ISO/IEC TR 30176

Edition 1.0 2021-11

TECHNICAL REPORT

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Internet of things (IoT) – Integration of IoT and DLT/blockchain: Use cases

ISO/IEC TR 30176:2021-11(en)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.020

ISBN 978-2-8322-1037-5

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CONTENTS

FOREWORD 5
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
4 Symbols and abbreviated terms 7
5 Use case scenarios 7
5.1 General 7
5.2 Use cases 7
6 Description of use case 9
6.1 Agricultural product tracing 9
6.1.1 Scope and objectives of use case 9
6.1.2 Narrative of use case 9
6.1.3 Actors: people, components, systems, integrated systems, applications and organizations 10
6.1.4 Issues: legal contracts, legal regulations, and constraints 11
6.1.5 Reference standards and/or standardization committees 11
6.1.6 Relation with other known use cases 11
6.1.7 General remarks 11
6.1.8 Data security, privacy and trustworthiness 11
6.1.9 Conformity aspects 11
6.1.10 User requirements and interactions with other actors 11
6.1.11 Drawing of use case 12
6.1.12 Data flow diagram of use case 12
6.1.13 Sequence diagram of use case 13
6.2 Financial services for fish farming 14
6.2.1 Scope and objectives of use case 14
6.2.2 Narrative of use case 15
6.2.3 Actors: people, components, systems, integrated systems, applications and organizations 15
6.2.4 Issues: legal contracts, legal regulations, and constraints 16
6.2.5 Reference standards and/or standardization committees 16
6.2.6 Relation with other known use cases 16
6.2.7 General remarks 16
6.2.8 Data security, privacy and trustworthiness 16
6.2.9 Conformity aspects 17
6.2.10 User requirements and interactions with other actors 17
6.2.11 Drawing of use case 17
6.2.12 Data flow diagram of use case 18
6.2.13 Sequence diagram of use case 19
6.3 Chattel mortgage services 21
6.3.1 Scope and objectives of use case 21
6.3.2 Narrative of use case 21
6.3.3 Actors: people, components, systems, integrated systems, applications and organizations 21
6.3.4 Issues: legal contracts, legal regulations, and constraints 22
6.3.5 Reference standards and/or standardization committees 22

AVA Documents
Document Sharing Hub

Full document details: ISO IEC TR 30176-2021

6.3.6 Relation with other known use cases 22
6.3.7 General remarks 22
6.3.8 Data security, privacy and trustworthiness 22
6.3.9 Conformity aspects 23
6.3.10 User requirements and interactions with other actors 23
6.3.11 Drawing of use case 23
6.3.12 Data flow diagram of use case 24
6.3.13 Sequence diagram(s) of use case 25
6.4 Distributed energy trading 26
6.4.1 Scope and objectives of use case 26
6.4.2 Narrative of use case 26
6.4.3 Actors: people, components, systems, integrated systems, applications and organizations 27
6.4.4 Issues: legal contracts, legal regulations, and constraints 28
6.4.5 Reference standards and/or standardization committees 28
6.4.6 Relation with other known use cases 28
6.4.7 General remarks 28
6.4.8 Data security, privacy and trustworthiness 28
6.4.9 Conformity aspects 29
6.4.10 User requirements and interactions with other actors 29
6.4.11 Drawing of use case 29
6.4.12 Data flow diagram of use case 30
6.4.13 Sequence diagram(s) of use case 31
6.5 Automated parking payment service 33
6.5.1 Scope and objectives of use case 33
6.5.2 Narrative of use case 33
6.5.3 Actors: people, components, systems, integrated systems, applications and organizations 33
6.5.4 Issues: legal contracts, legal regulations, and constraints 34
6.5.5 Reference standards and/or standardization committees 34
6.5.6 Relation with other known use cases 34
6.5.7 General remarks 34
6.5.8 Data security, privacy and trustworthiness 34
6.5.9 Conformity aspects 35
6.5.10 User requirements and interactions with other actors 35
6.5.11 Drawing of use case 35
6.5.12 Data flow diagram of use case 36
6.5.13 Sequence diagram(s) of use case 37
Bibliography 39

Figure 1 – General overview of smart agriculture 12
Figure 2 – Data flow diagram of agricultural product tracing 13
Figure 3 – Sequence diagram of agricultural product tracing 14
Figure 4 – The financial risks without collaboration 18
Figure 5 – Financial risks minimized through the collaboration of multiple participants 18
Figure 6 – Data flow diagram of financial service for fish farming 19
Figure 7 – Sequence diagram of the financial service for fish farming 20

Documents
Document Sharing Hub

Full document details: ISO IEC TR 30176-2021

Figure 8 – Stakeholders and their relationships in chattel mortgage monitoring financial services 24
Figure 9 – Data flow diagram of chattel mortgage service 25
Figure 10 – Sequence diagram of the chattel asset financial service 25
Figure 11 – Architecture for P2P energy trading 30
Figure 12 – Data flow diagram based on hierarchical cyber enhancement framework for energy trading 31
Figure 13 – Sequence diagram for the energy trading process 32
Figure 14 – Involved parties and their relationships in the automated parking payment service 36
Figure 15 – Data flow diagram of the automated parking payment service 37
Figure 16 – Sequence diagram of the automated parking payment service 37

Table 1 – Summary of use case scenarios 8
Table 2 – Actors for agricultural product tracing 10
Table 3 – Data security, privacy and trustworthiness for agricultural product tracing 11
Table 4 – Steps of the agricultural product tracing 14
Table 5 – Actors for financial services for fish farmers 16
Table 6 – Data security, privacy and trustworthiness for financial services for fish farmers 17
Table 7 – Steps of the financial service for fish farming 20
Table 8 – Actors for chattel mortgage services 22
Table 9 – Data security, privacy and trustworthiness for chattel mortgage services 23
Table 10 – Steps of the financial service for chattel mortgage service 26
Table 11 – Actors for distributed energy trading 28
Table 12 – Data security, privacy and trustworthiness for distributed energy trading 29
Table 13 – Steps of the distributed energy trading 32
Table 14 – Actors for the automated parking payment service 34
Table 15 – Data security, privacy and trustworthiness for the automated parking payment service 35
Table 16 – Steps of the automated parking payment service 38

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INTERNET OF THINGS (IoT) – INTEGRATION OF IoT AND DLT/BLOCKCHAIN: USE CASES

FOREWORD

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IEC TR 30176 has been prepared by subcommittee 41: Internet of Things and Digital Twin, of ISO/IEC joint technical committee 1: Information technology. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
JTC1-SC41/220A/DTR	JTC1-SC41/241A/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

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INTRODUCTION

Distributed ledger technology (DLT) provides the capability of a distributed ledger, which is shared across a set of DLT nodes and synchronized among DLT nodes using a consensus mechanism. Blockchain is a kind of DLT, which uses confirmed blocks organized in an append-only, sequential chain using cryptographic links. Blockchain is designed to be tamper resistant and to create final, definitive and immutable ledger records. Either DLT or blockchain can be quoted and used in terms of technology realization for application scenarios. Each participant in a blockchain and DLT network has their own tamper-resistant replica of transaction records associated with the participants who are individuals or organizations. Blockchain and DLT can be applied to solutions involving IoT systems which contain sensors, actuators, tags and readers, wearable devices, and service platforms, all of which are networked.

Through the analysis of the IoT involving the DLT and blockchain technology, the DLT and blockchain technology can help in solving the problems of IoT, especially those existing in the physical system, such as device digital identity, data source trustworthiness, key data forensics, data rights and interests, data assets and value exchange, etc. At the same time, the IoT also provides an important commercial application scenario for DLT and blockchain, and promotes entity and virtual economy combination. The integration of the IoT system with the DLT and blockchain technology can achieve complementary advantages and bring new business opportunities.

In fact, the integration of IoT system with DLT and blockchain can enable the creation of better solutions for many business sectors, particularly where those solutions involve information associated with physical entities, and where the solution spans many organizations with the need for trusted information to be shared by those organizations.

The solutions that can be provided by the integration are important for the business sectors such as agriculture, industry, healthcare, pharmaceuticals, environmental protection, transportation, security, finance, insurance, object tracing, supply chain, smart grid, and smart cities. This document is focused on collecting use cases in some of these sectors.

This document has been prepared based on the applications of IoT and DLT/blockchain technology with the template of IoT use cases.

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INTERNET OF THINGS (IoT) – INTEGRATION OF IoT AND DLT/BLOCKCHAIN: USE CASES

1 Scope

This document identifies and collects use cases for the integration of the DLT/blockchain within IoT systems, applications, and/or services.

The use cases presented in this document use the IoT use case template.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Symbols and abbreviated terms

APP application

DLT distributed ledger technology

HMI human–machine interface

5 Use case scenarios

5.1 General

Use cases presented in this document depict typical use cases involving blockchain/DLT and IoT systems, applications, and/or services; however, this document is not intended to be an exhaustive list of all realizations.

5.2 Use cases

Table 1 summarizes the use case scenarios in this document along with the key actors in each scenario.

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Table 1 – Summary of use case scenarios

Use case number	Name of use case scenario	Short description	Actors
1	Agricultural product tracing	The agricultural product tracing provides the digital capability of recording and tracing the entire process of the agricultural product, from sowing, cultivating and growing, harvesting, storage, transportation, and so on, to the end users. All the data associated with the entire process are collected and stored by the IoT and blockchain technologies to protect from and prevent any tampering of the data, which ensures the brand name, quality, and more importantly the tracing of the agricultural products.	Various sensor nodes, IoT gateways, agricultural product monitoring platform, APP, product testing agency, sellers, logistics service provider, and agricultural product consumers.
2	Financial services for fish farming	Financial services, such as insurance services and loans, are provided to fish farmers by collaboration between financial institutions and high-tech companies. The business collaboration model initiates the innovative way of financial services for fish farming, which is enabled by the IoT and blockchain technology.	Sensor nodes for fish farm monitoring, oxygen controllers, IoT gateways, aquaculture monitoring platform with blockchain, APP, financial service portal, banks, insurance companies, fish farmers.
3	Chattel mortgage services	This use case describes how to integrate IoT system with authorized device and platform integrated with blockchain to monitor the real-time status of chattel asset in the warehouse and during transportation, and provide the authorized data to the relevant stakeholders such as banks, chattel asset owners, chattel asset monitoring organizations, etc., so as to prevent fraudulent activities and reduce unnecessary high risks in providing chattel mortgage services.	Sensor nodes for the chattel asset monitoring, IoT gateway, chattel mortgage monitoring platform with blockchain, APP, financial service portal, banks.
4	Distributed energy trading	A blockchain-based trading infrastructure offers a distributed platform that enables peer-to-peer trading of energy between consumers and prosumers in a secure manner. The identity privacy and security of transaction is higher in the distributed platform compared to the traditional system, in which the energy transaction is usually performed through the central platform which is vulnerable to security threats.	Smart meter, aggregator (EAG) with blockchain, wallet, energy seller, energy buyer.
5	Automated parking payment service	Automated parking payment is a new way for users to pay a parking toll without manual payment and without use of a smart phone. This use case will give the main idea of what the seamless payment is and how to realize the seamless parking payment by automatically calculating and paying parking fees. The entire process is automatically realized by authorized devices, platform integrated with blockchain, wallet, and smart contracts.	Smart devices for the parking vehicles, IoT gateway, parking management platform with blockchain, wallet, parking manager, parking user.

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6 Description of use case

6.1 Agricultural product tracing

6.1.1 Scope and objectives of use case

The main scope of this use case includes:

- the advantages gained over the traditional agricultural product when the IoT and blockchain technologies are applied; and
- how the IoT and blockchain technologies are used in the agricultural product's tracing system.

The objectives of this use case are to:

- clarify the requirements for tracing the agricultural products;
- provide the general descriptions of an IoT system integrated with blockchain technology; and
- improve the online functionality, the end-to-end processes, and the reliability of the management of agricultural products.

6.1.2 Narrative of use case

6.1.2.1 Short description

The agricultural product tracing provides the digital capability of recording and tracing the entire process of the agricultural product, from sowing, cultivating and growing, harvesting, storage, transportation, and so on, to the end users. All the data associated with the entire process are collected and stored by the IoT and blockchain technologies to protect from and prevent any tampering of the data, which ensures the brand name, quality, and more importantly the tracing of the agricultural products.

6.1.2.2 Complete description

The agricultural product tracing lowers food safety risks and protects the reputation of the agricultural product's brand name and quality. A service for securely tracing the entire end-to-end process can be provided by an IoT system integrated with the blockchain technology. The IoT system is used to collect the data from the entire process, i.e. from sowing in the farmland to the consumer market, and the collected data can be stored in the blockchain preventing any potential data tampering.

Various types of sensor nodes can be deployed to measure and collect data on seed conditions, soil quality, lighting condition, weather, crop height, etc. in the agricultural product growth environment. Additionally, other types of sensor nodes can also be deployed to provide location and image/video (cameras) to collect key data on the growth, fertilization, watering, and harvesting time.

The data are transmitted automatically at the scheduled time intervals (e.g. sampling rates) to the agricultural product service platform, encrypted, and recorded in the blockchain along with the time stamp. The encryption key pairs are generated based on the ID of sensor nodes or devices.

After harvesting the agricultural products, the data from the harvested product, e.g. pick-up time, weight of the package, product code of the agricultural products, are uploaded to the agricultural product monitoring platform and stored in blockchain. When the product's test reports from a testing agency are available, the test reports are also stored in blockchain along with the data. The information provided by the logistics service providers, such as product packing information and transportation condition, can also be recorded in the blockchain.

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Meanwhile, all the participants in the entire end-to-end process are authenticated and their information is stored in the blockchain. Furthermore, the consumers will be able to trace all the data by the product codes from the product monitoring platform, providing the transparency between those who are in the entire end-to-end process and the consumers and also ensuring the product quality and reputation of the producer's brand.

6.1.3 Actors: people, components, systems, integrated systems, applications and organizations

Table 2 shows various actors involved in the agricultural product tracing. It also provides the description of each actor and its interactions with physical and virtual entities or other actors.

Table 2 – Actors for agricultural product tracing

Actor Name	Actor role	Actor description	Actor interactions (transactions between actors)
Sensor nodes	IoT devices for monitoring the crop growth	Various devices which acquire the data/information relevant to the crop growth, such as soil nutrition, water, light, temperature, humidity, etc.	IoT gateway
Tags	Physical entities	Physical entities that are attached to other physical entities providing information of the physical entities.	Tag readers
Tag readers	IoT devices	Devices read the associated information from the tags, such as the product code and entire process data of the agricultural products.	IoT gateway
IoT gateway	IoT gateway	A device which communicates with the sensor nodes in the proximity network and aggregates the data/information from the sensor nodes, and transmits the aggregated data/information to the agricultural product monitoring platform by which it is authenticated first.	Sensor nodes and the agricultural product monitoring platform
Agricultural product monitoring platform with blockchain	Application and service sub-system	A platform to provide the monitoring and tracing services of the agricultural products, supported by blockchain where the product data is stored. The smart contract on the product code within the validity period or on other transaction is operated in this platform involved with the participants.	IoT gateways, APP, agricultural product testing agencies, and logistics service providers
APP	IoT user / digital user	An application software through the human–machine interface (HMI) for the users to access the service of the agricultural product monitoring platform.	Agricultural product monitoring platform
Product testing agency	IoT user / human user	An organization qualified to test and certify the quality of the agricultural product and publish the test results to the agricultural product monitoring platform to be stored in the blockchain.	Agricultural product monitoring platform
Logistics service provider	IoT user / human user	A service organization that provides the logistics service and ensures the appropriate transportation conditions for agricultural products, and publishes the logistical information to the agricultural product monitoring platform to be stored in the blockchain.	Agricultural product monitoring platform
Sellers	IoT user / human user	Participants who sell the agricultural products to the consumers.	APP
Agricultural product consumers	IoT user / human user	Individuals who trace the agricultural product quality, buy, and consume the agricultural products.	APP

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6.1.4 Issues: legal contracts, legal regulations, and constraints

Individuals, organizations, companies or institutions will comply with the legal contract's terms and conditions, legal regulations and constraints in international, national, regional, or local area relating to the information security of agricultural product data from planting, testing, packing, to transportation, and relating to the personal privacy of the participants.

6.1.5 Reference standards and/or standardization committees

None.

6.1.6 Relation with other known use cases

None.

6.1.7 General remarks

None.

6.1.8 Data security, privacy and trustworthiness

Table 3 describes the security, privacy and trustworthiness associated with the data and information collected and stored in the agricultural product monitoring platform.

Table 3 – Data security, privacy and trustworthiness for agricultural product tracing

Data security requirements and implications for applications, systems, etc.
The data security requirements are essential for the service providers, participants and users. For example, the data from the agricultural product has not been tampered with, and the data are encrypted and stored in a distributed fashion. All participants who publish their data/information to the agricultural product monitoring platform are authenticated.
Privacy requirements and implications for applications, systems, etc.
The privacy requirements are important for every stakeholder, participant, and user. The data/information of stakeholders, participants and users are not obtained by unauthenticated users. Encryption or technologies with anonymous characteristics can be used to protect the data/information privacy.
Trustworthiness requirements and implications for applications, systems, etc.
The trustworthiness requirements for the agricultural product tracing are fundamental and essential. The agricultural product monitoring platform provides reliable and tamper-proof product data and information to the users. More importantly, the participants providing their data/information are the only ones who can be trusted and authenticated.

6.1.9 Conformity aspects

None.

6.1.10 User requirements and interactions with other actors

The users request and obtain the entire end-to-end process data of agricultural products provided by the service providers, such as sowing crops, growing process, harvesting, testing, storage, logistics, and sales.

The participants are authenticated by third parties to ensure that their identities are credible, and then the data of the agricultural products is provided by the authenticated participants, for example, farm managers, testing agencies, logistics service providers and sellers. The agricultural products have their own identifiers associated with the data provided by the participants.

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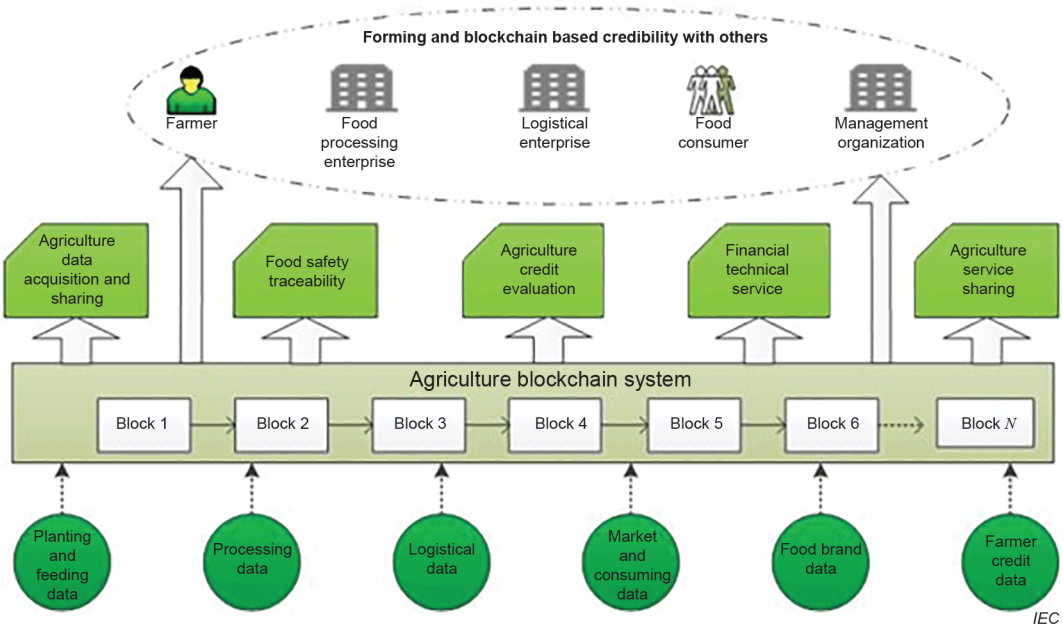
6.1.11 Drawing of use case

Figure 1 describes the use case of smart agriculture with an IoT system and blockchain technology. Agricultural product tracing is an essential part of the smart agriculture. The IoT systems and other third-party systems collect the data on planting, processing, logistics, marketing, food brand, and the participant's credit data. The third parties are also authenticated to access the system. All the data associated with the products are stored in the blockchain integrated in the agricultural product monitoring platform. The monitoring platform integrates the data from all the participants and provides the data sharing, food safety tracing, credit evaluation, and other financial services for various users. For example, the consumers can get a food safety tracing service, and a management organization can get shared data service. Blockchain helps to construct a peer-to-peer platform for the users and participants.



SOURCE: Figure 2 of Study report of JTC 1 /SC 41 AHG 18 [SC41N1089]

Figure 1 – General overview of smart agriculture

6.1.12 Data flow diagram of use case

The agricultural product tracing use case includes the following types of data flows:

1) Agricultural product data flow generated by IoT system and participants

   The agicultural product data are stored in the platform supported by blockchain. For example, the data associated with the operations for the product include the operation result, the participants and the time stamp. The data associated with testing include test reports, testing agency, and time stamp.

   The IoT systems collect the data associated with the agricultural product's growing, storage, logistics, and sales. For example, the data associated with the crop growing include temperature, humidity, the PH value of the soil, and pictures of the product appearance.

   Other participants provide their process data to agricultural product monitoring platform. For example, the testing agency provides the testing service for the agricultural products and generates the test reports.

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