



The Standards People

Security Conference

PDL for Trustworthy 6G

Presented by: Chonggang Wang, PhD, IEEE Fellow
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(Permissioned Distributed Ledger)

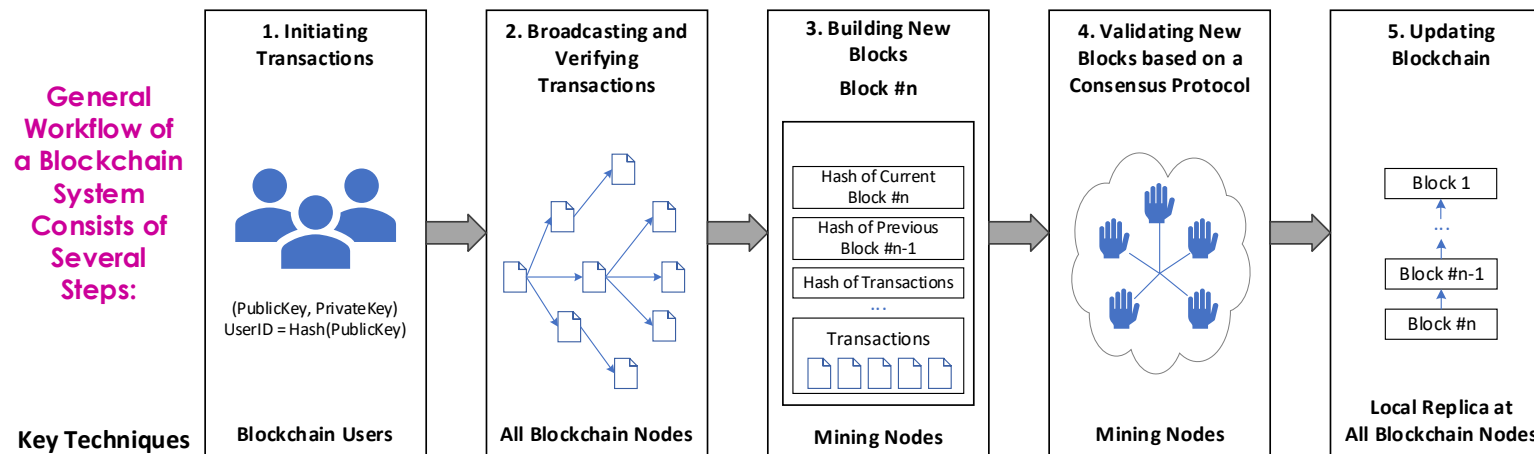


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Distributed Ledger Technology (DLT) Introduction

Two DLT Transaction Flow Models: **Order-Execute (Illustrated)**, Execute-Order-Validate (in Hyperledger)



Key Techniques in Each Step:

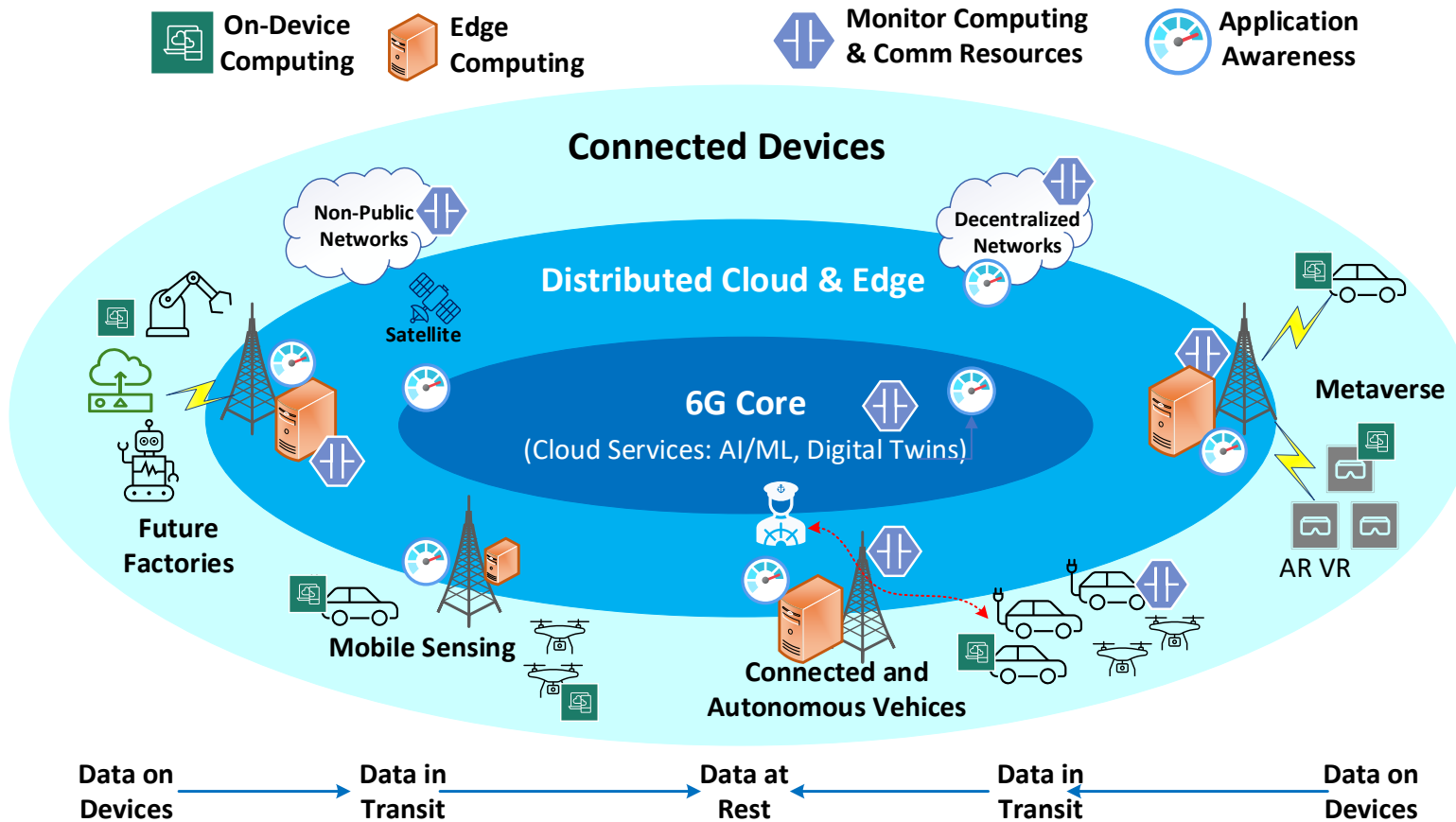
Key Techniques in Each Step:	1. Initiating Transactions	2. Broadcasting and Verifying Transactions	3. Building New Blocks	4. Validating New Blocks based on a Consensus Protocol	5. Updating Blockchain
Cryptography	Yes	Yes			
Hashing	Yes	Yes	Yes		
Merkle Tree			Yes		
Distributed Ledgers					Yes
P2P Networking		Yes	Yes	Yes	
Consensus Protocol			Yes	Yes	

- Blockchain** is a specific type of **Distributed Ledger Technology (DLT)**, which utilizes a chain of blocks as the underlying data structure.
 - Other DLTs: Directed Acyclic Graphs (DAG), hash graphs, etc.
- Blockchain issues:** privacy, scalability, energy efficiency, and interoperability, which can be solved by evolved Layer-1 (on-chain/main chain) and Layer-2 (off-chain/side chain) technologies.

Permissioned Distributed Ledger	Permissionless Distributed Ledger
Consensus Protocols: Scalability, Throughput, Energy Efficiency, etc.	
Proof-of-Work (PoW)	Proof-of-Stake (PoS)
Delegated PoS	Practical Byzantine Fault Tolerance (pBFT)

DLT Advantages: Decentralization | Transparency | Immutability | Security

6G: Distributed, Intelligent, Sustainable and Trustworthy Systems



6G Features:

- Integrated Satellite-Terrestrial Networks
- Distributed Computing and Communication
- Distributed and Connected Intelligence (e.g., Federated Learning)



Multi-Stakeholder Collaborative 6G Systems



Trustworthy 6G Systems

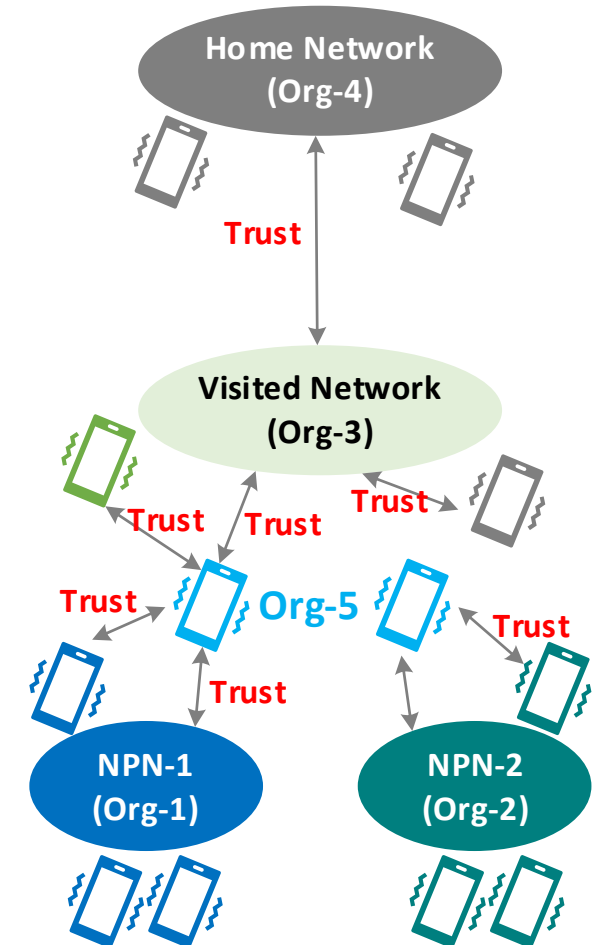
Distributed and User-Centric Trust

Distributed Trust

- Trust relationship built without relying on a centralized party
- Distributed trust can be established among devices, between devices and networks (home, visited, or NPNs), or between networks
- Distributed trust can enable trustworthy services, such as:
 - 1) Services that a device can provide to another device;
 - 2) Services that a network can provide to a device or vice versa;
 - 3) Services that a network can provide to another network.

User-Centric Trust

- Trust relationship relying on user credentials instead of SIM-based primary authentication in current 5G System
- User-centric trust can be established among devices, or between devices and networks
- User-centric trust can enable user-centric trustworthiness beyond existing SIM-based authentication and trust



Benefits of Distributed and User-Centric Trust



Increased system resiliency:

- Distributed trust removes the need for a centralized party such as home networks and avoids single point of failure

Improve system performance:

- Distributed trust enables direct interactions between devices and local networks without relying home networks.
- Local interactions are more efficient in terms of communication overhead

Support dynamic trust monitoring, evaluation and assessment

- The context of devices and networks changes dynamically.
- As such, dynamic trust monitoring, evaluation and assessment are required

Enable new service models in 5GS and beyond

- Dynamic and direct network access services (e.g., SIM-less services) between & across devices/users, visited networks and NPNs, which helps extend network coverage and improve user experience
- Distributed and trustworthy services among devices, between devices and networks, and between different networks.

ETSI ISG PDL – Goals and Scope



Provide the foundations for the operation of permissioned distributed ledgers

- Create an open ecosystem of industry grade solutions
- Deployable by different sectors

Foster the application of the technology

- Start from already available experiences
- Coordinate with existing initiatives

Define open operational mechanisms

- Support their demonstration
- Facilitate interoperability assessment

Support commercial applications

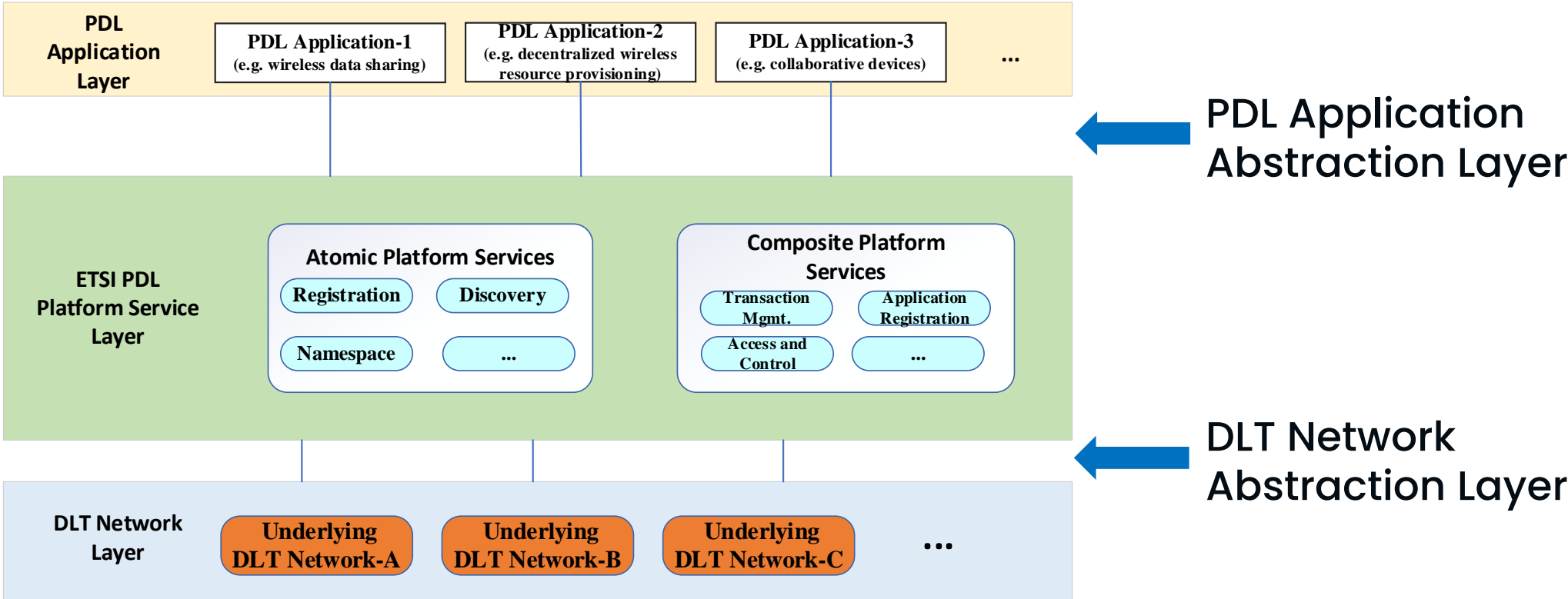
- Lifecycles
- Commercial value

ETSI ISG PDL – Published Reports and Specifications



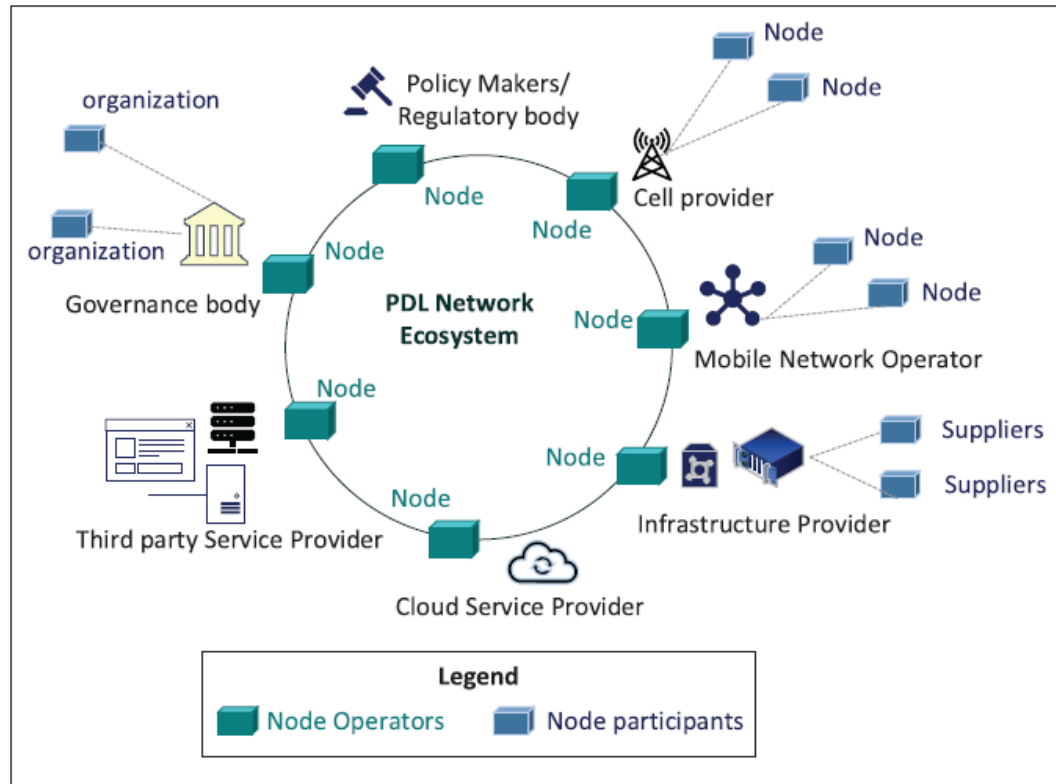
- PDL-001: Landscape of Standards and Technologies
- PDL-002: Applicability and Compliance to Data Processing Requirements
- PDL-003: Application Scenarios
- PDL-004: Smart Contracts PDL System Architecture and Functional Specification
- PDL-005: Proof of Concepts Framework
- PDL-006: Inter-Ledger interoperability
- PDL-008: Research and Innovation Landscape
- PDL-009: Federated Data Management
- PDL-010: Operations in Offline Mode
- PDL-011: Specification of Requirements for Smart Contracts' architecture and security
- **PDL-012: Reference Architecture**
- **PDL-013: Supporting Distributed Data Management**
- PDL-014: Study on non-repudiation techniques
- **PDL-015: Reputation Management**
- **PDL-018: Redactable Distributed Ledgers**
- **PDL-019: PDL Services for Identity and Trust Management**
- **PDL-020: Wireless Consensus Network**

PDL Reference Architecture



Source: Adapted from ETSI GS PDL-012

PDL-based Multi-Stakeholder Telecom Ecosystems



Use Case(s)	PDL Usage(s)
Identity Management	Use digital identifiers (e.g., decentralized ID or SSI) generated and stored on PDLs for identification and authentication
Roaming Services Monitoring and Settlement	Slice service rejection/failure reporting with PDL transaction and roaming services violation monitoring with smart contracts
Network Automation	Install network automation decision logic function in smart contracts
Intent-based Networks	Code intent-SLA translation logic in smart contracts
Automated Resource Provisioning	Use smart contracts as service contracts to enable dynamic resource provisioning
Infrastructure Sharing	Smart contracts across multiple network players to enable multi-operator and multi-vendor environment
Quality of Experience	Record QoE metrics in smart contracts
Native Artificial Intelligence (AI)	Use PDL to enable trustworthy and explainable native AI

Source: S. B. M. Baskaran, T. Faisal, C. Wang, D. R. Lopez, J. Ordonez-Lucena and I. Arribas, "The Role of DLT for Beyond 5G Systems and Services: A Vision," in IEEE Communications Standards Magazine, vol. 7, no. 1, pp. 32-38, March 2023

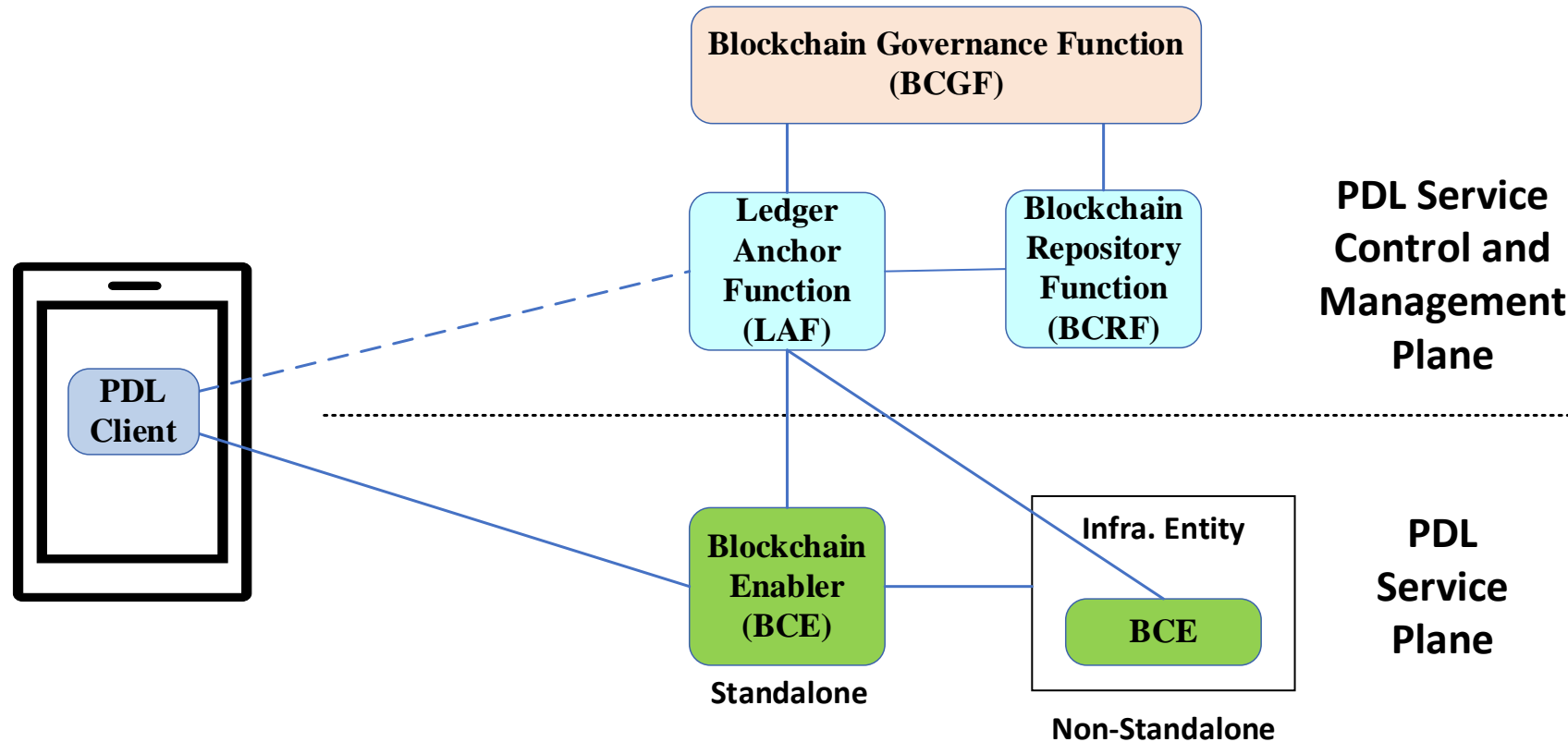
PDL Use Cases in 3GPP Networks



	For Operator Use						For 3 rd -party Use
General Use Cases	1. Telecom Infrastructure Registry	2. Operational Log Sharing	3. Security/Privacy Enhancement	4. Resource Sharing	5. Trustworthy and Explainable Network-Native AI	6. Smart Contract-based Direct Inter operation	7. Vertical Support
Sub-Use Cases	1.1 Single-domain Infrastructure Registry 1.2 Multi-domain Infrastructure Registry	2.1 Charging Bills 2.2 Service KPIs 2.3 UE Runtime Behaviours 2.4 Energy Consumption Measurement Data	3.1 Decentralized Data Storage 3.2 Data Auditing 3.3 Decentralized Certificate 3.4 Decentralized Credential 3.5 Decentralized Identity	4.1 Infrastructure Resource Sharing 4.2 Spectrum Resource Sharing 4.3 Digital Asset	5.1 Training Data Collection 5.2 Distributed Learning 5.3 Model Verification	N/A	N/A

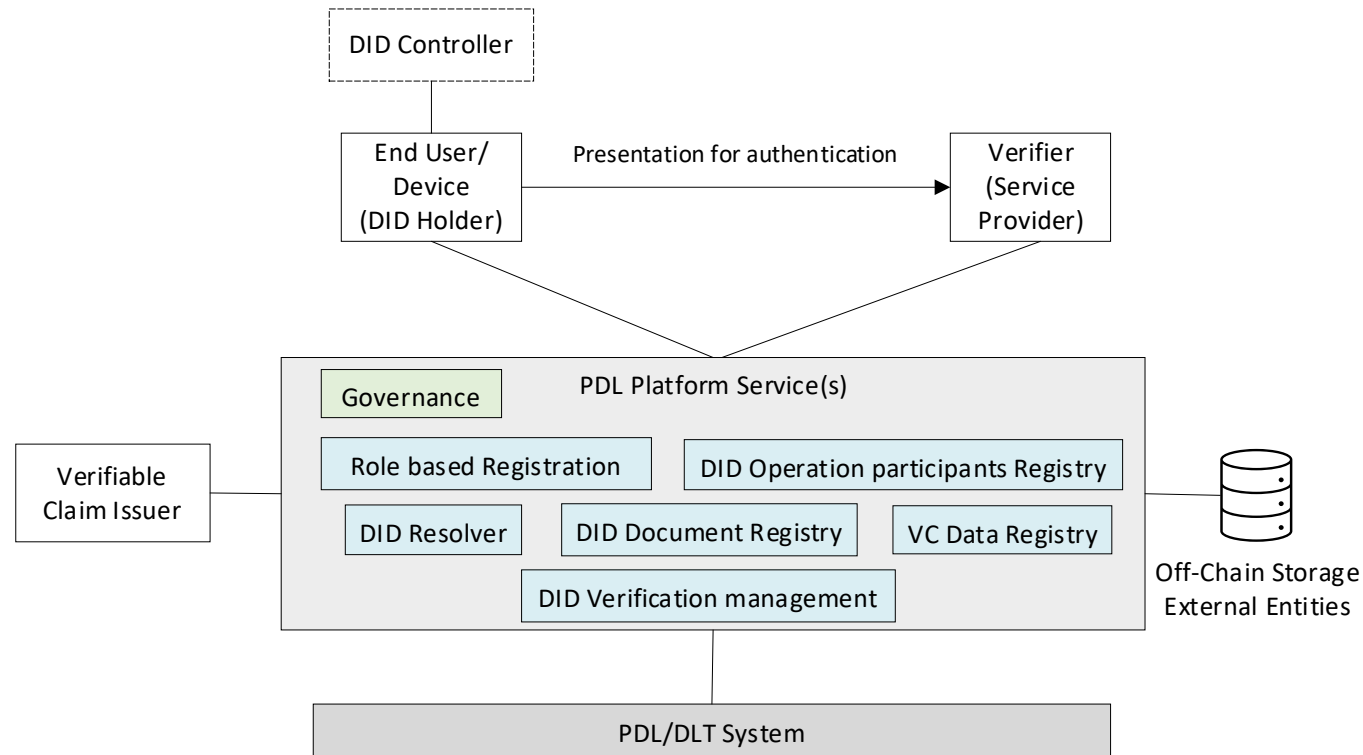
Source: ETSI GR PDL-021

General Architecture of PDL Functions/Services in 6G System



Source: Adapted from ETSI GS PDL-024

PDL-based Decentralized Identification and Trust Management



Source: ETSI GS PDL-023

- (DID Holder) Registration Management
- Data Management (DID, Data Document)
- Decentralized Identifier Verification Management

Potential Issues for Leveraging PDL to Enable Trustworthy 6G



Onboarding PDL-Enabled Devices to 6G Systems

- Blockchain Address Authentication
- Blockchain Key Materials
- PDL System Configuration

Provisioning PDL Services in 6G Systems

- PDL Function and Service Instantiation
- PDL Service Lifetime Management
- Smart Contract Management

PDL-based Trust Evaluation and Management

- Telecom-Native DID Systems

ETSI ISG PDL – Ongoing Work



- PDL-016: Assessment for Smart Contracts and oracles (Early Draft)
- PDL-017: eIDAS Applicability: Qualification of a PDL (Early Draft)
- PDL-021: 3GPP Use Cases (Final Draft for Publication)
- PDL-022: PDL Use in Supply Chain Management (Stable Draft)
- PDL-023: PDL Service Enablers for Decentralized Identification and Trust Management (Close to Stable Draft)
- PDL-024: Architecture Enhancements for PDL Service Provisioning in Telecom Networks (Early Draft)
- PDL-025: Wireless Consensus Network Composition and Organization (Early Draft)
- PDL-026: PDL in Settlement of Usage-Based Services (New WI)

Relevance to
Trustworthy 6G

For Further Reference about ETSI ISG PDL



ETSI ISG PDL: <https://www.etsi.org/technologies/permissioned-distributed-ledgers>

- PDL Terms of Reference, ETSI ISG PDL Portal : <https://portal.etsi.org/TB-SiteMap/PDL>
- Work Programme: <https://portal.etsi.org/tb.aspx?tbid=873&SubTB=873#It-50611-work-programme>
- PDL Community: <https://portal.etsi.org/TB-SiteMap/PDL/List-of-PDL-Members-and-Participants>

PDL Proofs of Concept (PoCs)

- PDL Wiki and PoC Proposal How-To: <https://pdlwiki.etsi.org/>

Research and Standardisation

- Research Projects interested in collaborating with PDL refer to: [PDL Work Programme](#), [PDL Membership List](#), [PDL Member Agreement](#)/[PDL Participant Agreement](#)
- ETSI Research and Standards Website, ETSI Research Strategy, ETSI Tools for Researchers, FAQs on Research and Innovation: <https://www.etsi.org/research>



Thank you for your attention

Any further questions?



Contact me:

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