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Permissioned Distributed Ledgers (PDL); Overview of use cases in 3GPP network and impact analysis on architecture integration

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Permissioned Distributed Ledger (PDL).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document will first provide an overview of use cases/scenarios of PDL specific to mobile networks, based on the deliverables published in major existing standardization bodies. It aims to form a common view to summarize the key benefits of PDL technology to mobile network domain (including its operation controls and services).

Within one or multiple operators, utilizing PDL technology can be widely adopted in different domains (e.g. ranging from end users, RAN/core network to service providers) of a mobile network system and different layers (e.g. data flow layer, management layer and business layer), thus this WI will further identify several key issues/challenges/deficiencies to specialize PDL solutions to a mobile network system and its essential impact to the mobile network system architecture, which could refer 3GPP 5G architecture as a base.

Some WIs already show an initial try by introducing a new network entity in mobile networks to connect to PDL services, this WI will comprehensively investigate if there will be any necessity to make modifications to the mobile network system architecture (starting with 3GPP 5G reference architecture) to integrate PDL in a holistic way.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ISO/TR 3242:2022: "Blockchain and distributed ledger technologies -- Use cases".

[i.2] ISO/PRF TR 6039: "Blockchain and distributed ledger technologies -- Identifiers of subjects and objects for the design of blockchain systems".

[i.3] ISO/WD TR 6277.2: "Blockchain and distributed ledger technologies -- Data flow model for blockchain and DLT use cases".

[i.4] ISO/WD 7603: "Decentralized Identity standard for the identification of subjects and objects".

[i.5] ISO/AWI 20435: "Representing Physical Assets using Non-Fungible Tokens".

[i.6] ISO 22739:2020: "Blockchain and distributed ledger technologies -- Vocabulary".

[i.7] ISO/TR 23244:2020: "Blockchain and distributed ledger technologies -- Privacy and personally identifiable information protection considerations".

[i.8] ISO/TR 23249:2022: "Blockchain and distributed ledger technologies -- Overview of existing DLT systems for identity management".

[i.9] ISO 23257:2022: "Blockchain and distributed ledger technologies -- Reference architecture".

[i.10] ISO/TS 23258:2021: "Blockchain and distributed ledger technologies -- Taxonomy and Ontology".

[i.11] ISO/TR 23455:2019: "Blockchain and distributed ledger technologies -- Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems".

[i.12] ISO/AWI TS 23516: "Blockchain and distributed ledger technology -- Interoperability Framework".

[i.13] ISO/TR 23576:2020: "Blockchain and distributed ledger technologies -- Security management of digital asset custodians".

[i.14] ISO/TS 23635:2022: "Blockchain and distributed ledger technologies -- Guidelines for governance".

[i.15] ISO/WD TR 23642: "Blockchain and distributed ledger technologies -- Overview of smart contract security good practice and issues".

[i.16] ISO/DTR 23644: "Blockchain and distributed ledger technologies -- Overview of trust anchors for DLT-based identity management (TADIM)".

[i.17] ITU-T/FG DLT D1.1 TS: "DLT terms and definitions".

[i.18] ITU-T/FG DLT D1.2 TR: "DLT overview, concepts, ecosystem.

[i.19] ITU-T/FG DLT D1.3 TR: "DLT standardization landscape".

[i.20] ITU-T/FG DLT D2.1 TR: "DLT use cases".

[i.21] ITU-T/FG DLT D3.1 TS: "DLT reference architecture".

[i.22] ITU-T/FG DLT D3.3 TS: "Assessment criteria for DLT platforms".

[i.23] ITU-T/FG DLT D4.1 TR: "DLT regulatory framework".

[i.24] ITU-T/FG DLT D5.1 TR: "Outlook on distributed ledger technologies".

[i.25] IEEE Std 3801™-2022: "Standard for Blockchain-based Electronic Contracts", vol., no., pp.1-26, 1 April 2022, doi: 10.1109/IEEESTD.2022.9745868.

[i.26] IEEE Std 2418.10™-2022: "Standard for Blockchain based Digital Asset Management", vol., no., pp.1-19, 30 June 2022, doi: 10.1109/IEEESTD.2022.9810177.

[i.27] IEEE Std 2146.1™-2022: "Standard for Entity-Based Risk Mutual Assistance Model through Blockchain Technology", vol., no., pp.1-18, 11 August 2022, doi: 10.1109/IEEESTD.2022.9853246.

[i.28] IEEE Std 2142.1™-2021: "Recommended Practice for E-Invoice Business Using Blockchain Technology", vol., no., pp.1-18, 18 March 2021, doi: 10.1109/IEEESTD.2021.9381780.

[i.29] IEEE Std 2140.2™-2021: "Standard for Security Management for Customer Cryptographic Assets on Cryptocurrency Exchanges", vol., no., pp.1-20, 10 January 2022, doi: 10.1109/IEEESTD.2022.9676563.

[i.30] IEEE Std 2140.1™-2020: "Standard for General Requirements for Cryptocurrency Exchanges", vol., no., pp.1-18, 4 November 2020, doi: 10.1109/IEEESTD.2020.9248667.

[i.31] IEEE Std 2140.5™-2020: "Standard for a Custodian Framework of Cryptocurrency", vol., no., pp.1-23, 17 July 2020, doi: 10.1109/IEEESTD.2020.9144688.

[i.32] IEEE Std 2142.1™-2021: "Recommended Practice for E-Invoice Business Using Blockchain Technology", vol., no., pp.1-18, 18 March 2021, doi: 10.1109/IEEESTD.2021.9381780.

[i.33] IEEE Std 2143.1™-2020: "Standard for General Process of Cryptocurrency Payment", vol., no., pp.1-14, 12 June 2020, doi: 10.1109/IEEESTD.2020.9115946.

[i.34] IEEE Std 2144.1™-2020: "Standard for Framework of Blockchain-based Internet of Things (IoT) Data Management", vol., no., pp.1-20, 18 January 2021, doi: 10.1109/IEEESTD.2021.9329260.

[i.35] IEEE Std 2418.7™-2021: "Standard for the Use of Blockchain in Supply Chain Finance", vol., no., pp.1-25, 28 October 2021, doi: 10.1109/IEEESTD.2021.9599622.

[i.36] IEEE Std 2418.2™-2020: "Standard for Data Format for Blockchain Systems", vol., no., pp.1-32, 23 December 2020, doi: 10.1109/IEEESTD.2020.9303503.

[i.37] IEEE™ P2145/D1: "Draft Standard for Framework and Definitions for Blockchain Governance", vol., no., pp.1-35, 10 March 2023.

[i.38] IMT-2030 Network Group: "6G blockchain scenarios and requirements".

[i.39] IMT-2030 Network Group: "6G blockchain architecture and key technology".

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[i.42] Urien, P. (2022): "Blockchain Transaction Protocol for Constraint Nodes" (Internet-Draft draft-urien-core-blockchain-transaction-protocol-09). Internet Engineering Task Force.

[i.43] The Personal Information Protection Law (PIPL) of the People's Republic of China, www.npc.gov.cn, Retrieved 2021-09-30.

[i.44] The Act on the Protection of Personal Information (APPI) of Japan, www.ppc.go.jp, Retrieved 2017-05-30.

[i.45] "AB-375, Chau. Privacy: personal information: businesses". California State Legislature. Retrieved 2018-11-19.

[i.46] The General Data Protection Regulation (GDPR) in the EU and the European Economic Area (EEA), Retrieved 2016-04-27.

[i.47] ETSI GR PDL 020 (V1.1.1): "Wireless Consensus Network".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence
AI4NET	AI for NETwork
APPI	Act on the Protection of Personal Information
AR	Augmented Reality
BC	BlockChain
BCaaS	BlockChain as a Service
BS	Base Station

CA	Certificate Authority
CCPA	California Consumer Privacy Act
CLOUD	Clarifying Lawful Overseas Use of Data act
DAPP	Decentralized APPlication
DLT	Distributed Ledger Technology
DRL	Deep Reinforcement Learning
E2E	End-to-End
ETSI	European Telecommunications Standard Institute
FL	Federated Learning
GDPR	General Data Privacy Regulation
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMT	International Mobile Telecommunications
IoT	Internet of Things
IRTF	Internet Research Task Force
ISO	International Standard Organization
ITU	International Telecommunication Union
KPI	Key Performance Indicator
LTE	Long Term Evolution
M2M	Machine-to-Machine
ML	Machine Learning
NET4AI	NETwork for AI
NF	Network Function
NFT	Non-Fungible Token
PKI	Public Key Infrastructure
QoS	Quality-of-Service
RAN	Radio Access Network
RSU	Road Side Unit
SAT	Security Asset Transfer
SIM	Subscriber Identity Module
SME	Small and Medium-sized Enterprises
UE	User Entity
UMTS	Universal Mobile Telecommunications Service
V2X	Vehicle-to-Everything
VC	Verifiable Credential
VR	Virtual Reality
XR	eXtended Reality

4 Information of Existing Standardization Organizations

4.1 ISO

In 2016, ISO/TC 307 "blockchain and distributed ledger technologies" has been set up to meet the growing need for standardization in this area by providing internationally agreed ways of working with it to improve security, privacy and facilitate worldwide use of the technology through better interoperability. This is especially relevant due to the number of SMEs, across various sectors, that are developing blockchain and distributed ledger technologies as a product.

The scope of ISO/TC 307 reads: "standardisation of blockchain technologies and distributed ledger technologies." ISO/TC 307 has 7 Working Groups (WG). Specifically, WG1 places the foundation by defining the necessary terminologies for ISO/TC 207 [i.6], [i.10]; WG2 Architecture [i.9]; WG3's interests are on smart contracts and their applications [i.13],[i.15]; WG4 focuses on security, privacy and identity [i.2], [i.4], [i.7], [i.8], [i.11], [i.13], [i.16]; WG5 studies the mechanism of blockchain systems' governance [i.14]; WG6 aims to identify typical use cases [i.1], [i.3], [i.5]; and WG7 investigates the interoperability issues of blockchain systems [i.11], [i.12].

In addition to the 7 WGs, ISO/TC 307 has 3 Advisory Groups (AGs), 4 Ad-Hoc Group (AHG) and 1 Joint Working Group (JWG). Blockchain and distributed ledger technologies is a rapidly evolving and expanding area. The need for collaboration and cooperation has been identified and ISO/TC 307 is liaising with the relevant ISO and IEC committees, as well as external organizations, to minimize any overlap.

4.2 ITU-T

The ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT) was established in May 2017 and concluded on 1st August 2019.

A key element of achieving this mission was to identify and introduce the foundation of the DLT ecosystem (including e.g. terms and definitions [i.17], taxonomies and concepts [i.18], and standardization activities [i.19]). In order to better understand how the technology can be applied in different scenarios and industries, FG DLT conducted an in-depth analysis of applications and services based on DLT, represented in its report [i.20] where 39 use cases were selected from the vertical (e.g. financial, healthcare, information and communication technology, entertainment, industrial, government and public sectors) and horizontal domains (e.g. identity, security and data management, governance and decentralized autonomous organizations, and crypto-infrastructure).

FG DLT has studied many of the DLT platforms available and described their key components and features. The common components and features are defined in the Focus Group's "DLT reference architecture" specification, which also describes their hierarchical relationship [i.21]. In addition, FG DLT identified "Assessment criteria for DLT platforms" described in a separate specification [i.22]. These 25 criteria aim to assist implementers to evaluate and compare different platforms.

Apart from considering technical issues, many implementers are concerned with the applicability of DLT in their respective legal and regulatory environments. Meanwhile, lawmakers and regulators are considering the need to adapt their instruments to this emerging technology. FG DLT has considered the key properties of DLT and their relevance to law and regulation in [i.23]. By analysing associated challenges and supplying practical recommendations addressing users, regulators, and technologists, the "DLT regulatory framework" developed by this FG aims to create awareness and mitigate risks. Developed by a multidisciplinary group of experts, the report in [i.23] describes DLT-property specific problems and risks, and guides stakeholders on how to address them. The "DLT Outlook" in [i.24] report explores the advancement of DLT beyond the current state of development, and addresses, inter alia, governance, computation networks, identity and privacy, resilience, risk and audit. The report in [i.24] summarizes existing studies, provides the reader with some future perspectives on these issues, and discusses related standardization aspects.

4.3 IEEE

The IEEE Future Directions Committee, represented by the societies of the IEEE, approved the formation of the IEEE Blockchain Initiative effective 1st January, 2018. This initiative will be the hub for all IEEE Blockchain projects and activities. The BLK encompasses a comprehensive set of projects and activities supported by the following core subcommittees: Pre/Standards, Education, Conferences and Events, Community Development and Outreach, Publications, and Special Projects. So far, it published 11 IEEE standards under this Standardization Association (SA).

The first area of the SA is about the general features and fundamental building blocks of DLT such as electronic contracts [i.25], digital asset management [i.26], E-invoice [i.28], [i.32], data format [i.36], Internet of Things (IoT) data management [i.34], supply chain finance [i.35] and its governance [i.37]. Another interest of the SA is about cryptocurrency, the standards cover its security management [i.29], the requirements for exchanges [i.30], defining a custodian framework [i.31] and the general payment process with cryptocurrency [i.33]; in addition, the SA also covers how to build mutual assistance model in a trustless environment based on blockchain/DLT [i.27].

Moreover, there are more than 50 additional standards under development.

4.4 IMT-2030

IMT-2030 aims to explore the possibility and application scenarios of combining blockchain with 6G networks/businesses in 6G scenarios. By analysing the development trend and security vision of 6G networks, it tries to extract the combination points of 6G and blockchain, using the decentralized, tamper-proof and consensus-based characteristics of blockchain to serve multiple scenarios of 6G networks/businesses [i.38].

Meanwhile, according to the characteristics of 6G networks/businesses, IMT-2030 reversely promotes the development of blockchain technology. Based on scenarios and requirements, it studies the key technologies involved in the integrated architecture of blockchain and communication networks [i.39].

4.5 IETF and IRTF

From IETF, there is no dedicated working group for DLT. However, blockchain technology is mentioned in several use cases in different drafts. For example, blockchain technology was used for building supply chain infrastructure, designing a secure asset transfer protocol as well as enhancing the RESTful protocol to design a blockchain transaction protocol for Constraint Nodes [i.40].

From IRTF, the Decentralized Internet Infrastructure Research Group (DINRG) investigates open research issues in decentralizing infrastructure services such as trust management, identity management, name resolution, resource/asset ownership management, and resource discovery. The focus of DINRG is on infrastructure services that can benefit from decentralization or that are difficult to realize in local, potentially connectivity-constrained networks. The objective of DINRG is to:

1) investigate (understand, document, survey) use cases and their specific requirements with respect to implementing them in a distributed manner;

2) to discuss and assess solutions for specific use cases with a focus on Internet level deployment issues such as scalability, performance, and security;

3) to develop and document technical solutions and best practices;

4) to develop tools and metrics to identify scaling issues and to determine whether components are missing; and

5) to identify future work items for the IETF.

Other topics of interest are the investigation of economic drivers and incentives and the development and operation of experimental platforms. For example, a Security Asset Transfer (SAT) interoperability architecture was proposed in [i.41]; and a transaction protocol for constraint nodes were proposed in [i.42].

4.6 Summary

The analysis in previous parts shows that most of the existing standardization organizations (such as ISO, ITU-T and IEEE) involve the study the blockchain/DLT itself. In other words, studies on its internal mechanisms are widely undertaken as a major research area. For example, ISO focuses on the standardization of the definition of blockchain/DLT, the reference service architecture; ITU-T covers the definition, framework, management, smart contract and even quantum-resistant blockchain, etc.

In addition, most of the existing standardization organizations involve studies on the applications of blockchain/DLT to various vertical industries. For example, ISO studies how blockchain/DLT can be applied to vertical industries; ITU-T has study items on deploying blockchain services within a telecommunication infrastructure such as blockchain-based self-organized IoT network, blockchain-based charging mechanism, personal healthy record databases and so on. IEEE has study items about Fintech, cryptocurrency, digital invoice and so on.

So far, among the existing standardization organizations, studies on applying blockchain/DLT in telecommunication industry, especially in the scope of 3GPP domain, are rare. Specifically, on the one hand, it is lack of further studies on the impact of blockchain/DLT to the architecture of a 3GPP network; on the other hand, how a 3GPP network can facilitate the development of blockchain/DLT applications is also missing. These two aspects are the focus of this study, which will fill the gap in the research community.