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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

General framework for distributed ledger technology (DLT)-based invoices

Recommendation ITU-T F.751.4

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Recommendation ITU-T F.751.4

General framework for distributed ledger technology (DLT)-based invoices

Summary

A DLT-based invoice is an invoice that can be issued, transferred and received in a structured electronic format over digital ledgers which allow automatic, electronic transactions based on smart contracts.

It presents as a novel invoice service category, emerging as a promising solution to tackle challenges by leveraging the capability of distributed ledger technology and the trust requirement of the stakeholders in the ecosystem.

The usage of DLT-based invoices is driven mainly by seeking to optimize an end-to-end trustworthy business process across the jurisdictions in the major processes, e.g., issuance, routing, processing, reimbursement, auditing and so on.

Recommendation ITU-T F.751.4 is not proposing a "regulatory" framework. However, for any tax implications, regulatory considerations must be addressed at a national level and are not the subject of the Recommendation.

The electronic exchange of the invoice content between trading partners' accounts receivable and accounts payable business processes is to be recorded over the invoice digital ledger in a trustworthy way with local tax compliance.

From a technology perspective, how the invoice will be transferred in a secure and interoperable way and how policies in different jurisdictions are enforced needs to be determined. Meanwhile, data privacy, security, trust and confidentiality have to be guaranteed, which is relevant to the following aspects:

– secure messaging infrastructure to ensure that senders and receivers can trust the system and confidently exchange invoices;

– programmable government tax policies that can be securely enforced;

– invoice data validation schemes to ensure the integrity of the invoice content;

– immutability of the digital distributed ledgers to allow stakeholders to store and validate the invoice based on their corresponding privileges.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.751.4	2022-03-16	16	11.1002/1000/14966

Keywords

DLT-based invoices, interoperability, security, smart contract.

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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General framework for distributed ledger technology (DLT)-based invoices

1 Scope

This Recommendation provides a general framework of DLT-based invoices on distributed ledger technology. The scope of this Recommendation also includes:

– overview of DLT-based invoices;

– requirements of DLT-based invoices;

– structure of DLT-based invoices;

– use cases.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 distributed ledger [b-ITU-T X.1400]: A type of ledger that is shared, replicated, and synchronized in a distributed and decentralized manner.

3.1.2 smart contract [b-ITU-T X.1400]: Program written on the distributed ledger system that encodes the rules for specific types of distributed ledger system transactions in a way that can be validated, and triggered by specific conditions.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 distributed ledger system: A system that implements a distributed ledger.

3.2.2 DLT-based invoices: An invoice that can be issued, transferred and received in a structured electronic format over digital ledgers which allow automatic, electronic transactions based on smart contracts.

3.2.3 entity: Anything that has a separately identifiable existence (e.g., organization, person, group or device). An entity uses distributed ledger technology to solve the problem of its business or information systems.

3.2.4 participating parties: The participants of the transaction, e.g., sellers, buyers, payment networks etc.

3.2.5 transaction: An incident or an operation that leads to a change in the status of a ledger, such as adding a record or an equivalent exchange based on currency.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CAE Customer Associating Enterprise

DLT Distributed Ledger Technology

SPV Simplified Payment Verification

TAI Trust Associated Index

TBI Trust Base Index

UTXO Unspent Transaction Output

VAT Value Added Tax

5 Conventions

This Recommendation uses the following conventions:

– The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this document is to be claimed.

– The keywords "**should**" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement needs not be present to claim conformance.

6 Overview of DLT-based invoices

6.1 Participants

6.1.1 Payment platform

A payment platform facilitates the transaction between customers and merchants.

6.1.2 Customers

Customers purchase items and may request an invoice for reimbursements.

6.1.3 Merchant (sellers)

Merchants initiate the invoice issuance together with the tax admins over the ledger based on the contracts or transactions.

6.1.4 Destination tax admins

The destination tax admin manages the inbound invoice validations together with the origin tax admin that issues the invoice.

6.1.5 Origin tax admins

Origin Tax Admin manages invoice issuance based on its local policy and the type of services that the sellers are supplying; the process could be processed by the smart contract issued by the origin tax admin.

6.1.6 BER (billing service provider)

BER is the billing service provider that collects the invoice billing request from the customers and submits the request to the tax admins.

6.1.7 Acquirer (invoice acquire service provider)

The acquirer acquires the invoice for interfacing with the Tax Admin for invoice validation and or reimbursement.

6.1.8 Wallet

A wallet is as a customer's account for storing their invoices.

6.1.9 Customer associating enterprise (CAE-Buyer)

Customers submit the invoice in the wallet to its customer associating enterprise (CAE-Buyer) for reimbursement; the CAE-Buyer claims its tax with its tax admin, when claiming the VAT reverse and invoice validations. The tax admin is generally considered as the destination tax admin.

6.1.10 Custom ledger

A custom ledger is the ledger hosted in customs and interconnected with the ledger hosted in the tax admin. It is generally used for attestation in cross-border VAT reverse processes.

6.1.11 Payment domain

The payment domain is a domain that the transactions are processed in; it includes the roles of merchants, payment platforms, customers and banks.

6.1.12 Tax domain

The tax domain is a domain that the invoices are issued, routed and reimbursed in, and includes the roles of tax admins, sellers, buyers and enterprises.

6.2 Architecture

6.2.1 Overview

For the initial deployment of DLT-based invoices, a permissioned ledger is generally considered at the initial stage in different jurisdictions, thus the scope of this Recommendation is taking this assumption as a prerequisite.

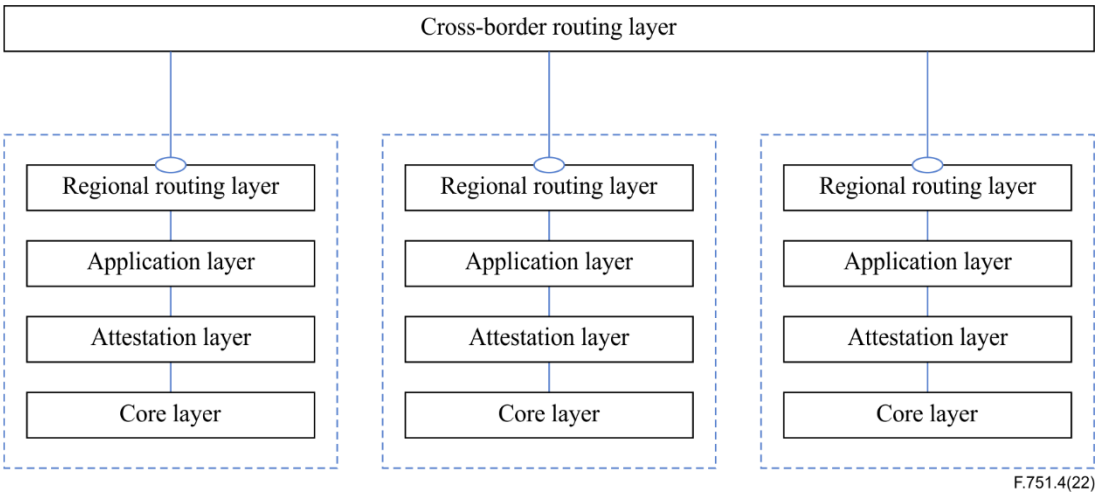

Figure 1 – Overall architecture of DLT-based invoices

The types of nodes anchored on the ledger typically include:

– transaction accounting nodes;
– tax accounting nodes;
– custom nodes;
– audit nodes;
– routing nodes;
– SPV nodes.

6.2.2 Core layer

The core layer is mainly composed of the consensus nodes from the tax authorities; it is in charge of the following functionalities:

– ledger consensus;

– security enforcement;

– identity management and verifications;

– smart contract management.

6.2.3 Attestation layer

In the attestation layer, the validators could be from relevant domains, e.g., payment domain, contract domain, tax domain etc. depending on different scenarios. The validators work together to redundantly validate and process the transactions, hence the data validation is not only depending on one domain but also linking to the relevant domains together with the core validators.

In practical cases, it is not realistic to capture all UTXO dependencies in a transient way. Rather than the transitive UTXO dependence, the relationship of hash linking to the transactions could be accumulated to authenticate the data on chain in a different timing window instead. A given block can add back-pointers to a set of blocks, capturing the dependencies in an accumulative way.

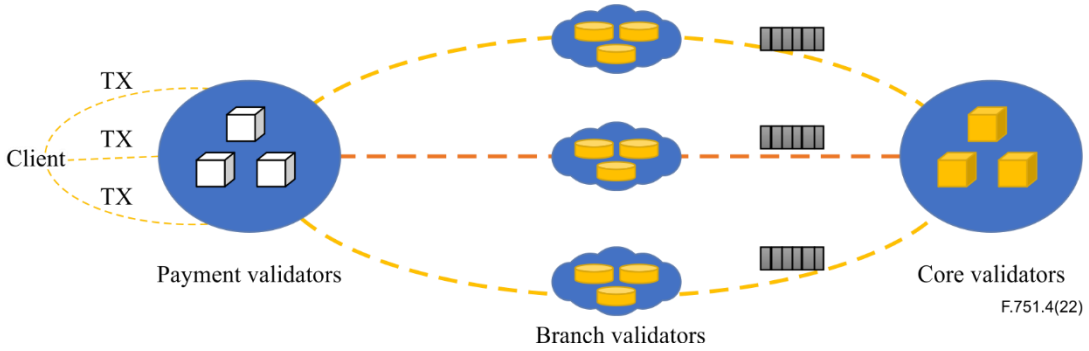

Figure 2 – Multilayer validation architecture of DLT-based invoices in attestation layer

Apparently, the above method could further validate the transaction data in different dimensions or it could otherwise pick up the fake transaction with contradictory relevant background or foreground dimensions.

Depending on the relationship of the dependencies, the direct trust level of transactions could be defined as Trust_Base_Index for one customer or merchant, e.g., the transactions TX1, TX4, TX6 and TXm compose Trust_Base_Index (TBI) over customer B; and the other trust factors that may have an indirect relationship with customer B could be defined as Trust_Associated_Index (TAI), e.g., TX1 and TX4 over Merchant A, TX5 and TX6 over Merchant C, TX5 and TX 3 over customer D, and TX3 over Merchant E in a successive way.

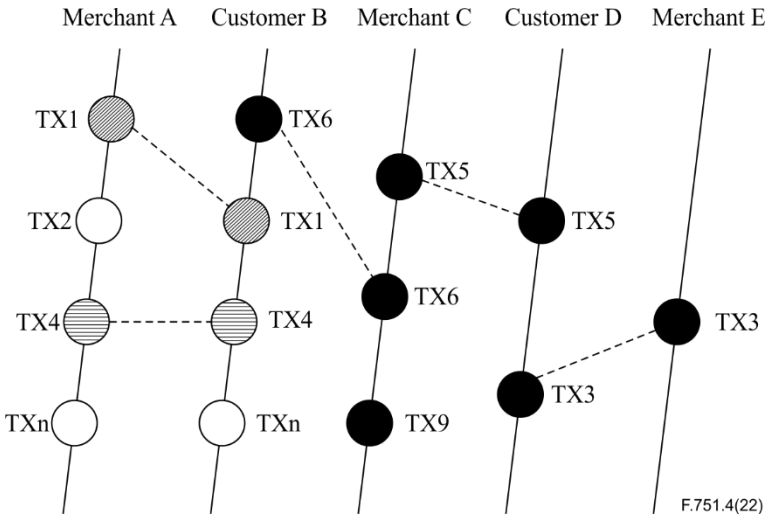

Figure 3 – Multilayer dependence compiling of DLT-based invoices

Both TBI and TAI can be used to verify the invoice data in different dimensions, thus ensuring that the integrity of the invoice content is not only in one dimension, but also in a plane.

6.2.4 Application layer

The functionality of the application layer could include, but is not limited to, the following aspects:

– invoice polling;

– reimbursements;

– VAT repayment.

6.2.5 Regional routing layer

To guarantee the interoperability, the regional routing of the invoice could be necessary depending on the transaction coverage jurisdiction, and the regional routing layer should be defined with the following functionalities:

– numbering system to process the routing of the transaction;

– invoice validation;

– reimbursement facilities based on the invoices;

– VAT repayment across the region.

The regional routing layer should be defined and enforced within a region, such as nationwide.

6.2.6 Cross-border routing layer

Aside from the regional routing layer, the cross-border routing layer should be defined to allow transactional validation across borders; the corresponding numbering and bridge should be defined to facilitate the capability.

7 General requirements

This clause identifies a set of general requirements that are required to be supported by the DLT-based invoices.

7.1 Identity requirement

The pre-authenticated node can be accepted to the permissioned ledger and recognized by an address in the ledger; the address maps to the registered profile of the nodes in the local shard ledger; and can be traced by header information of invoice blocks.

Thus, the nodes are required to be authenticated in a local shard and uniquely identified in the ledger, and each invoice issued on the ledger is required to be traced to its origin issue shard ledger.

7.2 Security requirement

The security requirements are classified as follows and mapped to the generic security principles, such as networking security, database security etc., and so no repeat definitions are needed here.

7.2.1 Engineering security

It is required to guarantee engineering security, including the following aspects:

– developing process security maintenance;

– deployment process security control.

7.2.2 Operational security

It is required to guarantee operational security, including the following aspects:

– operational security in tax admins;

– operational security in BERs;

– operational security in acquirers.

7.2.3 Data accuracy

It is required to guarantee data accuracy, including the following aspects:

– finality in invoice transaction, routing and settlement to avoid fraud;

– accuracy of oracle input/data.

7.2.4 Security in customer management

It is required to guarantee security in customer management, including the following aspects:

– ability to distinguish between un/authorized access;

– trust of custodial and safekeeping services;

– customer wallet and account management.

7.3 Privacy requirement

It is required to guarantee the privacy that invoice transactional data can only be accessed between the participating parties and the auditing party.

7.4 Interoperable requirement

Some level of consistency between at least similar DLTs is required to avoid unnecessary fragmentation, including:

– interoperable routing protocols;

– interoperable data diagrams;

– interoperable policy mapping and configuration.

7.5 Scalability requirement

The scalability requirement is to grow the total processing capacity with the number of validators in a permissioned ledger, including:

– parallel intra-shard transaction processing;

– cross-shard commit protocol that atomically handles transactions affecting multiple shards;

– ledger life-cycle management by collectively signed state blocks;

– low-latency "trust-but-verify" validation for low-value transactions.

8 Use cases

The invoicing process could be based on different scenarios, e.g.:

– Use case 1: Invoicing based on payment;

– Use case 2: Invoicing based on contract.

8.1 Invoicing process based on payment

The invoicing process based on payment may include the following phases:

– Phase A: transaction;

– Phase B: invoice issuance;

– Phase C: reimbursement;

– Phase D: tax clearance.

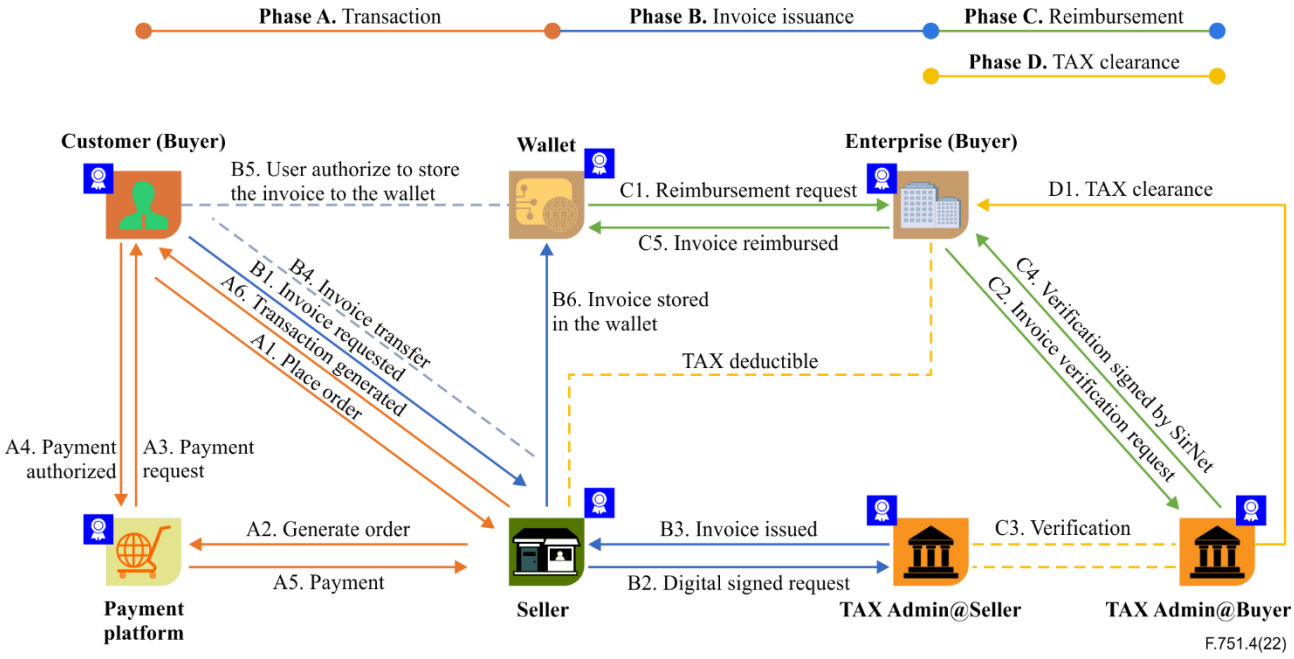

Figure 4 – Overall structure of DLT-based invoices

In the transaction phase, when the customer (buyer) places an order, the service provider (seller) generates the order over the payment platform, the payment platform then confirms the order after the customer authorization is received, and the receipt is generated when the payment has been processed. The receipt could be in the form of a payment block over a payment chain or a record in a centralized database.

In the invoice issuance phase, the invoice is issued by the origin tax admin of the merchant based on the customer's request from the customer's wallet for instance, and the payment receipt is used as the UTXO for the invoice issuance. The participating nodes include the core consensus nodes anchored on the core layer of the ledger as well as the SPV nodes, such as the merchant node and personal wallet node.

In the reimbursement phase, the customer associating enterprise (CAE) as an SPV node verifies the invoice when the customer initiates the reimbursement process and the invoice in the personal wallet is repaid as a UTXO.

In the tax clearance process, the destination tax admin nodes and CAE SPV node join the process, the invoice is used as the UTXO to repay the VAT.

8.2 Invoicing based on contract

The DLT-based invoices can be issued over the tax ledger under the context that the associated contract has been signed; the contracts can be issued over a preregistered contract ledger endorsed by the concerned parties, as shown in Figure 5.

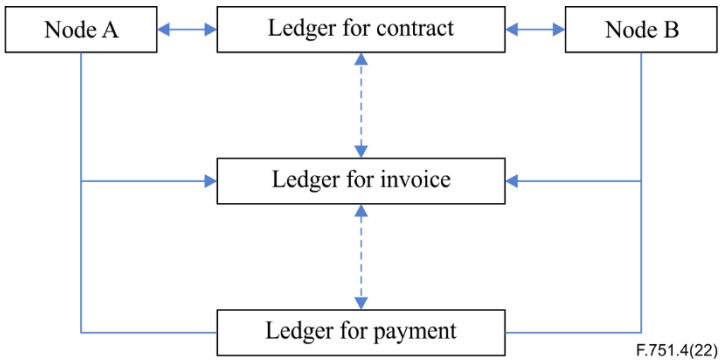

Figure 5 – Overall structure of contract-based invoices

The association of the relevant evident DLT-based objects can be programmable in assertions and can be displayed in the pages of the repository for the concerned owner in a way that is user friendly and configurable; the assertions can be complied to run automatically if the predefined contexts are satisfied, as shown in Figure 6.

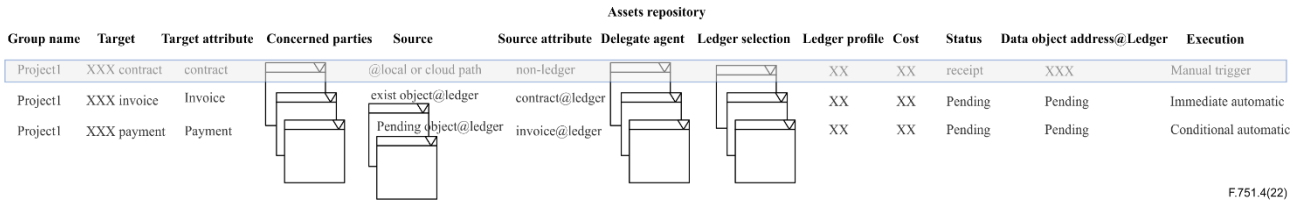

Figure 6 – Assets repository over ledger objects

The assertions are used to describe the basic building blocks of the asset repository. It defines the human readable logic, behaviour, cost, states and operations between digital ledger objects associating a predefined group for an asset repository of a person or an entity to enable automatic or manual triggered execution provided the pre-requisite conditions are met.

The assertions link the ledger objects to one another by associating the existing or pending source objects to the target object in the repository without requiring an explicit reference, either within a single ledger object or between ledger objects. Ledger objects' linkages are a fundamental aspect of the repository. By associating ledger objects to the assets repository and cross-linking it to the ledger objects created by other people, the active participant repositories create useful interactions by linking the associated data objects in different ledgers.

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