Poster Paper:
Towards a Comparison Framework for Blockchain Interoperability Implementations

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Research Aim

This work bridges the gap between theory and practice

**Belchior et al. (2021)**

- *Qualitative* survey on blockchain interoperability (BCI)
- Published in ACM Computing Surveys in Oct. 2021
- *Literature review* on 400+ documents → identified 67 BCI solutions
- *Categorized* those 67 solutions → “Blockchain Interoperability Framework”
- Authors point out “research gap between theory and practice”

**This work**

- Research problem: BCI Research *lacks practical focus*
- Practitioner’s view: which BCI solutions are production ready? Active developer community? Etc.
- Aim: *extend* the “Blockchain Interoperability Framework” to allow *empirical comparison* of BCI solutions

**Future work**

- Apply the proposed “Comparison Framework for BCI Implementations”
- Expand the initial set of BCI solutions to be analyzed
- Further extend the comparison framework to allow more precise results

Research Basis

Blockchain Interoperability Framework (Belchior et al., 2021)

Table 3. Evaluation of Blockchain Interoperability Solutions by Sub-Category According to the Blockchain Interoperability Framework

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Infra.</th>
<th>Decentral.</th>
<th>Channel</th>
<th>CC-Realization</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidechains &amp; Relays</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>[143, 182]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>[9, 98]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>[13, 63, 104, 121, 140]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>-</td>
<td>[56, 76, 113, 114]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>[24, 59, 83, 150, 161, 162]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[94, 97]</td>
</tr>
<tr>
<td>Notary Scheme</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>See Section 5.1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>-</td>
<td>[125, 174, 184]</td>
</tr>
<tr>
<td>ILTC</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>[38, 52, 57, 74, 122, 153, 195]</td>
</tr>
<tr>
<td>Blockchain of Blockchains</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>[108, 109, 188]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>[10, 147, 165]</td>
</tr>
<tr>
<td>Trusted Relays</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>[40, 68, 102, 134]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>[17, 23, 86, 88, 183, 190, 198]</td>
</tr>
<tr>
<td>B. Agnostic Protocols</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>[1, 2, 129, 146]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>[50, 62, 120, 136, 139, 151]</td>
</tr>
<tr>
<td>Blockchain &amp; Migrators</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>N/A</td>
<td>[74, 154, 187]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N/A</td>
<td>[75]</td>
</tr>
</tbody>
</table>

Notes: N/A stands for not applicable. Public connectors are represented in green, blockchain of blockchains in orange, and hybrid connectors in red.
Research Questions

Derived from the aim of bridging the gap between theory and practice

- **RQ1:** Which BCI solutions have a public *implementation*?
- **RQ2:** How can BCI implementations be *compared empirically*?
Blockchain Interoperability Implementations

Answering RQ1: which BCI solutions have a public implementation?

TABLE I
NUMBER OF BLOCKCHAINTS INTEROPERABILITY SOLUTIONS [2] AND IMPLEMENTATIONS

<table>
<thead>
<tr>
<th>Connector type</th>
<th>Mechanism</th>
<th>Number of solutions</th>
<th>Number of implementations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Connectors</td>
<td>Sidechains &amp; Relays</td>
<td>26</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Notary Schemes</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>HTLC</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Blockchains of Blockchains</td>
<td>Trusted Relays</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Agnostic Protocols</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Hybrid Connectors</td>
<td>Blockchain Migrators</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

- While a majority of Public Connectors and all Blockchain of Blockchain-based solutions have an implementation, only a minority of Hybrid Connectors have one.

Sources: https://github.com
https://docs.github.com/en/rest/reference/repos

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Blockchain Interoperability Implementations

List of identified BCI implementations with public GitHub repositories

**Public Connectors**

- RSK, [https://github.com/rsksmart/rskj](https://github.com/rsksmart/rskj), retrieved on Mar 31, 2022
- BTC Relay, [https://github.com/ethereum/btcrelay](https://github.com/ethereum/btcrelay), retrieved on Mar 31, 2022
- BitXhub, [https://github.com/meshplus/bitxhub](https://github.com/meshplus/bitxhub), retrieved on Mar 31, 2022
- Interledger, [https://github.com/interledger/rfcs](https://github.com/interledger/rfcs), retrieved on Mar 31, 2022
- Hyperledger Quilt, [https://github.com/hyperledger/quilt](https://github.com/hyperledger/quilt), retrieved on Mar 31, 2022
- CBT, [https://github.com/hpdic/cbt](https://github.com/hpdic/cbt), retrieved on Mar 31, 2022
- SCIP, [https://github.com/lampajr/scip](https://github.com/lampajr/scip), retrieved on Mar 31, 2022
- Uniswap, [https://github.com/Uniswap/v3-core](https://github.com/Uniswap/v3-core), retrieved on Mar 31, 2022
- Hyperledger Cactus, [https://github.com/hyperledger/cactus](https://github.com/hyperledger/cactus), retrieved on Mar 31, 2022
- ION, [https://github.com/clearmatics/ion](https://github.com/clearmatics/ion), retrieved on Mar 31, 2022

**Blockchains of Blockchains**

- ConsenSys, [https://github.com/ConsenSys/gpact](https://github.com/ConsenSys/gpact), retrieved on Mar 31, 2022
- Plasma, [https://github.com/plasmodlp/PAP-Governance](https://github.com/plasmodlp/PAP-Governance), retrieved on Mar 31, 2022
- Horizon, [https://github.com/Horizon-Protocol/Horizon-Smart-Contract](https://github.com/Horizon-Protocol/Horizon-Smart-Contract), retrieved on Mar 31, 2022
- 0x, [https://github.com/0xProject/OpenZKP](https://github.com/0xProject/OpenZKP), retrieved on Mar 31, 2022
- Blocknet, [https://github.com/blocknetdx/blocknet](https://github.com/blocknetdx/blocknet), retrieved on Mar 31, 2022
- Fusion, [https://github.com/FUSIONFoundation/efsn](https://github.com/FUSIONFoundation/efsn), retrieved on Mar 31, 2022

**Hybrid Connectors**

- Polkadot, [https://github.com/paritytech/polkadot](https://github.com/paritytech/polkadot), retrieved on Mar 31, 2022
- Cosmos, [https://github.com/cosmos/ibc](https://github.com/cosmos/ibc), retrieved on Mar 31, 2022
- AION, [https://github.com/aionnetwork/aion](https://github.com/aionnetwork/aion), retrieved on Mar 31, 2022
- ARK, [https://github.com/ArkEcosystem/core](https://github.com/ArkEcosystem/core), retrieved on Mar 31, 2022
- Komodo, [https://github.com/KomodoPlatform/atomicDEX-Desktop](https://github.com/KomodoPlatform/atomicDEX-Desktop), retrieved on Mar 31, 2022
- Horizon, [https://github.com/Horizon-Protocol/Horizon-Smart-Contract](https://github.com/Horizon-Protocol/Horizon-Smart-Contract), retrieved on Mar 31, 2022
- 0x, [https://github.com/0xProject/OpenZKP](https://github.com/0xProject/OpenZKP), retrieved on Mar 31, 2022
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Towards a Comparison Framework for BCI Implementations

Answering RQ2: how can BCI implementations be compared empirically?

Suggested empirical analysis of GitHub repositories:

- Popularity:
  - *Number of stars & forks* are the most important *measures of popularity* (Borges & Valente, 2018).
  - Number of stars (Jarczyk et al., 2014) & forks (Dabbish et al., 2012) indicate *quality*.

- Developer Community:
  - *Number of contributors* determines the *size of the developer community*.
  - *Last commit in the repository & total number of commits during the last month* indicate *developing activities*.
  - *Last commit in the superior project* provides insights into the *activity of the entire project* to which the repository belongs.
  - Developing activity can also serve as *quality* indicator (Dabbish et al., 2012).

- Source Code:
  - *Top language used* may be an important criteria for developers to decide which BCI implementation to *adopt*.
  - *Lines of code (LoC)* can be counted, indicating the *scope and developing effort*.

None of the proposed comparison criteria in itself objectively reflects the *quality* of a BCI implementation. In their entirety, however, they allow an initial quality assessment.

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Towards a Comparison Framework for BCI Implementations

Selected interim results

- BCI implementations *differ greatly* from each other on several comparison criteria, sometimes by a *factor of thousands*.
- Only around *one third* of the BCI implementations registered *commits within the last month*. However, *almost all* BCI implementations belong to a GitHub *project that registered recent commits*.
- BCI implementations with the *highest number of stars* have significantly *more Lines of Code* than BCI implementations with the *lowest number of stars*.
- 3 out of 7 most popular BCI implementations within a group using the same mechanism are mainly written in *Go* (although only 5 BCI implementations are mainly written in *Go*).
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Thank you for your attention!

Do you have any questions?
I am happy to receive suggestions for improvement!