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eorganizational proposal

**Group REPORT**

PDL INTER-LEDGER INTEROPERABILITY

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Reference

PDL-006 INTER-LEDGER INTEROPERABILITY

Keywords

Security, Conformity, Trust, Interoperability

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# Foreword

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# Modal verbs terminology

*[ETSI Drafting Rules](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)* [(](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*[EDRs)](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx),*

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# Executive summary

[*ETSI Drafting Rules* (*EDRs)*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*,*

# Introduction

*[ETSI Drafting Rules](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)* [(](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*[EDRs)](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx),*

Enabling communication between different DLT is a challenge that can be resolved in favor of scalability if interoperability is implemented with security, however the architecture, taxonomy and ontology of the DLT landscape is certainly very diverse and with a variety of technical issues and challenges that a lot of time and efforts are being invested in deploying approaches and solutions. This is in favor of the ecosystem as a whole. Priorities for multi-stakeholders are based on interoperability and cross-chain solutions for connecting the new era of internet.

The baseline for this document is aligned with the definition of ISO/IEC 17788:2014 “information Technology -Cloud Computing-Overview and vocabulary” whereby Interoperability is “the ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged.

The European Interoperability Framework (EIF) from the European Commission (EC) had first version adopted in 2010 between the new EU policies in the field of information technology with strong focus on openness and information management, data portability, interoperability governance, and integrated service delivery. Furthermore, NIFO (National Interoperability Framework Observatory) produce a variety of documents with recommendations for policy makers, researchers, and business stakeholders with the latest developments on digital government and interoperability across Europe. On the other hand, the European Blockchain Services Infrastructure (EBSI) is officially established with which inter-ledger interoperability will be a key ingredient for scalable business and connecting networks for cross-border communications. Actually, four use cases are applying on the top of EBSI and one of them is related to trusted data sharing which is a value for considering interoperability as a priority within the deployment of the European Digital Single Market.

# 1 Scope

This document will describe the key elements of interoperability to exchange information between different ledgers and to mutually use the information that has been exchanged.

# 2 References

## 2.1 Normative references

Normative references are not applicable in the present document.

## 2.2 Informative references

European Blockchain Services Infrastructure (EBSI)

<https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/EBSI>

European Interoperability Framework (EIF)

“Full Text: <https://ec.europa.eu/isa2/sites/isa/files/eif_brochure_final.pdf>

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

## 3.2 Symbols

## 3.3 Abbreviations

API: Application Programming Interface

DLT. Distributed Ledger Technology

EBSI: European Blockchain Service Infrastructure

EIF: European Interoperability Framework

EC: European Commission

NIFO: National Interoperability Framework Observatory

PDL: Permissioned Distributed Ledger

# 4 Why Interoperability between PDLs:

Motivation.

* + 1. Different sectors complementary services
    2. Third party auxiliary services (Access control, etc.)
    3. Different Jurisdictions (Cannot share a PDL)
    4. Business or personal Privacy issues (Idem)
    5. Antitrust
    6. Regulatory/Lawful access obligations
    7. Business secrets
* exploit different properties of each ledger, lowering cost and latency, better security and privacy (due to GDPR we can not store personal data in public ledgers), etc.
* Transferring and/or trading (or exchanging) value between chains
* Transferring information or generic messages between chains
* Allowing different tradeoffs between trust and cost
* Different levels of privacy
* Increasing the overall scalability and functionality

Combining two or more DLTs using interledger mechanisms allows a different tradeoff in terms of trust and cost, allows different levels of privacy, and can increase the overall scalability and functionality. A higher or wider-scale trust requires a larger network with more nodes and/or a more demanding consensus model. This is the case of public ledgers, which results in a higher computation cost, hence monetary transaction cost, and higher transaction delay compared to permissioned DLTs. Hence, transactions requiring a higher level of trust can be recorded on a public blockchain, whereas transactions which occur frequently but for which a lower level of trust is sufficient can be recorded on a permissioned DLT. Utilizing permissioned DLTs can support higher privacy, since all transactions on a public blockchain are public. Hence, data can be stored in permissioned DLTs for privacy, whereas hashes of the data stored on permissioned DLTs can be periodically stored on public blockchains to ensure immutability of the data. Finally, multiple permissioned DLTs can be combined with a public blockchain to exploit transaction locality, hence achieve scalability, while also allowing the permissioned DLTs to support different consensus models and programming functionality.

This document will envision the scenarios for multiple ledgers and distinguishing from this document considerations intra-chain or inside the same PDL which allows interoperability between applications but do not communicate with other PDL. Although it is a very important dimension of the interoperability which is part of the intrinsic mechanism of the PDL, in this section it is an introduction for a cross-chain or inter-ledger interoperability scenario.

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Figure 1 EXAMPLE OF NON INTER-LEDGER INTEROPERABILITY

As per the Figure 1, there is just one ledger, in this scenario it is a type of interoperability out of the scope of this document. Serve as illustrative, that functional components, sometimes security functional components others minimal functional components or simply optional functional components, are able to provide intra-chain interoperability, inside the PDL for a completeness of the DLT.

6. TYPES OF PDL INTEROPERABILITY

6.1. UNIDIRECTIONAL

1. A PDL receives information from other(s) blockchains (PDLs or not) to update their status (i.e. An oracle blockchain pushing information to a PDL)
2. A PDL sends information to others blockchain (PDLs or not) (i.e. A PDL updates the status of a delivery to vendor/procurement PDLs)

# 

Figure 2 EXAMPLE ONE OF INTER-LEDGER INTEROPERABILITY

In this basic scenario there are two ledgers whereby interoperate between them, one PDL is exchanging information with other PDL to mutually use such information in a perfected interest. As per the figure 2, the two ledgers represent two different PDL which make via Gateway or API an interoperability approach, but there are a variety of approaches. Independent ledgers into a same scenario can approach from a key parameters which are recommended to be in every ledger (Tooba would contribute this side)



Figure 3 EXAMPLE TWO OF INTER-LEDGER INTEROPERABILITY

In this scenario there are three ledgers that consolidate a common ledger as part of one PDL. Hence inter-ledger interoperability can occur between ledgers within a same PDL or between various PDL. (Christophe will contribute this side with a use case)

6.2. BIDIRECTIONAL:

1. A PDL can change the status of some registries of another PDL and vice versa but the same kind of registry can only be changed by one of them.

ii. Two PDL share the value/status of one or more registries. Any change in any PDL triggers a change in the other PDL.

# 7. PDL INTEROPERABILITY TOOLS:

1. Through APIs or Tooling (as depicted in PDL-003)
2. Through dedicated application (to discuss whether this is interoperability)
3. Through an inter-PDL dedicated application developed for automation of interoperability. This is the case when the two ledgers are not accessible by a single ‘user’.

7.1. APIs or Tooling: as depicted in PDL 03

7.2. Atomic swaps

Different categories can use the same basic mechanism; for example, atomic swaps based on Hashed Time-Lock Contracts (HTLCs) are used in atomic cross-chain transactions for direct trading between two peers, in transactions-across-a-network (also referred to as payment networks), ILP, and some bridging solutions. Hence, the difference between the categories with respect to their underlying mechanisms is not always absolute. However, at a higher-level the various categories differ in their initial application assumptions. Atomic cross-chain transactions target peer-to-peer trading between two parties that seek to exchange value. Transactions-across-a-network solutions and ILP generalize peer-to-peer transactions to payment networks, where payments are routed along paths that are comprised of off-chain payment channels. Bridging approaches target cross-chain transactions between existing ledgers. Sidechain approaches assume the existence of a main chain and support the transfer of value between the main chain and sidechains, which are regarded as subordinate to the main chain. Ledger-of-ledgers approaches introduce a new super-ledger with the goal of having multiple sidechain-like ledgers, which can also support the interconnection to existing ledgers, such as Ethereum and Bitcoin.

The various approaches differ in the reliability of performing interledger operations. Specifically, if atomic cross-chain transactions are performed by a single entity, then this entity can be a single point of failure. On the other hand, bridging approaches, sidechains, and ledger-of-ledger approaches involve multiple nodes that implement the interledger operations, hence their decentralized operation yields a high reliability. Finally, the reliability of approaches involving transactions-across-a-network W3C ILP depend on the existence of redundant paths between the end nodes that wish to transact.

Note:V.A. Siris, P. Nikander, S. Voulgaris, N. Fotiou, D. Lagutin, G.C. Polyzos, “Interledger Approaches,” IEEE Access, vol. 7, 89948-89966, 2019. DOI: 10.1109/ACCESS.2019.2926880

7.3. Sidechains

7.4. Layered value transfer protocols

7.5. Bridging

7.6. Apps for interoperability

7.7. Ledger-of-Ledger

# 8. PDL INTEROPERABILITY SOLUTIONS

8.1. Direct interoperability

8.2. Auxiliary PDL

1. The auxiliary PDL contains part of the information of third party PDLs for the shake of interoperability between those third PDLs
2. The auxiliary PDL is the consolidation of third party PDLs (and the reference for disputes?)

In the EU SOFIE[[1]](#footnote-1) project, interledger is used in various ways [Lag19]. For example, agricultural supply chain use case stores hash of private transactions to public ledger using interledger, to provide immutability for private transactions and help with dispute resolutions as described in Section 5.1. In context-aware mobile gaming use case, private ledger is used to store in-game assets used by the gamers. These assets can be traded in a public ledger between the gamers, but only if they are not active at the same time in the private ledger. The interledger is used to guarantee that the state of the asset is changed in an atomic manner between the ledgers, and the asset can be active only in one ledger at time.

In a similar manner, interledger is useful for any kind of situation where trust, transparency, and automation is required between multiple parties. These include sharing cybersecurity information [Nei2020] or automating disclosure of software vulnerabilities [Lag2020].

SOFIE project has released an interledger implementation[[2]](#footnote-2) written in Python supporting Ethereum, Hyperledger Fabric, and Guardtime KSI ledgers. The implementation connects any two ledgers: after a certain trigger occurs on one ledger, the transaction is sent to another ledger.

[Lag2019] D. Lagutin, F. Bellesini, T. Bragatto, A. Cavadenti, V. Croce, Y. Kortesniemi, H. C. Leligou, Y. Oikonomidis, G. C. Polyzos, G. Raveduto, F. Santori, P. Trakadas, and M. Verber. Secure Open Federation of IoT Platforms Through Interledger Technologies - The SOFIE Approach. In Proceedings of European Conference on Networks and Communication (EuCNC) 2019. Valencia, Spain, 2019.

[Nei2020] R. Neisse, J. L. Hernandez-Ramos, S. N. Matheu-Garcia, G. Baldini, A. Skarmeta, V. Siris, D. Lagutin, P. Nikander. An Interledger Blockchain Platform for cross-border Management of Cybersecurity Information. IEEE Internet Computing, pp. 1-11. IEEE, June 2020.

[Lag2020] D. Lagutin, Y. Kortesniemi, V. A. Siris, N. Fotiou, G. C. Polyzos and L. Wu. Leveraging Interledger Technologies in IoT Security Risk Management. Chapter in: Security Risk Management for the Internet of Things: Technologies and Techniques for IoT Security, Privacy and Data Protection, pp. 229-246. now publishers, June 2020.

* SOFIE Interledger use cases
  + food-supply-chain:
    - storing hashes of transactions (of a private ledger, even db) to a public DL
    - hierarchical DLT solutions
  + context aware mobile gaming ecosystem
* SOFIE Interledger component implementation

# 9. PDL INTEROPERABILITY REQUIREMENTS

9.1 Who will interoperate with

9.2. What information do you need to exchange

9.3. Which are the operations allowed

9.4. Traceability

9.5. Future-proof

9.6. Minimal viable governance

1. ***<https://www.sofie-iot.eu/>***  [↑](#footnote-ref-1)
2. ***<https://github.com/SOFIE-project/Interledger>***

   [↑](#footnote-ref-2)