to solve the various components of the supply chain, delivery of proprietary rights, user access permissions and audit and trust the source of the data.

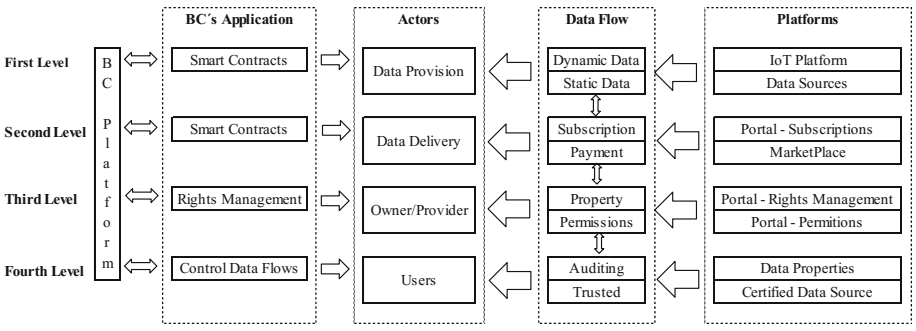

Fig. 3. Data Marketplace model

- **First Level - Data Provision.** The model considers this level by consensus acceptance of actors who can intervene in the data supply chain and contracting by Smart Contracts based on Blockchain.
  The actors' contractual each other via Smart Contracts based Blockchain according to the possible relationships supply.
- **Second Level - Data Delivery.** The model considers this level by consensus acceptance of actors who can intervene in data delivery chain and contracting by Smart Contracts based on Blockchain. The certificates Data deployments spend such suppliers and subscribing entities already accepted and contracted.
  This field up perspective using Blockchain to certify the origin and reliability of the sources.
- **Third Level - Rights Management and Access Permissions.** The model considers this level the management of supplier entities rights and access to data for users of data.
  In this perspective, the classification domain (e.g., free, payment for use or other restrictions to consider) the supplier/producer holder of rights of data sources with the use of Blockchain monitor the implementation of these rights. For users or VAS, apply permissions arising from its profile and contractors access.
- **Fourth Level - Producer guarantees the Internal Sources.** The model considers this level the producer or supplier of data ensures the audit of the origin of data and internal sources.
  This level features to implement mechanisms within the data producer to allow the traceability of the origin and processing of data to the supply, using the Blockchain as Ledger Distributed.

Based on reliable data and using the supply and delivery model, in the data marketplace, Organizations can introduce new key indicators, with better decision support for identification of investment priorities [32]. The implementation of a Decision Support System (DSS), strengthened by high quality data, allows the increase of the levels of performance and precision for the decision-making [33]. Organizations, in regional spaces, should focus on concepts such as Web 2.0 features coupled with a coherent online organizational identity [34], which reveals the need to obtain data that increases e-commerce transactions supported by Blockchain.

6 Conclusions

The information and knowledge economy make trusted data critical to empowering decision-making, rule automation with interaction machine-to-machine, machine learning, and the application of AI algorithms, to create new business opportunities. Data become a new product of value. The pricing of data will be inflated by possible cyber violations, which enhance financial losses, involving data from insurance policies for business protection.

The support infrastructure will require dynamic and secure cloud processing capabilities, resilient network, application code's quality with the paradigms "secure by design" and "privacy by design", to create value with exploring and synthesis of trusts data, that involve the concepts of Big Data and the use of Artificial Intelligence algorithms.

Data marketplaces will foster cross-sourcing with various data producers, involving different formats of data, IoT data, and crowdsourcing. The control of all supply chain begins in the trusted source, continue in the process of treating and create value, and finish with the delivery's satisfaction. To ensure security and reliability, we proposed four levels of application, goes by adding specific features, supported in the blockchain technology.

To solve the problem of confidence in the origin of the data we propose a working model supported Blockchain to address the four levels of this problem, Data Provision, Data Delivery, Rights Management, and Access Permissions, and Producer guarantees the Internal Sources.

Future work will be focused in the development of the prototype that allows operationalizing the proposed conceptual model and revises many of the aspects that may affect the scalability of this solution and may go through adopting different confidence and security mechanisms and treatment of data, involving machine learning and artificial intelligence.

Other lines of research that we can foresee are the review of ways to secure multiparty computation and cloud and look for ways to extend the value of data, especially the data is not shareable.

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