Poster Paper:
Towards a Comparison Framework for Blockchain Interoperability Implementations

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ABC RESEARCH

Austrian Blockchain Center

FFG Forschung wirkt.

wirtschaftsagentur wien Ein Fonds der Stadt Wien

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

Bundesministerium Digitalisierung und Wirtschaftsstandort

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? Ect.
- Aim: *extend* the "Blockchain Interoperability Framework" to allow *empirical comparison* of BCI solutions

Future work

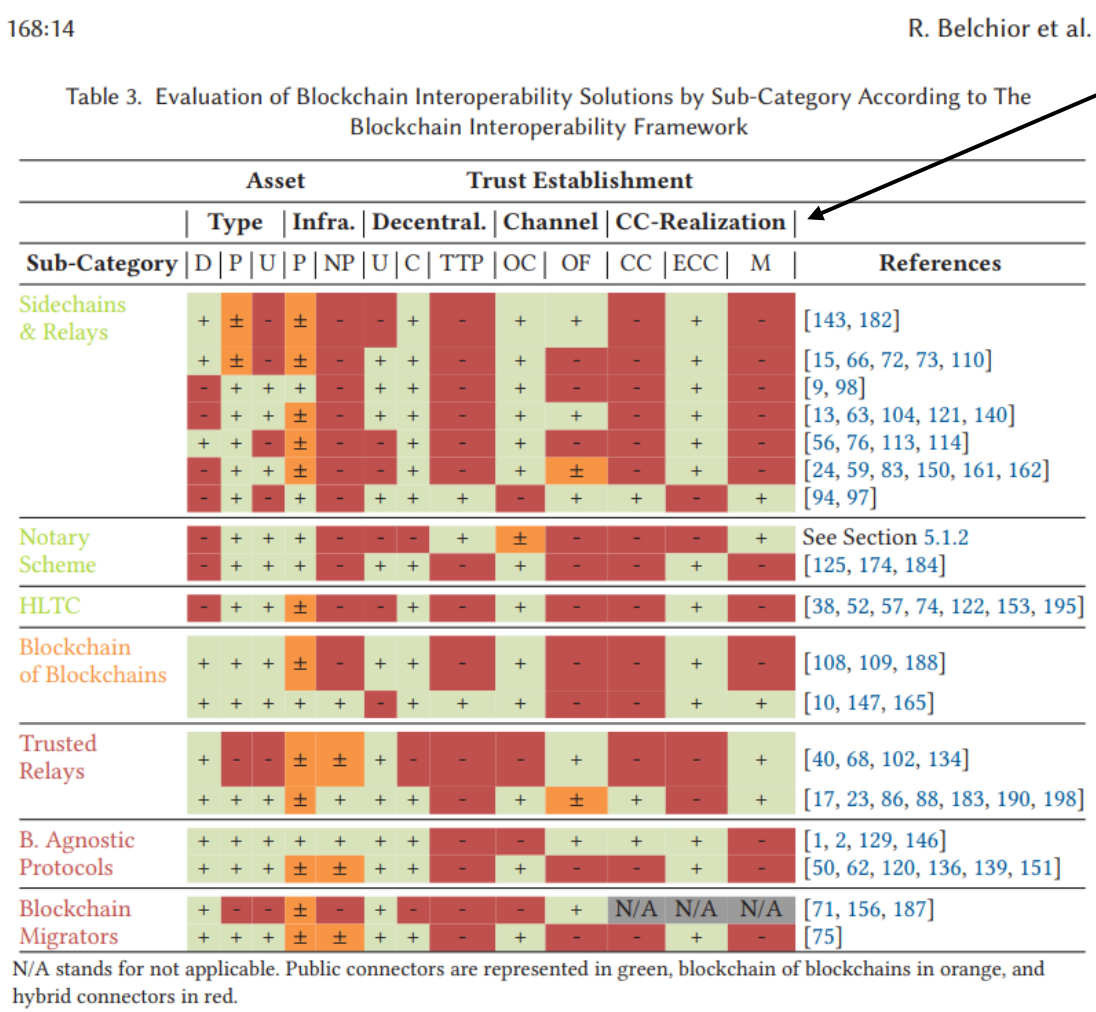
- Apply the proposed "Comparison Framework for BCI Implementations"
- Expand the initial set of BCI solutions to be analyzed
- Further extend the comparison framework to allow more precise results

Sources: Belchior, R., Vasconcelos, A., Guerreiro, S., & Correia, M. (2021). A survey on blockchain interoperability: Past, present, and future trends. ACM Computing Surveys (CSUR), 54(8), 1-41

Research Basis

Blockchain Interoperability Framework (Belchior et al., 2021)

Attributes



168:14 R. Belchior et al.

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

	Asset						Trust Establishment							
	Type			Infra.		Decentral.		Channel		CC-Realization				
Sub-Category	D	P	U	P	NP	U	C	TTP	OC	OF	CC	ECC	M	**References**
Sidechains & Relays	+	±	-	±	-	-	+	-	+	+	-	+	-	[143, 182]
	+	±	-	±	-	+	+	-	+	-	-	+	-	[15, 66, 72, 73, 110]
	-	+	+	+	-	+	+	-	+	-	-	+	-	[9, 98]
	-	+	+	±	-	+	+	-	+	+	-	+	-	[13, 63, 104, 121, 140]
	+	+	-	±	-	-	+	-	+	-	-	+	-	[56, 76, 113, 114]
	-	+	+	±	-	-	+	-	+	±	-	+	-	[24, 59, 83, 150, 161, 162]
	-	+	-	+	-	+	+	+	-	+	+	-	+	[94, 97]
Notary Scheme	-	+	+	+	-	-	-	+	±	-	-	-	+	See Section 5.1.2
	-	+	+	+	-	+	+	-	+	-	-	+	-	[125, 174, 184]
HLTC	-	+	+	±	-	-	+	-	+	-	-	+	-	[38, 52, 57, 74, 122, 153, 195]
Blockchain of Blockchains	+	+	+	±	-	+	+	-	+	-	-	+	-	[108, 109, 188]
	+	+	+	+	+	-	+	+	+	-	-	+	+	[10, 147, 165]
Trusted Relays	+	-	-	±	±	+	-	-	-	+	-	-	+	[40, 68, 102, 134]
	+	+	+	±	+	+	+	-	+	±	+	-	+	[17, 23, 86, 88, 183, 190, 198]
B. Agnostic Protocols	+	+	+	+	+	+	+	-	-	+	+	+	-	[1, 2, 129, 146]
	+	+	+	±	±	+	+	-	+	-	-	+	-	[50, 62, 120, 136, 139, 151]
Blockchain Migrators	+	-	-	±	-	+	-	-	-	+	N/A	N/A	N/A	[71, 156, 187]
	+	+	+	±	±	+	+	-	+	-	-	+	-	[75]

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

Categories

Solutions

Sources: Belchior, R., Vasconcelos, A., Guerreiro, S., & Correia, M. (2021). A survey on blockchain interoperability: Past, present, and future trends. ACM Computing Surveys (CSUR), 54(8), 1-41

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 BLOCKCHAINS INTEROPERABILITY SOLUTIONS [2] AND IMPLEMENTATIONS

Connector type	Mechanism	Number of solutions	Number of implementations
Public Connectors	Sidechains & Relays	26	17
	Notary Schemes	3	1
	HTLC	7	3
Blockchains of Blockchains		6	6
Hybrid Connectors	Trusted Relays	11	3
	Agnostic Protocols	10	5
	Blockchain Migrators	4	2

- 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

Blockchain Interoperability Implementations

List of identified BCI implementations with public GitHub repositories

Public Connectors

Lightning Network, https://github.com/lightningnetwork/lnd, retrieved on Mar 31, 2022

RSK, https://github.com/rsksmart/rskj , retrieved on Mar 31, 2022

BTC Relay, https://github.com/ethereum/btcrelay , retrieved on Mar 31, 2022

BitXhub, https://github.com/meshplus/bitxhub , retrieved on Mar 31, 2022

Interledger, https://github.com/interledger/rfcs , retrieved on Mar 31, 2022

Kyber Network, https://github.com/KyberNetwork/KyberSwap , retrieved on Mar 31, 2022

Hyperledger Quilt, https://github.com/hyperledger/quilt , retrieved on Mar 31, 2022

POA Network, https://github.com/poanetwork/tokenbridge , retrieved on Mar 31, 2022

XMR-BTC, https://github.com/h4sh3d/xmr-btc-atomic-swap , retrieved on Mar 31, 2022

Block Collider, https://github.com/blockcollider/bcnode , retrieved on Mar 31, 2022

ConsenSys, https://github.com/ConsenSys/gpact , retrieved on Mar 31, 2022

JugglingSwap, https://github.com/ZenGo-X/JugglingSwap , retrieved on Mar 31, 2022

Pantos, https://github.com/pantos-io/ethrelay , retrieved on Mar 31, 2022

Zendoo, https://github.com/HorizenOfficial/zendoo-sc-cryptolib, retrieved on Mar 31, 2022

Plasma, https://github.com/plasmadlt/PPAY-Governance , retrieved on Mar 31, 2022

NOCUST, https://github.com/liquidity-network/nocust-contracts-solidity , retrieved on Mar 31, 2022

Horizon, https://github.com/Horizon-Protocol/Horizon-Smart-Contract , retrieved on Mar 31, 2022

0x, https://github.com/0xProject/OpenZKP , retrieved on Mar 31, 2022

Wanchain, https://github.com/wanchain/go-wanchain , retrieved on Mar 31, 2022

Blocknet, https://github.com/blocknetdx/blocknet , retrieved on Mar 31, 2022

Fusion, https://github.com/FUSIONFoundation/efsn , retrieved on Mar 31, 2022

Blockchains of Blockchains

Polkadot, https://github.com/paritytech/polkadot , retrieved on Mar 31, 2022

Cosmos, https://github.com/cosmos/ibc , retrieved on Mar 31, 2022

AION, https://github.com/aionnetwork/aion , retrieved on Mar 31, 2022

ARK, https://github.com/ArkEcosystem/core , retrieved on Mar 31, 2022

Komodo, https://github.com/KomodoPlatform/atomicDEX-Desktop , retrieved on Mar 31, 2022

Overledger, https://github.com/quantnetwork/overledger-sdk-javascript , retrieved on Mar 31, 2022

Hybrid Connectors

Hyperledger Fabric, https://github.com/hyperledger/fabric , retrieved on Mar 31, 2022

CBT, https://github.com/hpdic/cbt , retrieved on Mar 31, 2022

SCIP, https://github.com/lampajr/scip , retrieved on Mar 31, 2022

Uniswap, https://github.com/Uniswap/v3-core , retrieved on Mar 31, 2022

Hyperledger Cactus, https://github.com/hyperledger/cactus , retrieved on Mar 31, 2022

ION, https://github.com/clearmatics/ion , retrieved on Mar 31, 2022

Canton, https://github.com/digital-asset/canton , retrieved on Mar 31, 2022

HyperService, https://github.com/HyperService-Consortium/HyperService-Language , retrieved on Mar 31, 2022

blockchain-interop, https://github.com/pf92/blockchain-interop , retrieved on Mar 31, 2022

VeriSmart, https://github.com/informartin/VeriSmart , retrieved on Mar 31, 2022

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*.

Sources: Borges, H., & Valente, M. T. (2018). What's in a github star? understanding repository starring practices in a social coding platform. Journal of Systems and Software, 146, 112-129.
Jarczyk, O., Gruszka, B., Jaroszewicz, S., Bukowski, L., & Wierzbicki, A. (2014, November). Github projects. quality analysis of open-source software. In International Conference on Social Informatics (pp. 80-94). Springer, Cham.
Dabbish, L., Stuart, C., Tsay, J., & Herbsleb, J. (2012, February). Social coding in GitHub: transparency and collaboration in an open software repository. In Proceedings of the ACM 2012 conference on computer supported cooperative work (pp. 1277-1286).

Towards a Comparison Framework for BCI Implementations

Extending the Blockchain Interoperability Framework (Belchior et al., 2021) with a component that allows an empirical comparison of BCI implementations

TABLE II
COMPARISON FRAMEWORK FOR BLOCKCHAIN INTEROPERABILITY IMPLEMENTATIONS

Measurement group	Comparison criteria
Categorization	Connector type
	Mechanism
Popularity measures	Number of stars
	Number of forks
Developer community & activity measures	Number of contributors
	Last commit in repository
	Last commit in superior project
	Number of commits (last months)
Source code measures	Top language used
	Lines of code

as in Belchior et al., 2021

proposed comparison criteria allowing GitHub-based empirical analysis

- 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!