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# Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee {ETSI Technical Committee|ETSI Project|<other>} Permissioned Distributed Ledger (PDL).

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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](https://portal.etsi.org/Services/editHelp%21/Howtostart/ETSIDraftingRules.aspx) (Verbal forms for the expression of provisions).

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# Executive summary

# Introduction

# 1 Scope

This document will specify technical solutions for enabling a telecom network to be capable of provisioning various PDL services over the infrastructure itself. The scope of the WI aims to specify required end-to-end enhancements/modifications on:

1) The telecom network architecture across user entities, (radio) access network, core network and service providers (e.g., by adding new functions or modifying functions);

2) Functionalities of the new functions and/or modified functions; and

3) Interfaces and procedures among the new functions and/or existing functions.

# 2 References

## 2.1 Normative 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.

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The following referenced documents are necessary for the application of the present document.

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## 2.2 Informative references

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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]

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the [following] terms [given in ... and the following] apply:

## 3.2 Symbols

For the purposes of the present document, the [following] symbols [given in ... and the following] apply:

## 3.3 Abbreviations

For the purposes of the present document, the [following] abbreviations [given in ... and the following] apply:

# 4 Native PDL Service Provisioning in Telecom Networks

## 4.1 General Concept

As a nationwide infrastructure, telecom network already becomes a fundamental service provisioning platform for various service applications, across basic mobile Internet connectivity to compute-oriented tasks for both mobile users and over-the-top (OTT) service providers. Thanks to the distributed, reliable and high availability natures, ICT infrastructure shows unique benefits PDL service provisioning as well.

However, different from normal (mobile/OTT) applications, a PDL service is in a form of a blockchain network consisting of a set of distributed peer nodes interconnecting each other. As a result, PDL service provisioning within telecom network is a non-trivial task, because an operator must consider how a blockchain network can be instantiated within the telecom network infrastructure given the specific requirements of a PDL service as well as the resource constraints of the telecom network in itself.

The new requirements on native PDL service provisioning drives a need of architecture enhancement of the telecom network itself. A native PDL service provisioning is based on an end-to-end (E2E) telecom network infrastructure in a dynamic environment; in addition, a native PDL service provisioning can serve both as an OTT and as telecom operator’s services. The specified enhancements (via extending architectural and signalling aspects) integrate the blockchain capability as part of the native/fundamental features of the telecom network.

## 4.2 Key Characteristics of Native PDL Service Provisioning

The major differences of provisioning a PDL service natively in a telecom network are listed as follows.

1. Telecom-Native: Current blockchain systems are usually based on Internet or some cloud platforms. In the former case, any node of the blockchain system can participate the blockchain directly through the Internet; in the latter case, the deployment and management of blockchain nodes are done within one or among multiple datacentres by cloud service providers. A native telecom PDL service provisioning will be based on the entire infrastructure, where blockchain nodes could be potentially deployed on a UE, a base station, and/or a network node in core networks. The environment is obviously more complicated and thus challenging.
2. Telecom-Control: The entire service provisioning involves distributed devices/nodes/network functions and coordination with other control entities. The signalling and interactions among network entities/functions have to comply with 3GPP network protocol requirements and accept unified scheduling. In other words, unlike the cases of Internet and clouds, native PDL service provisioning implies a set of new functionalities and procedures under the control of telecom operators, who have to follow 3GPP standards.

# 5 Support for Native PDL Service Provisioning

## 5.1 Assumptions on The Telecom Network Architecture

*Editor Notes: here we will introduce an existing telecom network architecture that does not include our enhancement. This gives a playground where we can play. a 5G architecture and with a certain degree of generalization should be fine.*

*The reason is: so far, no telecom network can provision a compute node/function in the core network. Having such a feature is already new. We can clarify that after 5G, the next generation of telecom networks evolve towards such a direction where native compute capability shall be supported. Then we can start to talk about how LAF can do its jobs.*

A typical telecom network architecture is assumed as the foundation of the proposed enhancements for PDL service provisioning. Specifically, we consider a 5G network architecture consisting of different network segments such as UE, RAN, transport network, core network and data network (Internet).

Generally, given the assumed telecom network architecture, there are two new NFs that will be added. The first one is a control function, which is called Ledger Anchor Function (LAF). Another function is a BC/DL Enabler Function, which is the main function to realize a PDL service with the resource within the telecom network. LAF controls BC/DL Enabler function to provision PDL services over the telecom network infrastructure.

## 5.2 Ledger Anchor Function (LAF)

LAF acts as an anchor function for handling a request of a PDL service provisioning, monitoring the current status of deployed PDL services and is responsible for maintenance of a deployed PDL service. The services/functionalities of LAF are listed below.

LAF accepts blockchain requirements from business side, analyzes and decides on requirements, activates BC enablers in the network, and completes chain creation.

LAF supports BC enabler's profile management and maintenance functions. The information of BC enabler in communication network is one of the decision-making bases for creating blockchain.

LAF has BC capability selection function. According to certain security policies or requests, select appropriate BC enabler and deploy it to response nodes.

LAF supports profile management and maintenance functions of blockchain, basic static information such as number of blockchain nodes, alliance members, consensus mechanism, etc.

LAF supports horizontal distributed deployment and vertical master-slave node deployment of LAF, so LAF supports communication interface with other LAFs.

LAF supports communication with traditional network elements to obtain information about BC enabler.

## 5.3 BC/DL Enabler Function

BC/DL Enabler Function receives and executes the commands from LAF. This function acts as a container of necessary BC/DL modules. BC/DL enabler is under the full control of LAF. The services/functionalities of DL enabler are listed below:

On the one hand, a BC Enabler Function will act as a BC client only and interface both to the end users and LAF. It interacts with LAF for control signalling such as registration, configuration retrieval; in addition, it also acts as a broker for the end users interacting with the actual PDL service such as transaction composition and submission to peer nodes in a BC network (i.e., a PDL service).

On the other hand, a BC Enabler Function will act as a BC peer node running the actual protocol for a PDL service. A BC Enabler Function can be a micro, lightweight or full BC node, which is defined by the specific functions from the BC Enabler Function. The differences of the node modes are specified as follows.

* *Micro Mode*: This mode has the ability of a client, and at the same time has the ability to accept and verify transactions submitted by the client, compose transactions and package them into micro blocks, and broadcast them to other peer nodes in a PDL service. Note that, a BC Enabler Function running in micro mode does not
* *Lightweight Mode*: This mode contains the functions that a BC Enabler Function running in a micro mode. However, when there are nodes running in a micro mode in the BC network, nodes running with lightweight mode have the ability to validate micro blocks created by nodes in micro mode and participate consensus process.
* *Full Mode*: This mode contains all functions of the lightweight mode. In addition, a BC Enabler Function running in this mode will keep the ledger data with its local storage.

## 5.4 BC Repository Function (BCRF)

BCRF is a repository function providing required software components for the realization of a PDL service when LAF controls to deploy a PDL service within the telecom network infrastructure.

The main function of a BCRF is to provide necessary software to a resource node whenever the necessary software capability is missing on the resource node. Specifically, a resource node sometime is not installed with all software that is needed to run a BC network, such as the distributed consensus protocol. Therefore, when a resource node is selected while a certain software is missing, LAF will retrieve the software and install it on the targeted resource node. After that the resource node is capable of running the PDL service.

In general, BCRF collects software libraries, toolkits and binary codes of popular BC realizations. Specifically, first, BCRF provides software libraries of various distributed consensus protocols (e.g., PBFT, RAFT, PAXOS and so on), from which LAF can pick one consensus protocol that a PDL service provisioning request specifies. In addition, BCRF provides standardized data structures of ledger organization, transaction (block) header format (such as the Merkel tree or Trie implementation libraries); furthermore, BCRF provides software libraries for hash function (e.g., Chameleon, MD5 and SHA-256), encryption (e.g., RSA, ECC and Littice) and digital signature algorithms (e.g., DSA and ECDSA).

## 5.5 Deployment Options

### 5.5.1 Options for LAF

Logically, LAF is an NF in the core network. However, its instantiation can be either centralized, distributed with or without a hierarchy of multiple layers or mixed options.

A centralized option means that LAF instances all locate at a center office such as in the operator’s central service room. For example, a central server room can be a telecom cloud service platform. In practice, LAF instances in this deployment option are far from the edge of the telecom network.

A distributed option means that LAF instances distribute at different domains in the telecom network logically and/or geographically. Each LAF may manage and control the local PDL service requests. Among the distributed LAF instances, there should be a synchronization mechanism in order to avoid collisions; in addition, there should also be a coordination mechanism among the distributed LAF instances when inter-domain PDL service provisioning is needed. In practice, LAF instances in this deployment option can be deployed closer to the edge of the telecom network.

A hierarchy option is a mixture of a distributed option and a centralized option. This means that there will be a centralized LAF but with different layers of LAF instances in a distributed manner. If there is a conflict such as for service provisioning or status asynchrony, the collision will be handled by an LAF instance at a higher layer. In this option, there exists one or more LAF instances with central authority to organize, control and manage the LAF instances at the lower layer.

### 5.5.2 Options for BC Enabler Function

The placement of a BC Enabler Function can locate at any type of nodes in the telecom network. For example, it can run on a UE, an NF either in control plane, user plane or both. A BC Enabler Function can also be instantiated standalone as an individual function or even a server machine when natively co-locating with other entities does not meet the provisioning requirements. In any instantiating form that a BC Enabler Function can be deployed, the execution mode of the BC Enabler Function cam be one of the modes specified in clause 5.3.

### 5.5.3 General Architecture with PDL Capability Enhancement



Figure 1 A general architecture with LAF and BC Enabler Function

With the specified functions and deployment options of LAF and BC Enabler Function, a general architecture with the specified two new NFs is shown in Figure 1. In general, instances of the BC Enabler Function are managed by LAF. As introduced, a BC Enabler Function can be instantiated together with a UE, a component in RAN, or a NF in core network; in addition, a BC Enabler Function can be a standalone function locating in RAN and core network as well. BC Enabler Function is the actual NF where a PDL service is deployed.

For LAF, it controls and manages the BC Enabler Function in the network for PDL service provisioning. As introduced, LAF instances can be centralized or distributed/hierarchically organized. In general, LAF is a NF logically belonging to the core network.

For both NFs (i.e., LAF and BC Enabler Function), when they are instantiated as standalone instances, they also follow the standards in 3GPP for communications with other NFs and between the two NF themselves.

In addition, BCRF locates in the core network part to support LAF and the potential PDL service provisioning by providing required software implementation libraries. Note that BCRF will be updated periodically so that it can keep the collected libraries up-to-date.

# 6 Procedures of Native PDL Service Provisioning

*Editorial Note: the concrete procedures in this clause will be provided later.*

## 6.1 Instantiation

This procedure specifies the instantiation of one or multiple DL enablers within the telecom network infrastructure, given the resource status of the network itself. This procedure will involve other control plane NFs.

## 6.2 Discovery

This procedure specifies the discovery of existing BC/DL enablers that exist in a telecom network. The discovery is required by LAF in different scenarios.

## 6.3 Creation

This procedure specifies how LAF identifies and creates specific PDL services by activating corresponding DL enablers that are already instantiated in the telecom network.

## 6.4 Lifecycle Management

This procedure specifies how LAF can monitor, update and terminate a PDL service after its provisioning.

## 6.5 Others if any

# 7 Conclusion

*TBD …*

Annex A (normative or informative):
Title of annex

Annex (informative):
Bibliography

# History

|  |
| --- |
| **Document history** |
| V0.0.0 | 04-2023 | Initial table-of-content (ToC) created |
| V0.0.1 | 04-2023 | Brief contents updated for major clauses |
| V0.0.2 | 06-2023 | Enhance clause 5.1 to 5.3, and add clause 5.4 |
| V0.0.3 | 06-2023 | Adding a new NF – BCRF |
|  |  |  |