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Blockchain and distributed ledger technologies — Data flow models for blockchain and DLT use cases

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ISO/TR 6277

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Blockchain and distributed ledger technologies — Data flow models for blockchain and DLT use cases

Technologies des chaînes de blocs et technologies de registre distribué - Modèles de flux de données pour les chaînes de blocs et les cas d'utilisation de DLT

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Foreword

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This document was prepared by Technical Committee ISO/TC 307, *Blockchain and distributed ledger technologies.*

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Introduction

This document consolidates a set of system-level models from ISO 23257:2022 and ISO/TR 3242:2022 to give a data-flow-centric description framework for blockchain and distributed ledger technology (DLT) use cases. The framework enables a data flow analysis approach for blockchain and DLT use cases which has been defined in ISO 23257:2022, successfully applied across all use cases in ISO/TR 3242:2022 and extended in this document to display more detailed information on data flows.

The robust descriptive capabilities provided by this framework can help to improve blockchain and DLT application design and enhance interoperability. It can be beneficial for:

— clear understanding of data types and data flows in distributed ledger systems that allows for better-designed, fit-for-purpose systems;

— better governance and risk management;

— a sound basis for interoperability modelling for the use cases that require data exchange in hybrid or orchestrated systems environment.

Understanding data flows can be a necessary foundation for DLT users to ensure data privacy and data confidentiality in DLT use cases, or a decision-making basis when implementing technology selection or scheme assessment. From this perspective, data flow analysis is especially essential to scenarios which frequently involve data flows among stakeholders or devices. To illustrate the features of data flows in DLT use cases with above characteristics, this document provides three uses cases which apply the description framework to unfold data flows among devices, data flows along with business process, as well as data flows between physical and virtual spaces. These use cases can also provide an insight into the role of data flow analysis in balancing business value maximization and risk controls.

This document is organized as follows:

— Clause 5 presents an overview of DLT data flows, including data flow categories, data categories, roles/subroles and considerations related to data flow.

— Clause 6 and Clause 7 provide analysis of typical intra-system and inter-system data flows for DLT systems.

— Clause 8 provides three DLT use cases based on a descriptive and visualization template focusing on data flows.

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Blockchain and distributed ledger technologies — Data flow models for blockchain and DLT use cases

1 Scope

This document uses a set of models that describe the flows of different types of data between distributed ledger technologies (DLT) and related systems, as well as between different DLT nodes.

It provides a descriptive analysis of data flows in the development of use cases, as well as the basis for understanding the characteristics of DLT data flows, to support DLT application design and system analysis.

The models referenced are in accordance with ISO 23257:2022 and the use case analysis approach provided in ISO/TR 3242:2022.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22739, *Blockchain and distributed ledger technologies — Vocabulary*

ISO 23257, *Blockchain and distributed ledger technologies — Reference architecture*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22739, ISO 23257 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
cloud computing
paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand

Note 1 to entry: Examples of resources include servers, operating systems, networks, software, applications, and storage equipment.

Note 2 to entry: Self-service provisioning refers to the provisioning of resources provided to cloud services performed by cloud service customers through automated means.

[SOURCE: ISO/IEC 22123-1:2023, 3.1.1]

3.2
data category
class of data items that are closely related from a formal or semantic point of view

[SOURCE: ISO 30042:2019, 3.8, modified — Example and Notes to entry deleted.]

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3.3
data flow
sequence in which data transfer, use, and transformation are performed during the execution of a computer program

[SOURCE: ISO 23257:2022, 3.5]

3.4
decentralized identifier
DID
identifier that is issued and managed in a decentralized system and designed to be unique within a context

Note 1 to entry: Decentralized identifiers are used in systems that do not rely on central registration authorities.

[SOURCE: ISO 22739:2024, 3.18]

3.5
derived data
data created as a result of processing that involves steps other than or in addition to direct retrieval and validation of information from data functions

[SOURCE: ISO/IEC 20926:2009, 3.17]

3.6
DLT account
distributed ledger technology account
representation of an entity participating in a transaction in a DLT system

[SOURCE: ISO 22739:2024, 3.26]

3.7
edge
boundary between pertinent digital and physical entities delineated by networked sensors and actuators

Note 1 to entry: Pertinent digital entities means that the digital entities which need to be considered can vary depending on the system under consideration and the context in which those entities are used.

[SOURCE: ISO/IEC TR 23188:2020. 3.1.2]

3.8
end user identifiable information
EUII
derived data associated with a user that is captured or generated from the use of the service by that user

Note 1 to entry: Data that is linked to the user but is not DLT user data.

Note 2 to entry: End user identifiable information includes connectivity data, usage data.

[SOURCE: ISO/IEC 19944-1:2020, 3.1.2, modified — Notes 1 and 2 to entry added.]

3.9
role
set of activities that serves a common purpose

[SOURCE: ISO/IEC 22123-1:2023, 3.1.10]

3.10
peer-to-peer
P2P
relating to, using, or being a network of equal peers that share information and resources with each other directly without relying on a central entity

[SOURCE: ISO 22739:2024, 3.70]

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3.11
smart contract
computer program stored in a distributed ledger technology system wherein the outcome of any execution of the program is recorded on the distributed ledger

Note 1 to entry: A smart contract can represent terms in a contract in law and create a legally enforceable obligation under the legislation of an applicable jurisdiction.

[SOURCE: ISO 22739:2024, 3.88]

3.12
sub-role
subset of the activities of a given role

[SOURCE: ISO/IEC 22123-1:2023, 3.3.11]

3.13
transaction record
record documenting a transaction of any type

Note 1 to entry: Transaction records can be included in, or referred to, in a ledger record.

Note 2 to entry: Transaction records can include the result of a transaction.

[SOURCE: ISO 22739:2024, 3.95]

4 Abbreviated terms

API	Application programming interface
DID	Decentralized identifier
DLT	Distributed ledger technology
ICT	Information and communications technology
IoT	Internet of things
n.e.c.	Not elsewhere classified
PIA	Privacy impact assessment
PII	Personal identifiable information
PoC	Proof of concept
SDG	Sustainable development goal
SME	Small and medium-sized enterprise
VC	Verifiable credential

5 Overview of data flow for DLT

5.1 General

The impetus for introducing DLT-specific data flow models is to support technical and business process analysis. The models mentioned in this document are in accordance with ISO 23257:2022 and applied across all use cases in ISO/TR 3242:2022 combined with the behavioural UML models. The focus on the approach in this document is exploring diverse ways of applying it to data flow analysis on DLT use cases. The approach

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taken in this document derives from architectural approaches in cloud computing and service-oriented design. If a service model is a collection of components that represents a business service, a data flow model that is described across component-based view of a system can help bring clarity to both technical and business objectives in system design.

It can be seen in ISO/TR 3242:2022 and elsewhere that applications and systems deploy blockchain and DLT to provide robust and purposeful system transparency in highly distributed, multi-party systems, on cloud-based execution environments. The data flow models reviewed here can be used in tandem with service-modelling approaches to gain greater insight into system functionality and business process performance.

5.2 Categories of data flows

ISO 23257:2022 and ISO/TR 3242:2022 identify five fundamental data flows relative to DLT systems:

— Data flow N: data flowing within and between the nodes of the DLT system.

— Data flow A: data flowing between separate DLT systems when they interoperate.

— Data flow B: data flowing between a DLT system and non-DLT systems connected to it.

— Data flow C: data flowing between administration applications and a DLT system.

— Data flow D: data flowing between user applications and a DLT system.

NOTE ISO 23257:2022 defines Data flow Z as data flowing among the nodes of the DLT system. ISO/TR 3242:2022 includes data flow within the nodes of the DLT system and defines Data flow Z as data flowing within and between the nodes of the DLT system. This document adopts the definition in ISO/TR 3242:2022 and uses the code N instead of Z to avoid confusion.

5.3 Data categories

This document identifies data categories in the DLT ecosystems, to help understanding DLT data flows and support transparency about DLT data. A data taxonomy is also useful for the conversation about data between different roles/sub-roles. This document provides the following four sets of data categories:

— data categories from data storage perspective;

— data categories from data sources;

— identifier data categories;

— other data categories.

5.3.1 Data categories from data storage perspective

5.3.1.1 General

In order to balance the advantages and performance of DLT systems, off-ledger data storage has increasingly become a common auxiliary way of data storage in DLT system, especially in the DLT applications involving large amount of DLT user data.

The main concern for on-ledger data and off-ledger data is the difference of scope of data processing and use. In most cases, processing and use of off-ledger data have no much difference with data in other types of IT systems, however, it is usually impossible to delete on-ledger data, which makes it more crucial to provide specific ways of ensuring transparency and privacy protection.

5.3.1.2 On-ledger data

On-ledger data are data stored inside a DLT system, which includes small amounts of data from DLT users. Due to the size-limit of DLT ledger, on-ledger data can also include hashes related to off-ledger data from DLT users.

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5.3.1.3 Off-ledger data

For large amounts of data from DLT users, or personal identifiable information (PII) which might need to be deleted or updated by the PII principal, it is common practice to store the data on a cloud on the user's infrastructure or a public storage provided by a third party or network. Off-ledger data also includes data from the DLT provider data and data derived when a DLT application is used.

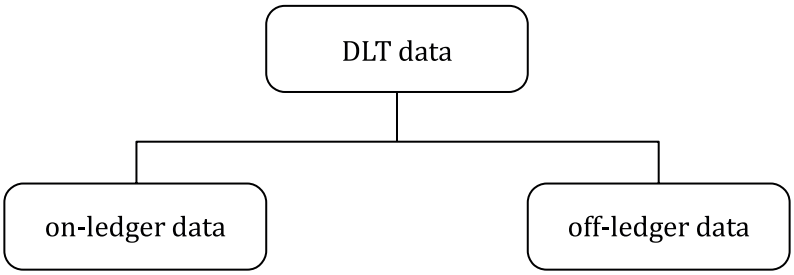

Figure 1 — Data categories from storage perspective

5.3.2 Data categories from data sources perspective

5.3.2.1 General

ISO 23257:2022 defines six DLT roles, including DLT developers, DLT administrators, DLT users, DLT providers, DLT governors and DLT auditors. Among these DLT roles, DLT administrators, DLT users and DLT providers are most closely related to DLT data. In order to support different stakeholders to carry out data-related activities, or to formulate data-related policies, this document identifies seven data categories which are associated to different DLT roles (see Figure 2).

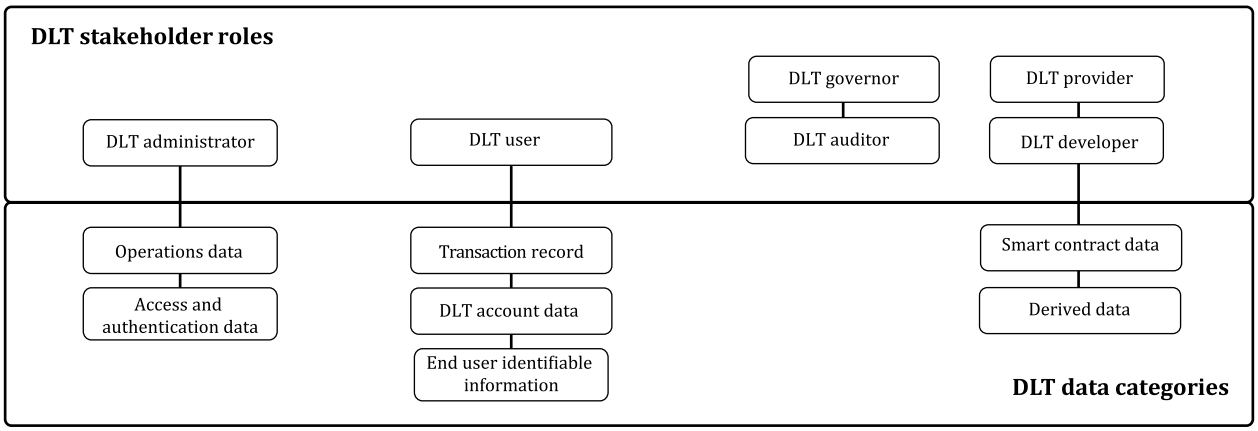

Figure 2 — DLT stakeholder roles and related DLT data categories (reproduced from ISO 23257:2022)

5.3.2.1.1 Transaction record

Transaction record can be financial transaction data, or generalized transaction data such as genome data, voter record, transport data, product production data. Transaction records might be on-ledger data or off-ledger data with related hashes stored on ledger. Transaction record is generated when a DLT user uses a DLT system to record a transaction.

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5.3.2.1.2 DLT account data

A smart contract or digital asset, for example, can be associated with a DLT account. Corresponding DLT account data are data representing an entity whose data are recorded on a DLT system. DLT account data are generated or updated when a DLT user creates a DLT account or uses the account.

5.3.2.1.3 End user identifiable information

End user identifiable information is linkage to the user but is not directly created by DLT users. End user identifiable information includes connectivity data, usage data.

5.3.2.1.4 Operations data

Operations data are data which is used for supporting the operation of DLT system, which includes service logs, configuration data.

5.3.2.1.5 Access and authentication data

Access and authentication data are data used within DLT system to manage access DLT capabilities, DLT data or smart contract, which includes passwords, cryptographic keys, security certificates. Access and authentication data are controlled by DLT administrator and are critical to its administrative activities.

5.3.2.1.6 Smart contract data

Smart contract data includes not only executable codes of program but also execution results. Smart contract data can be generated when a DLT developer creates or maintains the smart contract, or a DLT operator runs the smart contract.

5.3.2.1.7 Derived data

Derived data include data describing the connections of the DLT system, data describing the usage of the DLT services, etc. Derived data also include end user identifiable information.

5.3.3 Identifier data categories

ISO/TR 6039 specifies the identifiers data including:

— Subject identifiers: natural persons and legal entities used by administrations of countries, for specific (international) government functions and in some industries. Subjects are entities with rights and obligations.

— Object identifiers: object identifiers used for government purposes and in several industries. Objects are entities without right and obligations.

5.3.4 Other data categories

5.3.4.1 Overview

There are many other types of data and data types of selected examples that are important in financial use cases are presented in 5.3.4.2 to 5.3.4.4.

5.3.4.2 Market price data

Market prices are available for many objects. These include, but are not limited to:

— stock prices of listed companies at exchanges;

— currency rates of Forex markets;

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— commodity prices for commodity markets;

— derivatives rates;

— interest rates (Central Banks reference rates and market rates);

— prices of retailers and web-retailers for goods and services.

5.3.4.3 Accountancy data categories

— Stock data: Accountants use specific terminology included in the IFRS standard which uses a balance sheet that can be presented in an annual report. These stock data include: the value of the goods, debtor position, creditors position presented on the balance sheet. The stock data covers the aggregation of data at a certain point in time.

— Flow data: Accountants use terminology included in the IFRS standard for flow data such as a) profit and loss account and b) cashflow statement. Flow data includes the flow of values, as they change over time, during a predefined time period.

5.3.4.4 Message data in networks

— Messages: Data in messages can be structured or unstructured. The (industry) networks used for Business to Government (B2G) or for Business to Business (B2B) purposes include mostly instructions on the structure of the data messages used in the network involved.

5.4 Roles from the perspective of data flow

5.4.1 DLT stakeholder roles and stakeholder data

Data flows are triggered by the data-related operations of stakeholders, between system components that belong to or are associated with them. Stakeholders achieve their aims by means of role-based interactions with the DLT system.

ISO 23257:2022, 9.2 describes a set of roles/sub-roles which address the main activities associated with DLT systems and gives overall descriptions for activities of these roles/sub-roles. When discussing data flow and data taxonomy, the detailed data-related activities of these roles/sub-roles are necessary information.

5.4.2 Roles/sub-roles and their activities related to data flow

5.4.2.1 Data-related activities of DLT users

A DLT user often uses a DLT system on their devices, by using a DLT application or an application that interacts with a DLT API. Examples of its activities include:

— providing data to DLT systems;

— using data obtained from DLT systems on their devices;

— installing applications on devices.

5.4.2.2 Data-related activities of DLT administrators

A DLT administrator performs administrative activities which might be data-oriented or produce data. Examples of its activities include:

— developing plans to ensure blockchain data backup and recovery, as well as possible data replication and failover;

— ensuring compliance of data storage and processing;

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— discovery, classification and protection of data;

— managing access and authentication data;

— managing application configuration data;

— managing cross-ledger data exchange;

— managing long-term preservation of data.

5.4.2.3 Data-related activities of DLT providers

As defined in ISO 23257:2022, DLT provider is the business stakeholder owning and operating one or more DLT nodes. DLT providers can have data interaction with DLT users and are also responsible for the operation of data.

DLT providers include three sub-roles:

— DLT system operators;

— DLT node operators;

— DLT application operators.

5.4.2.3.1 Data-related activities of DLT system operators

Examples of DLT system operators' activities include:

— providing audit data activities according to audit's requests;

— maintaining operation data.

5.4.2.3.2 Data-related activities of DLT node operators

Examples of DLT node operators' activities include:

— data tracking to achieve the system performance quality control;

— managing access control of data shared by different DLT users on the same node.

5.4.2.3.3 Data-related activities of DLT application operators

Examples of DLT application operators' activities include:

— providing data, applications and data related services;

— processing and using data including data from DLT users under an agreement.

5.5 Considerations related to data flow

5.5.1 Data security

Data security covers preservation of confidentiality, integrity and availability of data.

For DLT systems, it is necessary to ensure full-link security in end-to-end data channel, from IoT, user devices to DLT systems.

5.5.2 Privacy protection

As specified in ISO/TR 23244:2020, there is a series of challenges for privacy protection in DLT systems, which are generally based on characteristics that differentiate them from other ICT systems.

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ISO/TR 23244:2020 also lists a range of areas which privacy within a DLT system covers:

— privacy of blockchain users;

— personal information stored within blockchain blocks;

— personal information stored in external resources referenced in DLT content (off-ledger);

— privacy of transactions or data.

Besides, security of authorization data for related parties to use DLT users' data are also an important concern.

A given DLT system might contain PII or it might contain no PII. Establishing whether a given system contains PII requires a privacy impact assessment (PIA), which is dealt with by ISO/IEC 29134. A PIA ideally can be undertaken as part of the design of a DLT system in order to ensure that the solution is capable of compliance with relevant privacy requirements.

5.5.3 Governance of data

Governing bodies of DLT data are structured differently from traditional IT systems. There are multiple stakeholders involved in the life cycle of DLT data. ISO/TS 23635:2022 identifies three main tasks that each group of stakeholders can govern a DLT system through:

— Evaluation of the current and future use of DLT system and identification of obligations and risks.

— Direct preparation and implementation of policies, procedures and internal control frameworks to ensure that the use of DLT systems meets obligations and mitigates significant risk.

— Monitoring of conformance of policies, procedures and performance of the internal control framework operations to ensure sufficient risk mitigation and compliance to obligations.

ISO/IEC 38505-1:2017 also provides an example data management life cycle. See Figure 3.

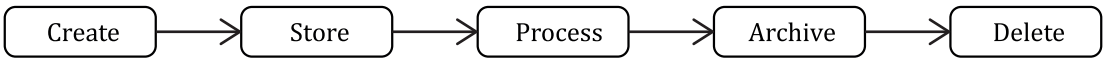

Figure 3 — Example data management life cycle

NOTE Archivists use another life cycle model. To archive is one of two final dispositions, the other being delete.

For DLT system, the storing of data involves numerous stakeholders, and the deletion of on-ledger data which is designed to be immutable also needs to be reconsidered.

5.5.4 Interoperability

ISO/IEC 22123-1:2023 defines interoperability as the ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged.

The interoperability related to data applies to the external flows of data identified.

6 Intra-system data flow

6.1 Overview

A typical process with a serial of data flows taking place within a DLT system is a transaction life-cycle (see Figure 4). Two stages are considered for a whole transaction process, respectively preliminary stage and full life cycle transaction stage. For the full life cycle stage, although a transaction life cycle can differ because of differing protocols or implementations, this document takes a 5-steps-life cycle including submit, broadcast, consensus, execute and feedback as an example.

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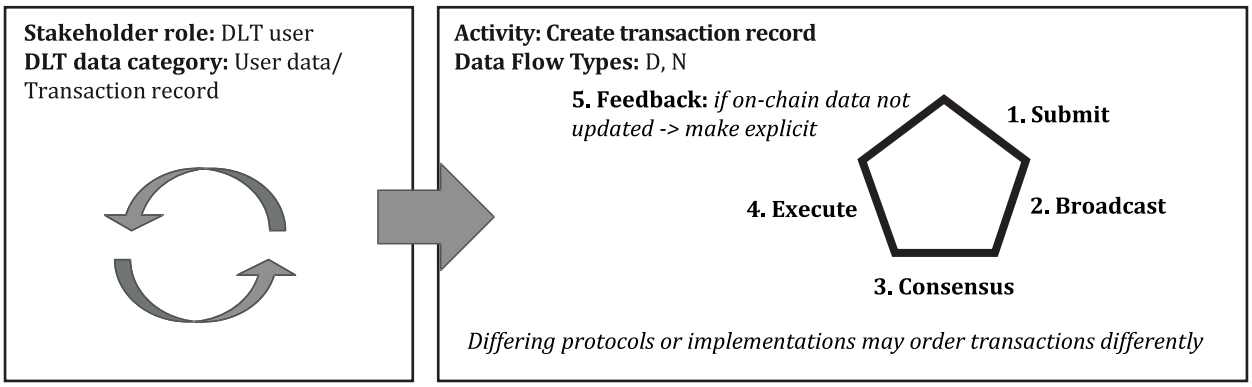

Figure 4 — Intra-system data flow process: User creates transaction record

NOTE 1 The data life cycle model works well only when there are clearly identifiable stages in "real-life". When data are actively modified and used during all their lifetime, life cycle model could be unhelpful.

To clarify the data involved activities, this document identifies the following information for each step.

— data categories (from data storage and DLT system role perspectives);

— data flow categories;

— actions of data: data creation, data storage, data processing, data transmission.

NOTE 2 Data content is use case specific.

6.2 Data flow during DLT transaction procedure

6.2.1 Preliminary stage

6.2.1.1 DLT system setup

After the DLT system is created, the DLT developer and provider set up multiple distributed nodes, system configuration, administrator accounts, etc. Accordingly, the operation data and access authentication data are created and stored consistently among multiple nodes.

6.2.1.2 DLT user account registration

The DLT user performs registration on the DLT system before utilizing on-chain services. Optionally, the user can provide identifiable information to establish the link between account and physical item.

— Data creation: the DLT account data are created, including account identity, balance, status, etc.

— Data storage: the account data are consistently stored at distributed nodes. Conforming to the applicable requirements, policies, rules and considerations in ISO/TR 23244, the sensitive information in DLT account data can be stored on the blockchain system with protection based on access control, encryption, etc. Alternatively, the sensitive information can be linked to on-chain identifier and stored in an off-ledger datastore with restricted access.

6.2.2 Full life cycle data flow in one transaction

6.2.2.1 Outline

One transaction implementation is illustrated in Figure 5.

— S1: Transaction submission. The transaction message is submitted by user or admin system. If it is submitted by user, this message can be viewed as data flow D. Otherwise, it is data flow C.

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