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ITU-T Focus Group on Application of
Distributed Ledger Technology
(FG DLT)

Technical Report FG DLT D1.2

Distributed ledger technology overview, concepts, ecosystem

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The procedures for establishment of focus groups are defined in Recommendation ITU-T A.7.

Deliverables of focus groups can take the form of technical reports, specifications, etc., and aim to provide material for consideration by the parent group in its standardization activities. Deliverables of focus groups are not ITU-T Recommendations.

The ITU Telecommunication Standardization Advisory Group established the ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT) in May 2017.

FG DLT concluded and adopted its Deliverables on 1 August 2019.

Type	**Number**	**Title**
Technical Specification	FG DLT D1.1	DLT terms and definitions
Technical Report	FG DLT D1.2	DLT overview, concepts, ecosystem
Technical Report	FG DLT D1.3	DLT standardization landscape
Technical Report	FG DLT D2.1	DLT use cases
Technical Specification	FG DLT D3.1	DLT reference architecture
Technical Specification	FG DLT D3.3	Assessment criteria for DLT platforms
Technical Report	FG DLT D4.1	DLT regulatory framework
Technical Report	FG DLT D5.1	Outlook on DLTs

The FG DLT Deliverables are available on the ITU webpage, at https://itu.int/en/ITU-T/focusgroups/dlt/.

For more information about FG DLT and its deliverables, please contact Martin Adolph (ITU) at tsbfgdlt@itu.int.

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Distributed ledger technology overview, concepts, ecosystem

Summary

This technical report is a deliverable of the ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT).

It provides an overview of distributed ledger technology (DLT), introduces key concepts and describes the DLT ecosystem.

Keywords

DLT; distributed ledger technology; ledger; blockchain; concepts; ecosystem

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1 Scope

This document provides an overview, concept and ecosystem for distributed ledger technology (DLT).

2 Definitions

This document uses the terms defined in [b-DLT 1.1].

3 Abbreviations and acronyms

This document uses the following abbreviations:

BFT Byzantine Fault Tolerant

DLT Distributed Ledger Technology

DPoS Delegated Proof of Stake

ID Identity

PoS Proof of Stake

PoW Proof of Work

4 Overview and concept of DLT

The overview and concept of DLT can be found in Annex A of [b-DLT 1.1]. Additionally, the following points require consideration.

4.1 Key characteristics

A distributed ledger is a ledger that is shared, replicated, and synchronized in a distributed manner.

The key characteristics of DLT systems are [b-NIST]:

- Append only – An append only ledger is used to provide full transactional history. Unlike traditional databases, transactions and values in a DLT are not overwritten.
- Immutable – Distributed ledgers are cryptographically secure and immutable, ensuring that the data contained within the ledger has not been tampered with, and that the data within the ledger is attestable.
- Shared – The ledger is shared amongst multiple nodes. Some nodes contain the full state of the ledger while other nodes do not necessarily contain the full state of the ledger. This provides transparency and optimal efficiency across the node participants in the DLT network.
- Distributed – The distributed nature of DLT allows for the scaling of nodes in a DLT network. By increasing the number of nodes, the ability for a bad actor to impact the consensus protocol used by the DLT is reduced thus, making it more resilient to attacks by bad actors.

4.2 Classification of DLT

There are three types of DLT systems: permissionless, permissioned and hybrid.

Permissionless distributed ledger systems are open to anyone validating blocks, without needing permission from any authority. Users are not required to obtain permissions to maintain and operate permissionless distributed ledger systems. Its systems are often implemented using open source software; freely available to anyone who wishes to download it.

Permissioned distributed ledger systems, on the other hand, require permissions. Users validating blocks must be authorized in permissioned distributed ledger systems. Since only authorized nodes are maintaining the distributed ledger, it is possible to restrict read access and to restrict who can issue transactions.

Hybrid distributed ledger systems combine the privacy benefits of a permissioned distributed ledger system with the security and transparency benefits of a permissionless distributed ledger system. This gives businesses significant flexibility to choose what data they want to make public and transparent and what data they want to keep private.

4.3 Consensus mechanisms

Consensus mechanisms are the rules and procedures by which nodes across a distributed ledger agree on validating transactions.

A key aspect of DLT technology is determining which user validates the next block. This is achieved by implementing one of many possible consensus mechanisms. For permissionless DLT networks, there are generally many nodes competing at the same time to validate the next block.

There are many types of consensus mechanisms, with the most common being: Proof of Work, Proof of Stake, and Byzantine fault tolerant-based [b-NIST].

In a proof of work (PoW) system, a node validates the next block by being the first to solve a computationally intensive puzzle. The solution to this puzzle is the "proof" that they have performed the work. The probability of validating a new block depends on the instantaneous computational power devoted to the task. As a reward for validating a block, the node (miner) will receive a certain amount of crypto assets or transaction fees.

Proof of stake (PoS) is a consensus process where an existing stake in a particular distributed ledger system (e.g., the amount of stored value held) is used to reach consensus instead of energy intensive computations. Proof of stake (PoS) is based on the idea that, since users must invest directly into a particular system to participate in consensus, they are more likely to want that system to succeed and less likely that they will want to subvert it. For example, stake is often an amount of crypto asset that the DLT network user has invested into the system. Nodes participating in the PoS consensus mechanism are rewarded by receiving the transaction fees included in each block they are the first to successfully validate. The Delegated Proof of Stake (DPoS) is another approach to PoS where a set number of nodes are elected or selected to function as the block-producing full validating nodes for the network.

In DLT systems, Byzantine faults may occur when some nodes in the network behave abnormally. The BFT-based consensus algorithm has been designed and implemented to solve this problem by ensuring that the distributed ledger system functions normally even with abnormal nodes involved in the network. In BFT-based consensus, all nodes in the network need to participate in the consensus process which involves performing multiple rounds of voting and communication to reach consensus on a block. It is therefore more compatible with small systems, which have a limited number of nodes. Additionally, since BFT requires that all participants agree on the list of participants in the network, the protocol is normally only used in permissioned distributed ledger systems.

5 Ecosystem of DLT

An ecosystem is a collection of stakeholders such as organizations and users in conjunction with other entities, performing separate roles.

There are four aspects of DLT ecosystems: the hardware aspect, business aspect, software development aspect and the protocol development aspect [b-GetSmarter].

5.1 Hardware aspect of the DLT ecosystem

The hardware aspect of DLT ecosystems is comprised of a large number of nodes where each node could either be a computer, server, or storage device. Three modalities of nodes can exist: block producing validating nodes, non-block producing full validating nodes, and partial/light nodes. A block producing full validating node participates in a consensus process and contains an entire replica of the distributed ledger, including every transaction that has been executed since its inception. A non-block producing full validating node does not participate in a consensus process and contains an entire replica of the distributed ledger, including every transaction that has been executed since its inception. A partial or light node contains only a partial transaction list but must be connected in some way to a full node to make sure that their data is accurate and useful.

In a permissionless DLT, anyone can create a node, but each node should be able to provide adequate processing power and storage capacity. The more nodes there are on the network, the more likely it is to be well distributed amongst varied stakeholders, thus resulting in a lower risk of fraud, error, or system failure.

The DLT network connects all the nodes to each other. For DLT systems, a stable, reliable, and sufficient supply of electricity is a mandatory requirement. The energy consumption of DLT networks using a PoW consensus mechanism, however, is generally high and may require consideration for energy sourcing. Many DLT users prefer a physical (hardware or paper) wallet to store their public and private keys and passwords, which then becomes part of the hardware ecosystem.

5.2 Business aspect of the DLT ecosystem

The business aspect of the DLT ecosystem consists of users, investors, block producers, corporations, and developers.

DLT users are entities that engage with a DLT by using a DLT application, product or service to accomplish a specific purpose such as an asset transfer.

Investors are the people or organizations that provide capital to create the DLT ecosystem. They are motivated by profit but are also values- and mission-based as many investors aim to help solve social and economic issues.

Block producers are full validating nodes that actively participate in a given DLT network's consensus mechanism. For DLT systems using PoW, miners are the block producers and they intend to profit from their efforts to validate DLT transactions. On the Bitcoin network, for instance, miners try to be the first to produce the solution to the highly-complex and computationally-intensive mathematical puzzles. Their reward is a certain number of bitcoins.

Corporations utilize DLT for business activities and will often push new technologies to a large group of customers or end-users. They basically create a space where end-users can transact more easily, interact with other stakeholders more efficiently, and spend time and money more wisely while the corporation itself benefits from increased data security and integrity on the backend. Corporations should, however, use DLT in compliance with applicable legislation and regulations.

Developers are the people who build the applications, products or services utilizing the DLT protocols and networks. They develop distributed applications and provide technical support.

5.3 Software aspect of the DLT ecosystem

DLT leverages various types of software applications. A "software ecosystem" is defined as a set of entities interacting with a shared market for software and services, together with relationships among them.

DLT applications can be written in a variety of languages including C++, Java, Go, Rust, Solidity, JavaScript, Python, and many others [b-Snowball]. Fundamentally, DLT should be language-neutral as long as each is fully compliant with the underlying requirements and software specifications.

However, each software language has its relative strengths and weaknesses, so careful consideration must be given in choosing the right language to meet the specific goals and needs of a given DLT.

These applications generally fall into three categories: financial, semi-financial, and non-financial applications. The first involves money being used and managed. The second category includes business processes which may involve money but focus on the completion of tasks or execution of contracts. The last category is very open-ended and may include anything from election voting, governance, data record storage, and ID authentication. There are literally tens of thousands of distributed applications that have been created to date, with many more being developed daily.

5.4 Protocol development aspect of the DLT ecosystem

The protocol aspect of DLT ecosystems consists of developers and academia.

Developers are involved with setting up DLT protocols that serve networks. The protocol layer is concerned mostly with how cryptographic keys interact with the network. There are two kinds of protocols: open-source and closed-source. Open-source development communities allow for anyone to download, audit and submit changes to the protocol. Accepting changes might be decided by a system of voting or through a responsible disclosure program. Closed-source DLT networks are employed by private entities and accessible only to operations of a specific class. The developer will encode the private information and alter the encoded value locally before sending it to an aggregator.

Researchers and academia aid in educating others on the implications of DLT systems and defining its limitations. With private companies and open source communities constantly releasing new DLT software, researchers and academics play an important role in providing formal peer reviews of the technical, environmental, economic, political, psychological, and sociological claims of the industry. These unbiased comparisons result in new knowledge that can then be used to inform all other stakeholders.

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