UNIVERSITY of NICOSIA

A Blockchain Benchmarking Framework

Enabling users to deploy, monitor, analyze and compare the behavior of many different blockchain networks, expose the user to a UI, abstracting the complexities and time-consuming configuration processes.

UBRI Connect 2022

rippleimpact | university blockchain research initiative

Introduction

Our Team

We are a team of blockchain researchers and developers hosted at the Institute For the Future (IFF) at the University of Nicosia. We pursue core and applied research on blockchain protocols and networks.

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Introduction

Background

The Facts

- The current blockchain ecosystem is fragmented.
- There are different implementations of heterogeneous blockchain protocols.
- The deployment processes of such protocols:
  - have many dependencies and assume a certain level of technical expertise
  - are complex and time-consuming, and
  - are based on primitive command line deployment/testing scripts.

The Challenges & Complexities

- Comparing and evaluating the performance of different blockchain implementations is a challenge.
- Understanding their behaviour, especially in the presence of faults or malicious attacks is a challenge.
- Setting up and configuring private deployments of blockchain protocols is complex, and time consuming.
- Stress testing the protocols under "close-to-real" conditions is complex.

Introduction

Aim

The Need

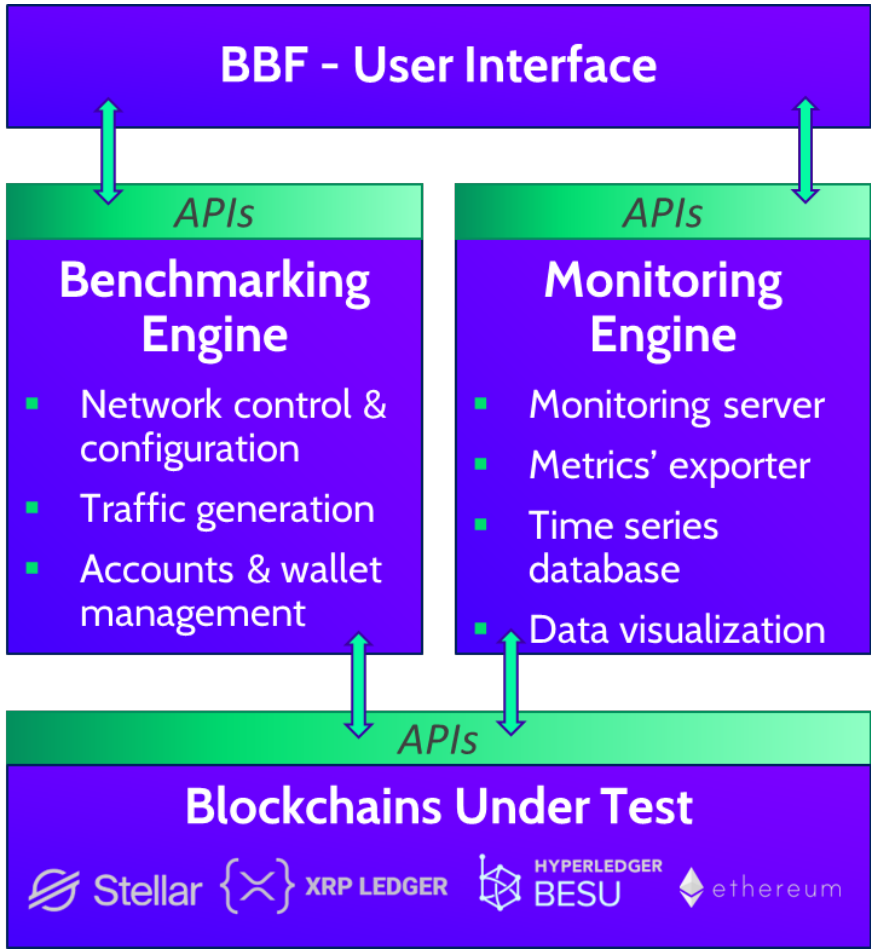
- There is a need for an open-source, easy to use, holistic, and extendable framework that enables technical and non-technical teams to deploy, monitor, analyze, compare, and report various blockchain performance activities.
- We envision a Blockchain Benchmarking Framework that will provide a user interface that enables a seamless interaction between the user and the framework, without advanced programming skills.

The Solution

- A modular BBF that aims to:
  - automate the deployment processes of various blockchain protocols, abstracting the technical details from the end-user.
  - Detect, investigate, monitor, analyze, manage and report on blockchain performance activities.
  - Provide a friendly UI that will enable users to have a seamless and easy interaction with the developed framework abstracting the users from any underlying complexities.

Blockchain Benchmarking Framework

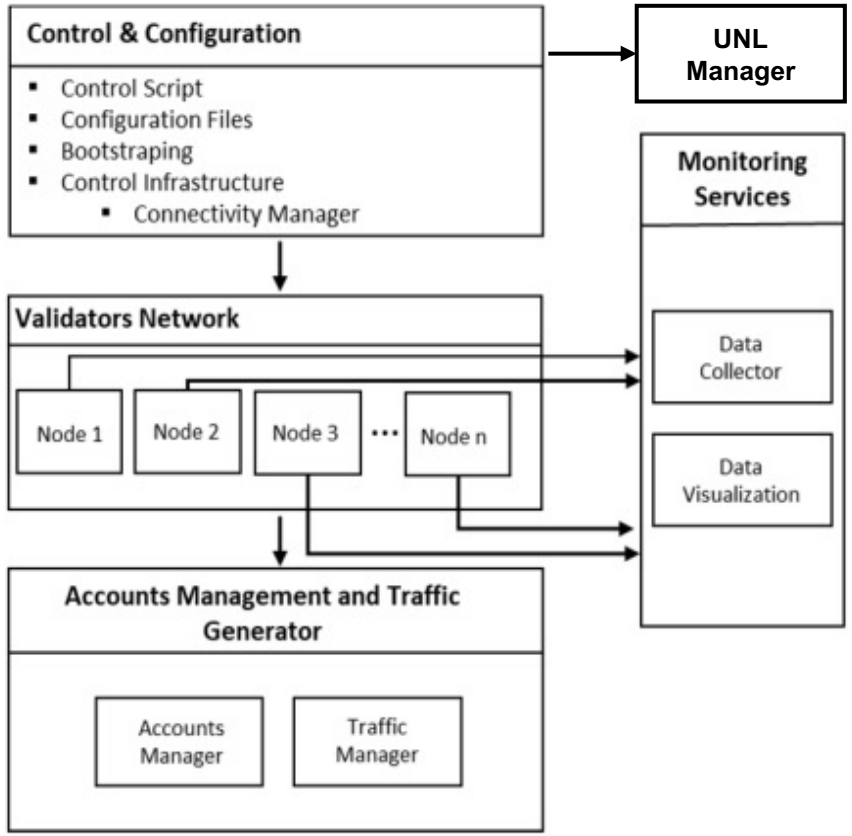
The Architecture



Blockchain Benchmarking Framework

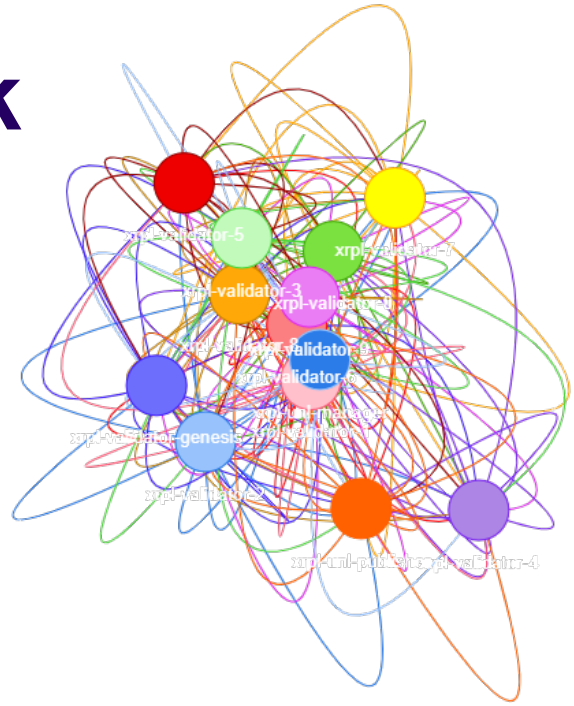
The XRPL Case

- **Control and Configuration:** This module **considers the deployment process** of the network (e.g., generation of configurations files, bootstrapping the network, adapting the connectivity between the nodes/validators etc.)
- **Validators Network:** This module enables the **dynamic spawn of a blockchain network of *n*** number of nodes that act as validators.
- **Accounts Management and Traffic Generator:** This module is responsible **for creating new accounts and injecting traffic** (in form of transactions) towards the network participants.
- **Monitoring Services:** This module **gathers data and enables different data visualizations** by looking at the transactions performed in the network. Furthermore, the module reads data regarding the health of the nodes that participates within then network
- **UNL Manager:** This module is a **web service** responsible to **serve** the **Unique Node List** of each validator. Thus, we are able based on a **scenario** file (Json) adapt the validator's **connectivity** during **runtime**.



Blockchain Benchmarking Framework

The XRPL Case



- **XRPL Experimental Setup:**
  - **Nodes:** 10 proposers (8 of them acting as validators)
  - **Network Topology:** Full mesh network
  - **Traffic Generation:** 1M transactions submitted to random accounts, transferring a random amount of the XRP token.
  - **Exposed Metrics:** ServerLatency, validationQuorum, loadFactor, Peers, Uptime, serverStateDurationUs, convergeTimeS and proposers.

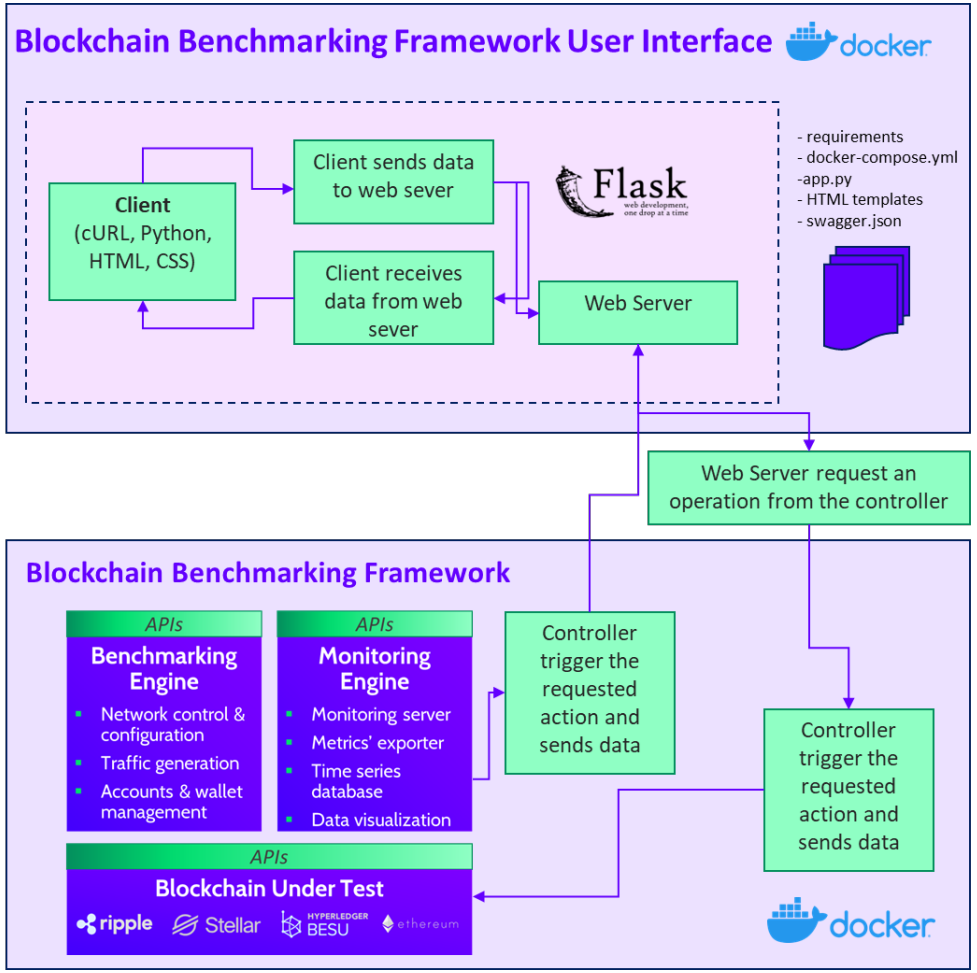
- **XRPL Client Setup:**
  - Ubuntu 18.04 LTS
  - Intel(R) Xeon(R) Gold 6230
  - CPU @ 2.10GHz (6 Cores)
  - 12 GB RAM DDR4

XRPL Case: Experimental Evaluation								
	Run	Nodes	Validator Quorum	Transactions	Successful Transactions	Time (h)	Converge Time (sec)	Server Latency (sec)
	1	10	8	1.000.000	975.621	~ 2.05	2.7	1
	2	10	8	1.000.000	976.020	~ 2.05	2.7	1
	3	10	8	1.000.000	975.554	~ 2.05	2.7	1
	4	10	8	1.000.000	975.570	~ 2.05	2.7	1
	5	10	8	1.000.000	975.769	~ 2.05	2.7	1
Mean Value					***9757.06***	***~ 2.05***	***2.7***	***1***

BBF User Interface

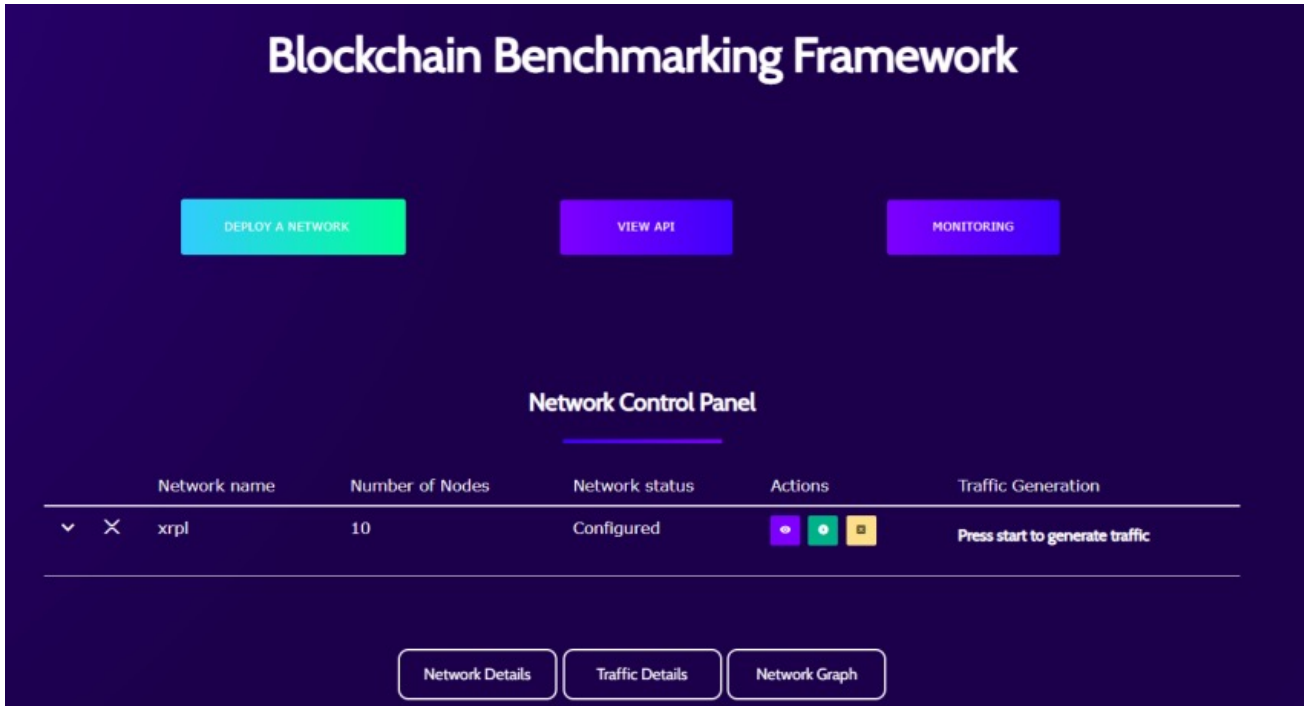
Model Architecture in a Nutshell

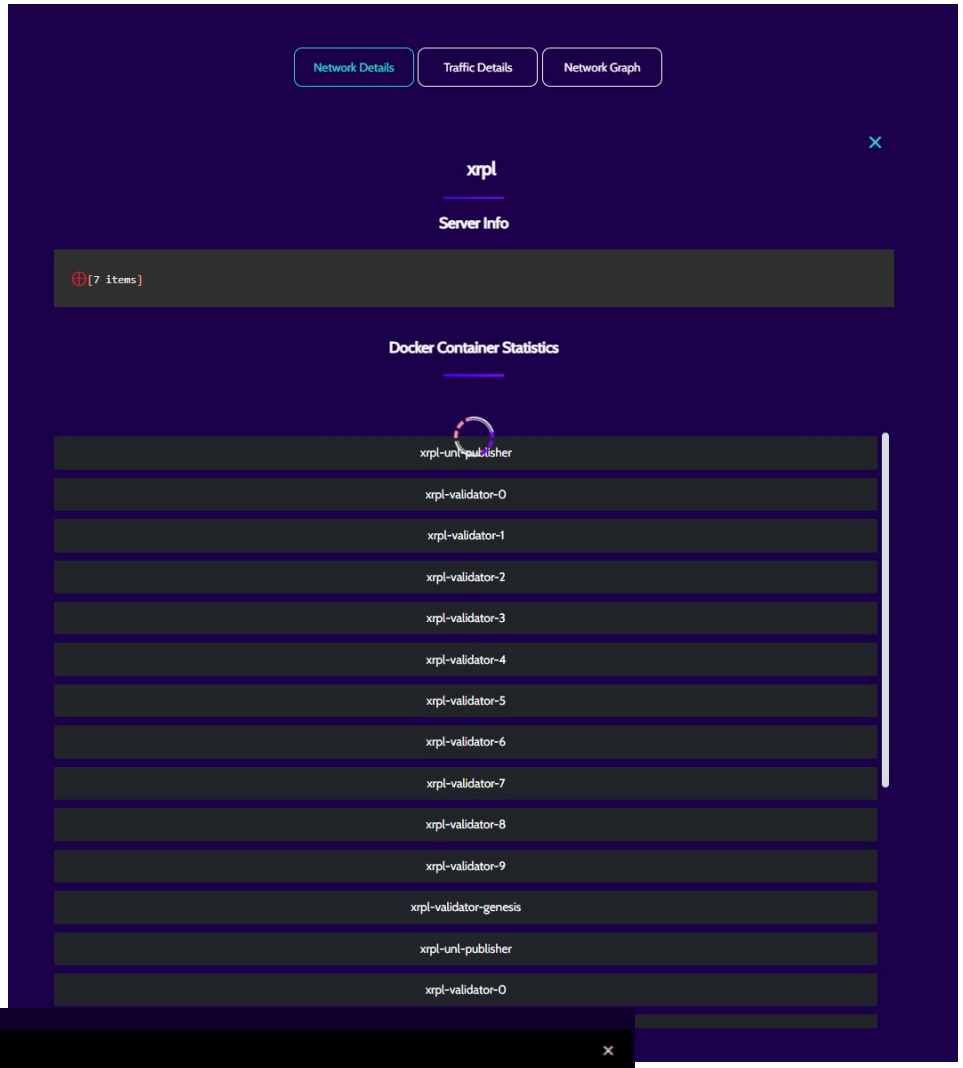
- Dockerized Application
- The user downloads our GitHub repository
- Executing a single script (*./initialize.sh*):
  - Blockchain Benchmarking framework repositories are downloaded.
  - Docker images are built.
  - Bbf-gui-apis docker container starts and exposes port 443.
- A named pipe is created and binded in the docker container volume.
- All requests to the benchmarking framework are passed through the pipe and executed locally.
- Responses from the asynchronous calls are returned in the Web Application and served from the flask server.

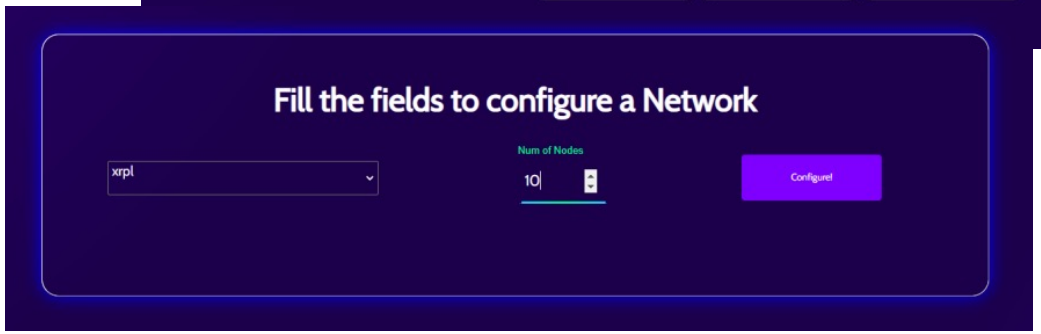


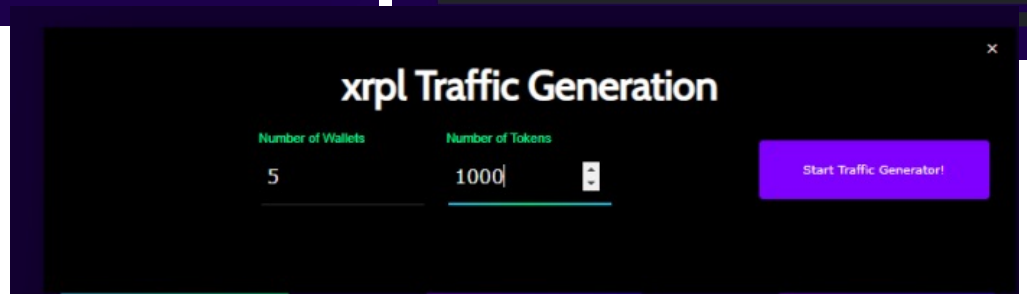
BBF User Interface

The Application









Community Building

- **Medium Articles**
  - The Big Bang of Blockchain Consensus Algorithms: The Case of the XRP Ledger
  - The Big Bang of Blockchain Consensus Algorithms (Part II)
  - The Big Bang of Blockchain Consensus Algorithms (Part III)
- **Open Sourced Github Repositories**
  - https://github.com/UNIC-IFF/blockchain-benchmarking-framework/tree/development
  - https://github.com/antlggl/xrpl-unl-manager/tree/7c32bc36506be1ab4e675815a753289245adf432
- **Papers/Journals**
  - Benchmarking Blockchains: The case of XRP Ledger and Beyond (http://hdl.handle.net/10125/80070)
  - M. Touloupou, K. Christodoulou, A. Inglezakis, E. Iosif and M. Themistocleous, "Towards a Framework for Understanding the Performance of Blockchains," *2021 3rd Conference on Blockchain Research & Applications for Innovative Networks and Services (BRAINS)*, 2021, pp. 47-48, doi: 10.1109/BRAINS52497.2021.9569810.
  - M. Touloupou, M. Themistocleous, E. Iosif and K. Christodoulou, "A Systematic Literature Review Toward a Blockchain Benchmarking Framework," in *IEEE Access*, vol. 10, pp. 70630-70644, 2022, doi: 10.1109/ACCESS.2022.3188123.
  - Christodoulou, K.; Iosif, E.; Inglezakis, A.; Themistocleous, M. Consensus Crash Testing: Exploring Ripple's Decentralization Degree in Adversarial Environments. *Future Internet* **2020**, *12*, 53. https://doi.org/10.3390/fi12030053
  - Iosif E., Christodoulou K., Touloupou M., Inglezakis A. (2020) Leadership Uniformity in Raft Consensus Algorithm. In: Themistocleous M., Papadaki M., Kamal M.M. (eds) Information Systems. EMCIS 2020. Lecture Notes in Business Information Processing, vol 402. Springer, Cham. https://doi.org/10.1007/978-3-030-63396-7_9


The Big Bang of Blockchain Consensus Algorithms: The Case of the XRP Ledger

Klitos Christodoulou Follow
Jul 6, 2020 · 13 min read

By Klitos Christodoulou, Antonios Inglezakis, Marios Touloupou, Iosif Elias


1.1 Benchmarking the behaviour Consensus Algorithms

The blockchain trilemma (scalability, security, triggered a competition between initiatives and wider blockchain ecosystem. These initiatives alternative to Bitcoin implementations for Dist bang of implementations, as attempts to solve to a wide spectrum of different, heterogeneous

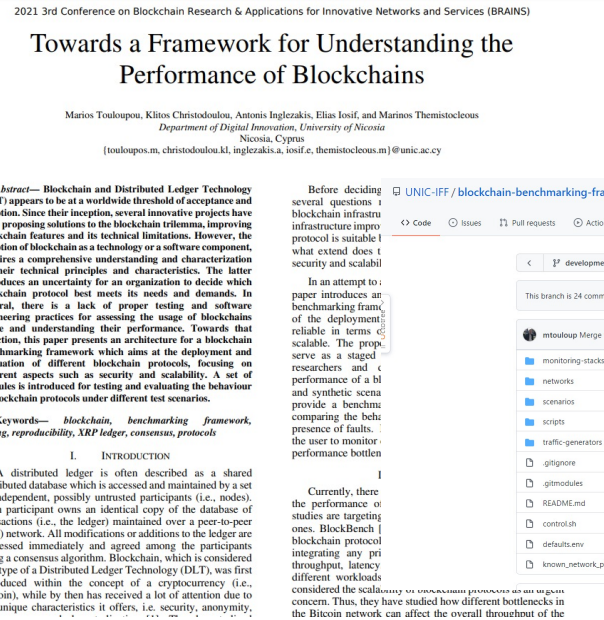
The Big Bang of Blockchain Consensus Algorithms (Part II)

Distributed Ledgers Research Centre Jul 20, 2021 · 8 min read

By Marios Touloupou, Antonios Inglezakis, Iosif Elias, and Klitos Christodoulou

Part I — Rewind

In a previous article (Part I), we have demonstrated an automated deployment of a testing environment for the XRP Ledger (XRPL). In such an ...e able to generate a set of different synthetic test ...r (https://xrpl.org/index.html). Specifically, ...can compile rippled from source code and build


2021 3rd Conference on Blockchain Research & Applications for Innovative Networks and Services (BRAINS)

Towards a Framework for Understanding the Performance of Blockchains

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***Abstract*— Blockchain and Distributed Ledger Technology (DLT) appears to be at a worldwide threshold of acceptance and adoption. Since their inception, several innovative projects have been proposing solutions to the blockchain trilemma, improving blockchain features and its technical limitations. However, the adoption of blockchain as a technology or a software component, requires a comprehensive understanding and characterization of their technical principles and characteristics. The latter introduces an uncertainty for an organization to decide which blockchain protocol best meets its needs and demands. In general, there is a lack of proper testing and software engineering practices for assessing the usage of blockchains usage and understanding their performance. Towards that direction, this paper presents an architecture for a blockchain benchmarking framework which aims at the deployment and evaluation of different blockchain protocols, focusing on different aspects such as security and scalability. A set of modules is introduced for testing and evaluating the behaviour of blockchain protocols under different test scenarios.**

Keywords*— *blockchain, benchmarking framework, testing, reproducibility, XRP ledger, consensus, protocols

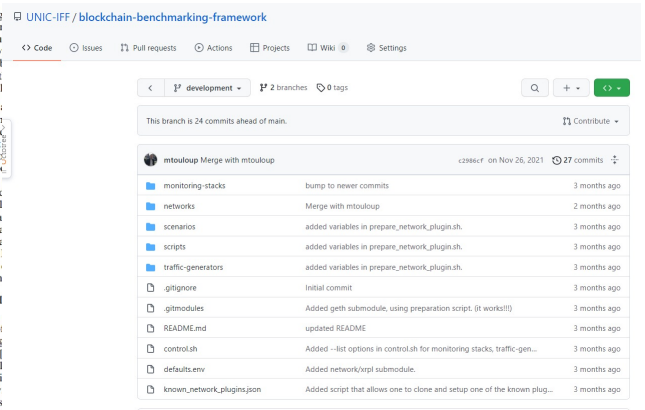
I. INTRODUCTION

A distributed ledger is often described as a shared distributed database which is accessed and maintained by a set of independent, possibly untrusted participants (i.e., nodes). Each participant owns an identical copy of the database of transactions (i.e., the ledger) maintained over a peer-to-peer (p2p) network. All modifications or additions to the ledger are expressed immediately and agreed among the participants using a consensus algorithm. Blockchain, which is considered as a type of a Distributed Ledger Technology (DLT), was first introduced within the concept of a cryptocurrency (i.e., Bitcoin), while by then has received a lot of attention due to the unique characteristics it offers, i.e. security, anonymity,

Before deciding ... several questions ... blockchain infrastru... infrastructure impro... protocol is suitable ... what extend does ... security and scalabi...

In an attempt to ... paper introduces an ... benchmarking frame... of the deployment ... reliable in terms ... scalable. The prop... serve as a staged ... researchers and ... performance of a bl... and synthetic scena... provide a benchm... comparing the beha... presence of faults. ... the user to monitor ... performance bottlen...

Currently, there ... the performance o... studies are targeting ... ones. BlockBench ... blockchain protocol ... integrating any pri... throughput, latency ... different workloads ... considered the scalability of blockchain protocols as an urgent concern. Thus, they have studied how different bottlenecks in the Bitcoin network can affect the overall throughput of the



Acknowledgements

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