



Codenotary

WORLD'S FASTEST
IMMUTABLE DATABASE

IMMUDB - <https://immudb.io>

Sep, 2022





WHY IMMUDB

immudb is a ledger database that has been developed with performance, scalability and versatility in mind.

Users see it as a great alternative to using a blockchain or ledger service for storing rich data, transactions and streams.

VERIFICATION CRYPTOGRAPHICALLY SOFTWARE **DevOps**
CODENOTARY
SOFTWARE SUPPLY CHAIN TAMPERPROOF **TRUST**
PROVENANCE **CYBERSECURITY** DevSecOps

IMMUDB, WORLD'S FASTEST IMMUTABLE DATABASE

+7,800
Stars
On GitHub

10 million
writes/sec
Throughput



12 million
Downloads

2.6
Petabytes
Largest known
immudb database

INTEGRATES
WITH LOTS OF
ENVIRONMENTS



IMMUDB FEATURE OVERVIEW



Easy to setup and run



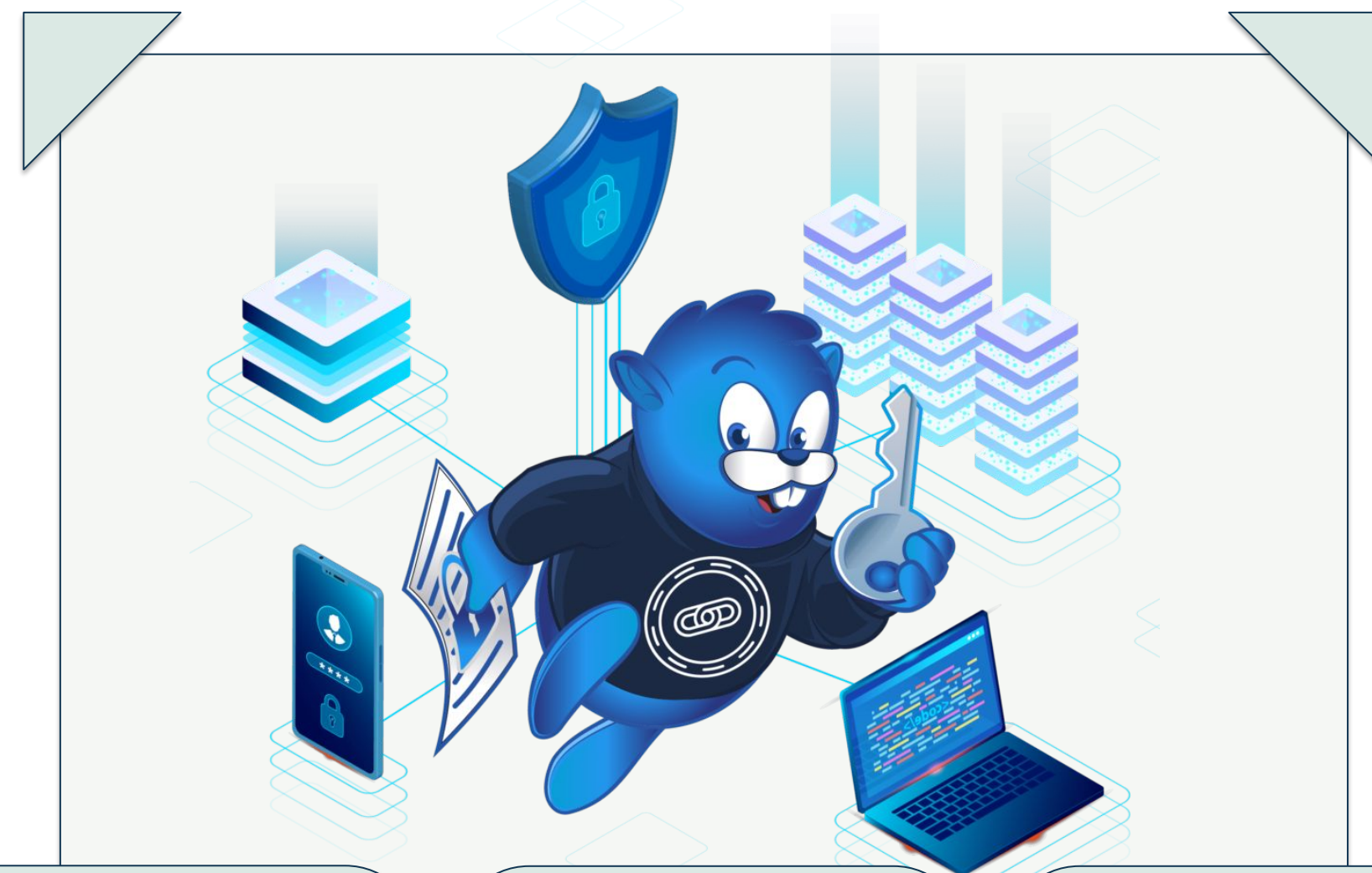
Fast and reliable immutable database



Secure GRPC and REST interfaces and SDKs



Powerful, easy to use and administrate



Immutable

Data is never overwritten. See the history of data updates.



Auditable

Tamper-evident history system
Ensure data authenticity.



Secure

Data ownership is verifiable by clients and auditors.

```
docker run -it -d -p 3322:3322 --name immudb codenotary/immudb:latest
```


IMMUDB ADVANCED FEATURES



Full transactional support



Data replication and Amazon S3 storage support



Auditor deployments for external verification



GDPR compliance (logical deletion & data expiration)

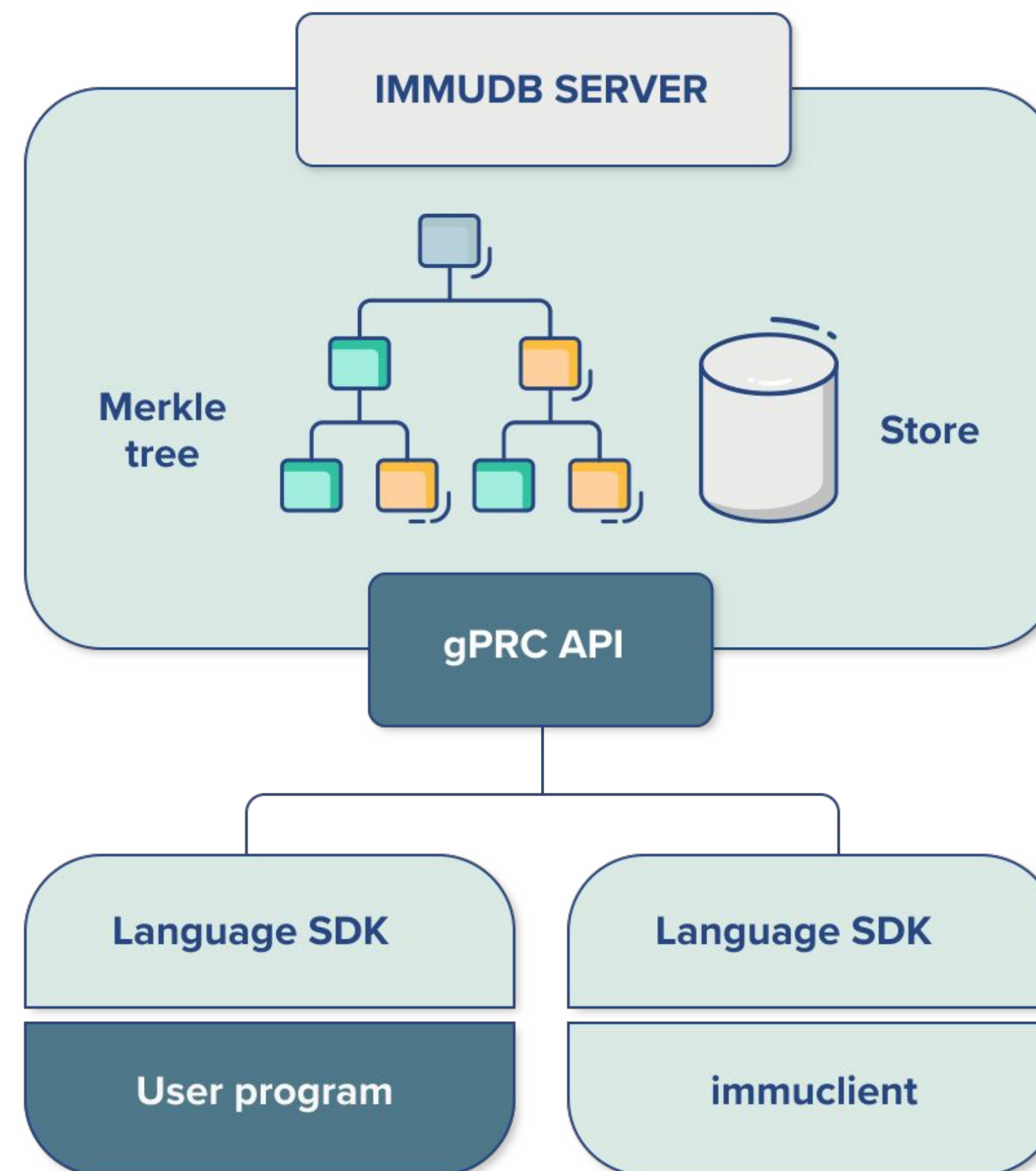


IMMUDB INTERFACES



.NET

{REST:API}



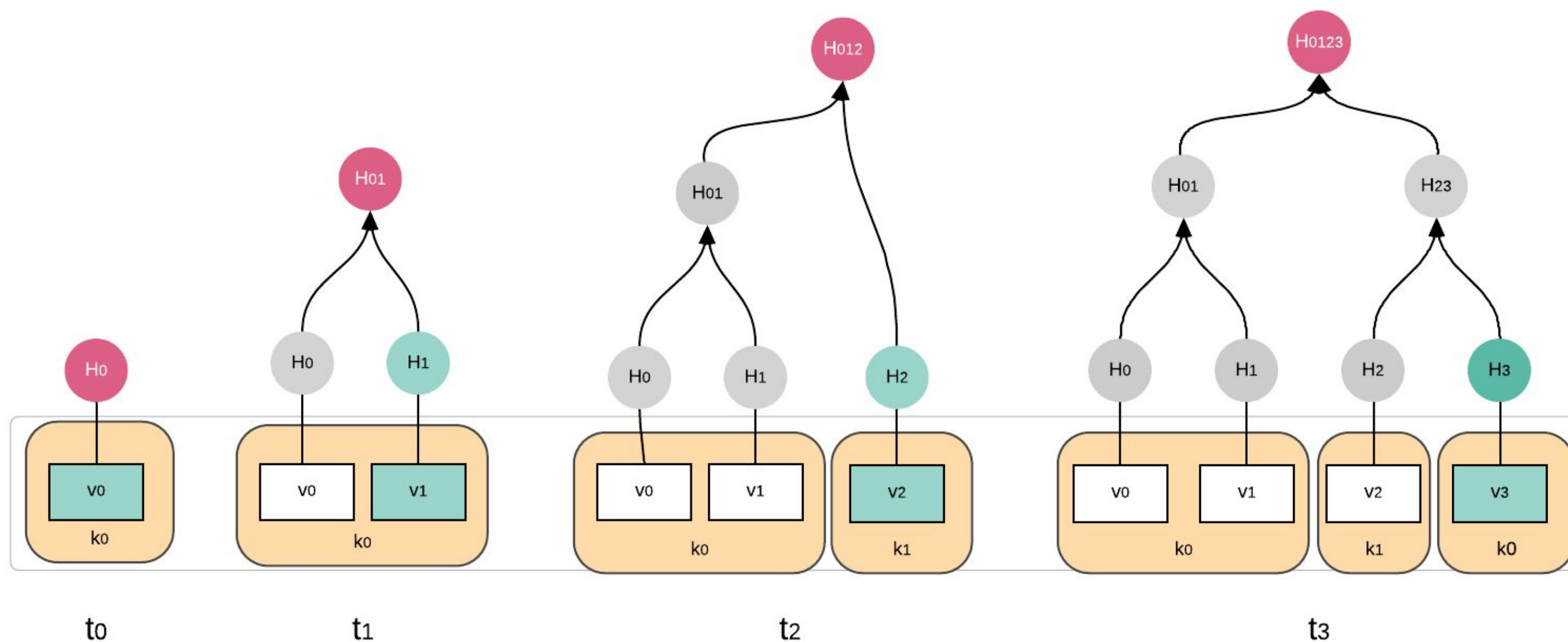
IMMUDB DATA MANAGEMENT

Append-only data structure

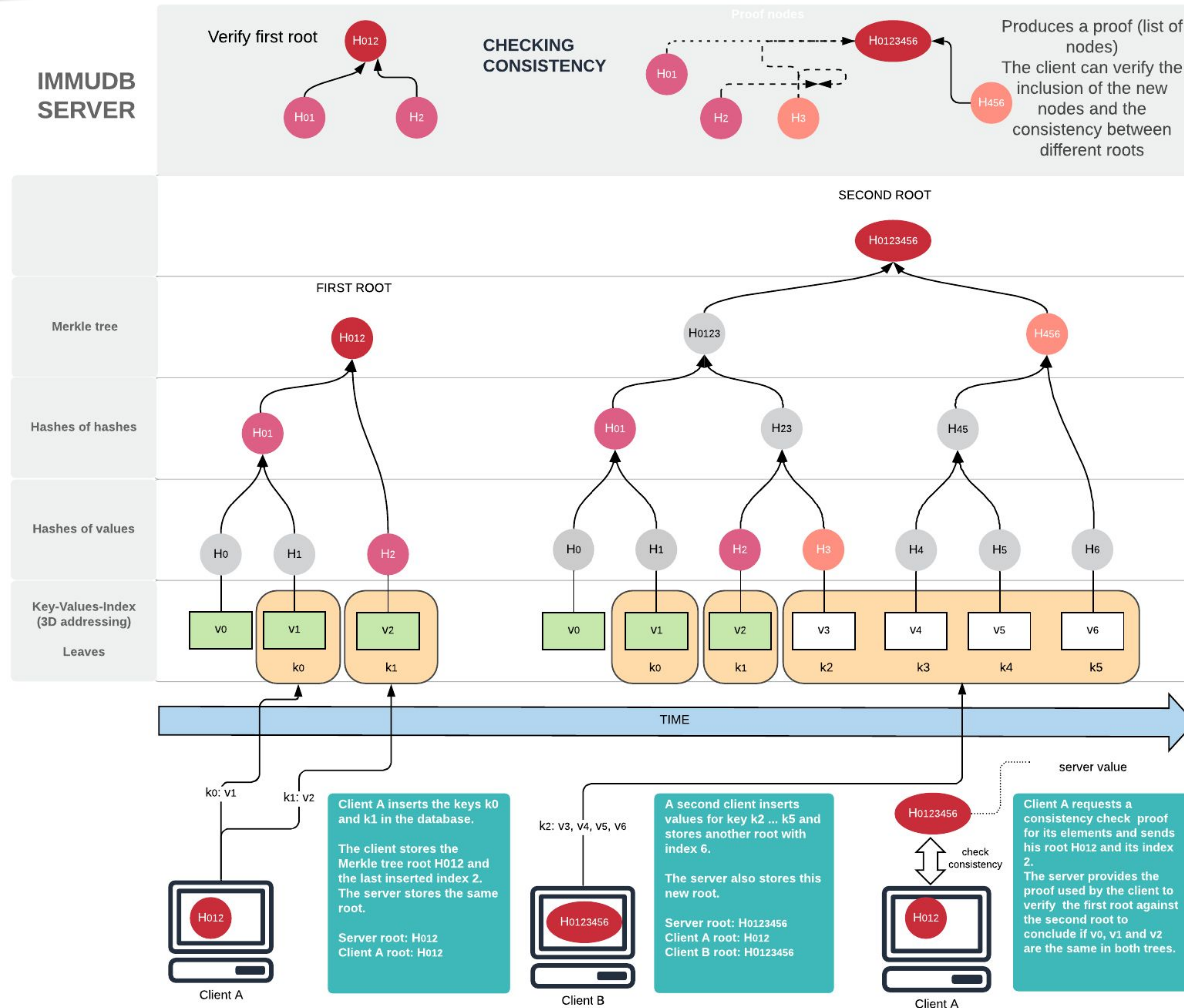
Multiple Merkle-trees are combined for cryptographic-client-verification

No entry is ever overwritten, and the history remains intact

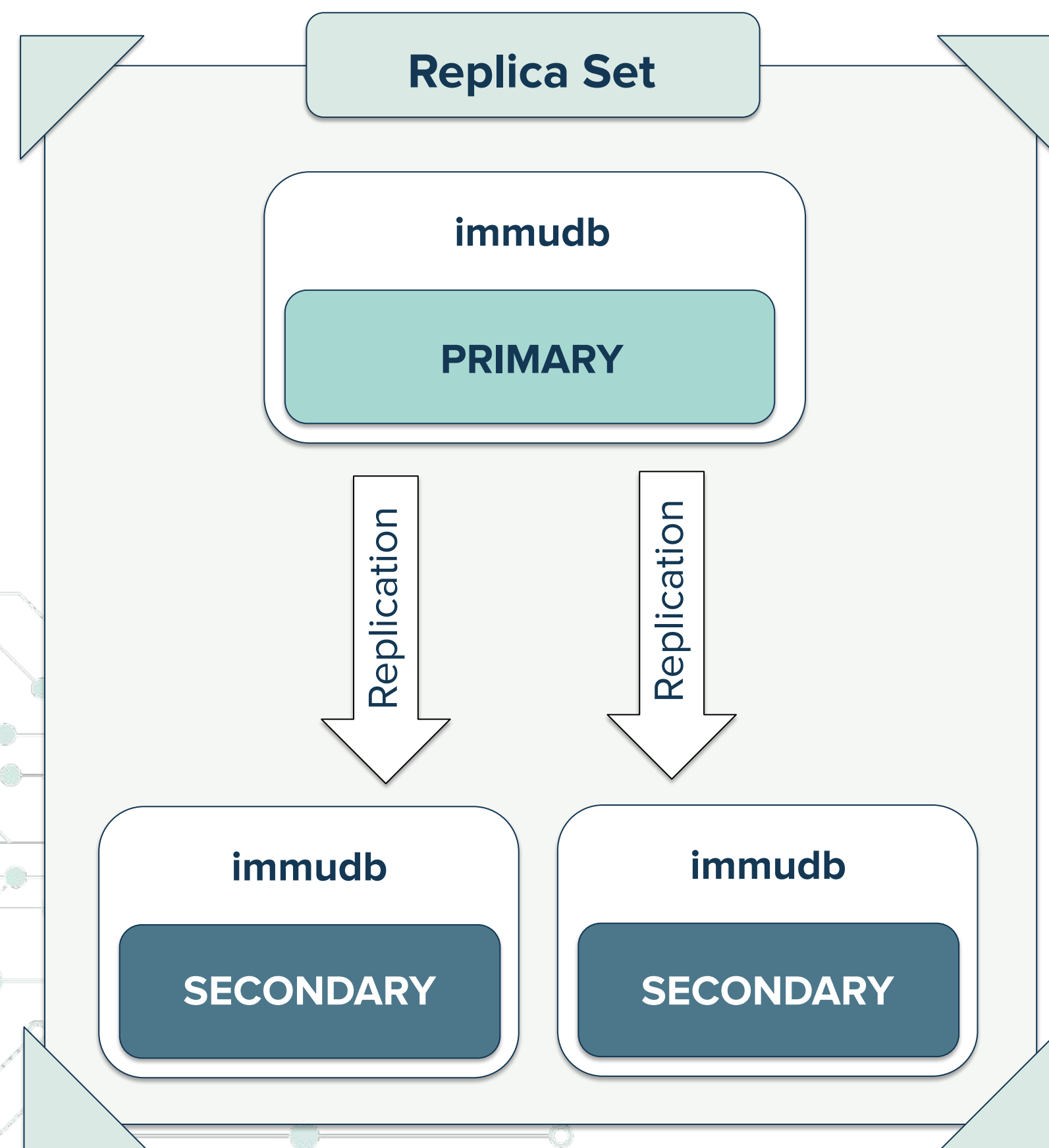
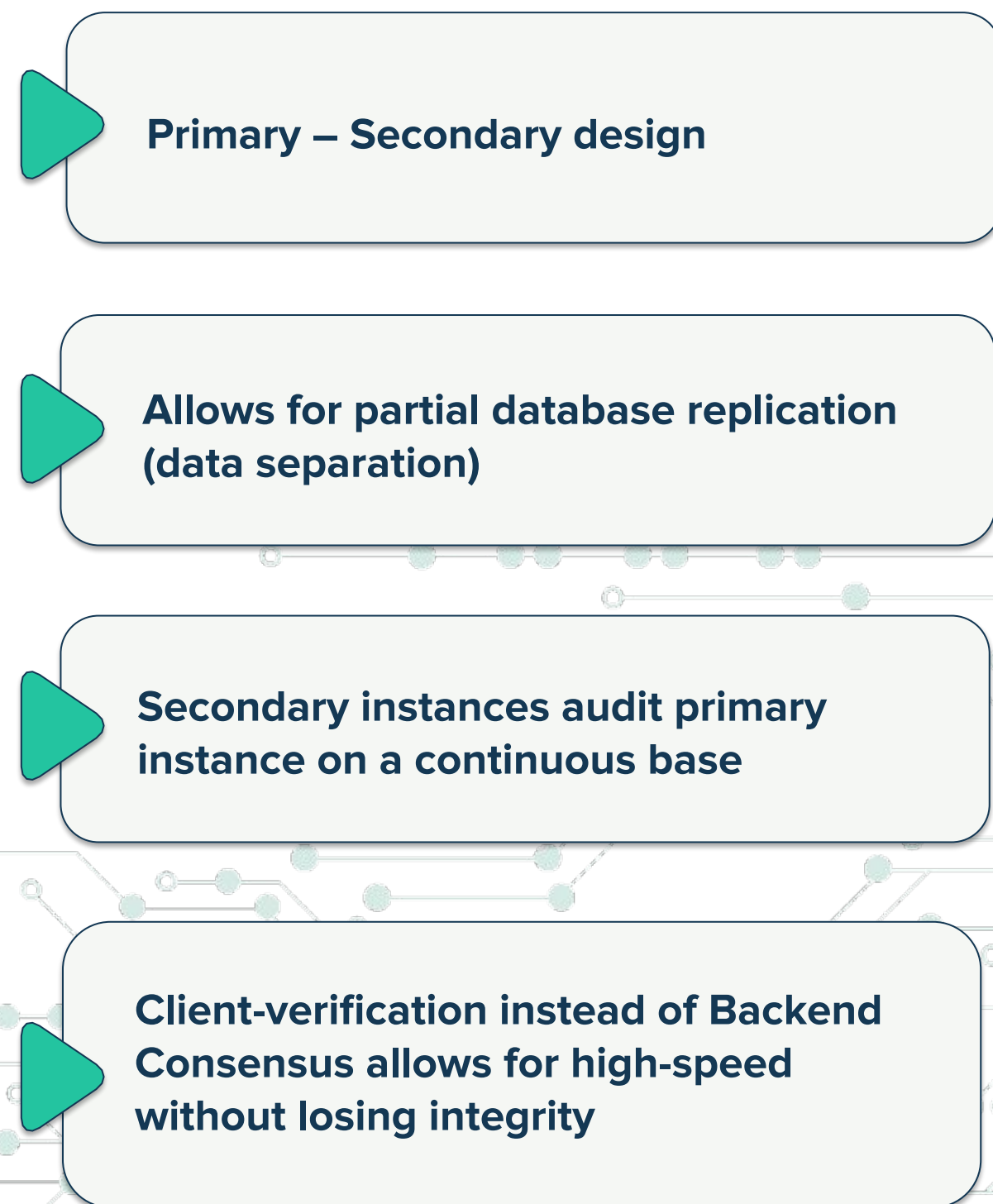
Client-verification instead of Backend Consensus allows for high-speed without losing integrity



IMMUDB CLIENT VERIFICATION



IMMUDB REPLICATION



IMMUDB HIGH PERFORMANCE

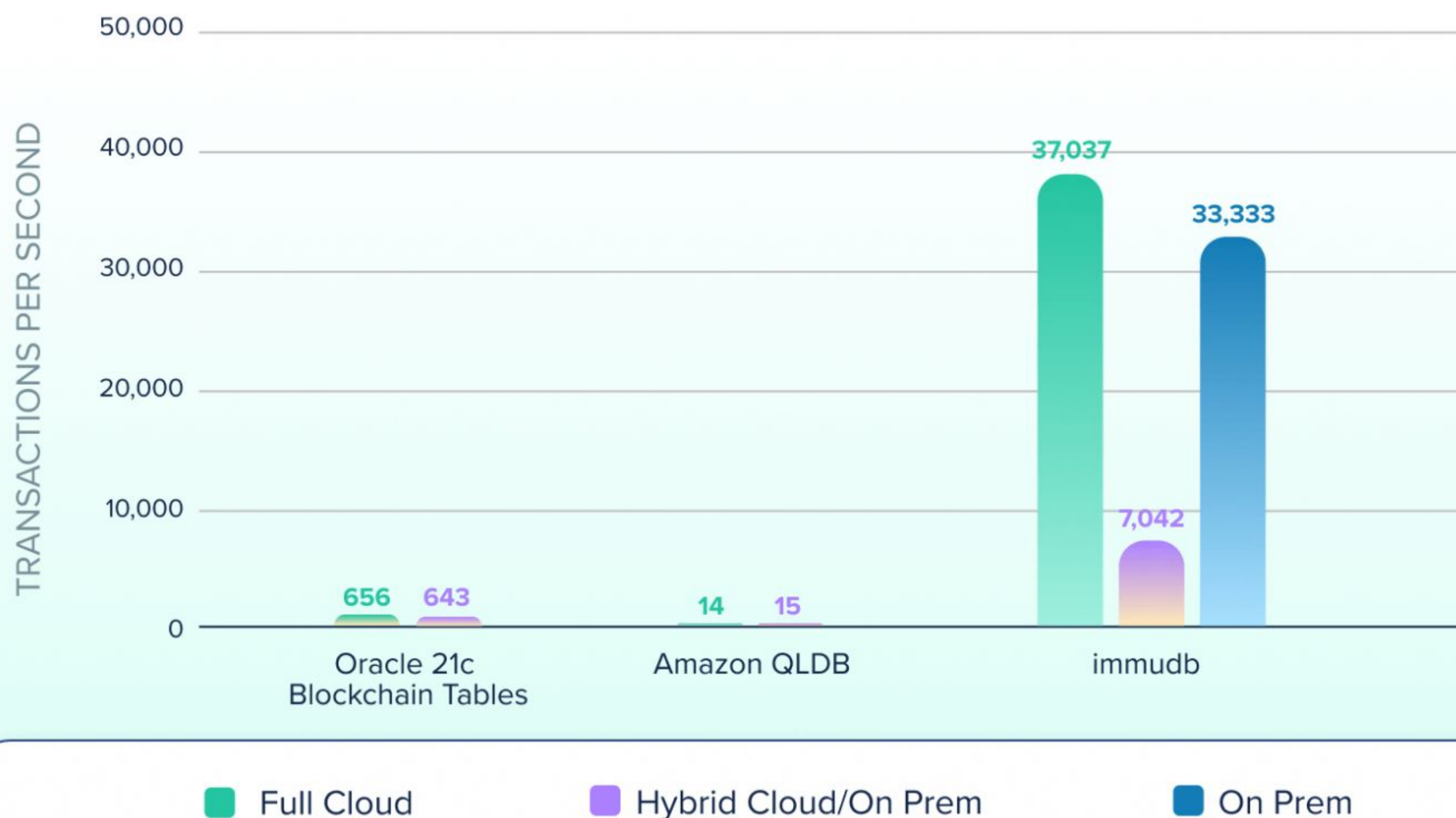
Faster than any other immutable data service

Supports many use cases where Blockchain won't fit

Supports hash and rich data storage at high speed

Many projects replaces AWS QLDB and Blockchain components with immudb

DATABASE THROUGHPUT COMPARISON



IMMUDB EMBEDDED WEB CONSOLE



Built-in browser console



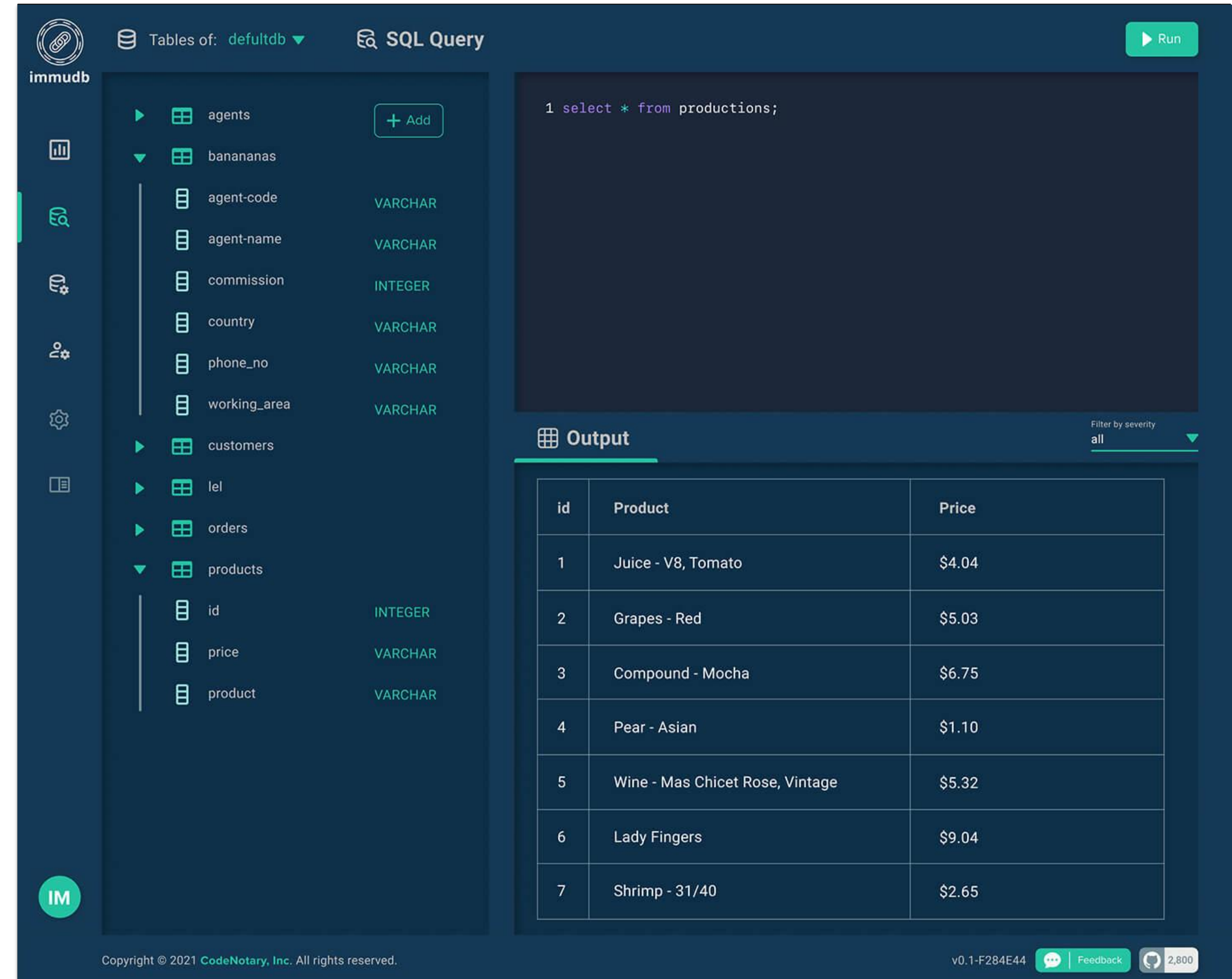
Visual user and database management



Visual data exploration and query engine



Monitor usage statistics and performance metrics



The screenshot displays the IMMUDB Embedded Web Console interface. On the left, a sidebar shows a list of tables: agents, bananas, customers, lel, orders, and products. The 'products' table is expanded, showing columns: id (INTEGER), price (VARCHAR), and product (VARCHAR). In the center, an SQL query editor contains the query: `1 select * from productions;`. On the right, the 'Output' section shows the results of the query in a table format.

id	Product	Price
1	Juice - V8, Tomato	\$4.04
2	Grapes - Red	\$5.03
3	Compound - Mocha	\$6.75
4	Pear - Asian	\$1.10
5	Wine - Mas Chicet Rose, Vintage	\$5.32
6	Lady Fingers	\$9.04
7	Shrimp - 31/40	\$2.65

At the bottom of the interface, there is a footer with copyright information: Copyright © 2021 CodeNotary, Inc. All rights reserved. and a version number: v0.1-F284E44. There are also links for Feedback and a user count of 2,800.

IMMUDB USE CASES



USE CASES



Integration with your DevOps ensures code security throughout the development and deployment process. Embed immudb into your **Azure DevOps** with Jenkins and Kubernetes. Use just **Jenkins**. Alternatively, integrate with **Git Lab** or **GitHub**.



Guarantee File Integrity of your critical data. Examples include storing your organization's sensitive financial, credit card transactional, invoices, contracts, educational transcripts, and other important data.



Ensure integrity of your legal **Documents and Invoices**, contracts, forms, and your downloads and emails.



Save your Internet of Things (IoT) sensor data as a failsafe plan for loss of data.



Keep your investment guidelines or stock market data tamperproof for your investment bank or client financial portfolios.



Store important log files to keep them tamperproof to meet regulations like PCI compliance.



Protect medical data, test results, or recipes from alteration.



Companies use immudb to protect credit card transactions and to secure processes by storing digital certificates and checksums.

**USE CASE - EVIDENCE****Goal:**

CI/CD and application build logs need to be stored auditable and tamper-evident.
A very high **Performance** is required as the system should not slow down any build process.
Scalability is key as billions of artifacts are expected within the next years.

Next to a possibility of integrity validation, data needs to be retrievable by pipeline job id or digital asset checksum.

Implementation:

As part of the CI/CD audit functionality, data is stored within immudb using the Key/Value functionality. Key is either the CI/CD job id (i. e. Jenkins or GitLab) or the checksum of the resulting build or container image.

FINANCIAL DATA PROCESSING



USE CASE - FINANCE

Goal:

Store the source data, the decision and the rule base for financial support from governments timestamped, verifiable.

A very important functionality is the ability to compare the historic decision (based on the past rule base) with the rule base at a different date. Fully cryptographic verifiable **Time Travel** queries are required to be able to achieve that comparison.

Implementation:

While the source data, rule base and the documented decision are stored in verifiable Blobs in immudb, the transaction is stored using the relational layer of immudb.

That allows the use of immudb's time travel capabilities to retrieve verified historic data and recalculate with the most recent rule base.

IOT SENSOR DATA



USE CASE - IoT

Goal:

IoT sensor data received by devices collecting environment data need to store that data locally in a cryptographically verifiable manner until the data is transferred to a central datacenter. The data **integrity needs to be verifiable** at any given point in time and **while in transit**.

Implementation:

immudb runs embedded on the IoT device itself and is consistently audited by external probes. The data transfer to audit is minimal and works with minimum bandwidth and unreliable connections.

Whenever the IoT devices are connected to a high bandwidth the data transfer happens to a data center (large immudb deployment) and the source and destination data integrity is fully verified.

TAMPERPROOF CLINICAL TRIALS



USE CASE - MEDICAL

Goal:

Blockchain PoCs were unsuccessful due to complexity and lack of developers. Still the goal of data **immutability** as well as client verification is a **must**. Furthermore, the system needs to be easy to use and operate (allowing backup, maintenance windows aso.).

Implementation:

immudb is running in different datacenters across the globe. All clinical trial information is stored in immudb either as transactions or the pdf documents. Having that single source of truth with versioned, timestamped and cryptographically verifiable records enables a whole new way of transparency and trust.

E-COMMERCE AND NFT MARKETPLACE



USE CASE – E-COMMERCE

Goal:

No matter if its an eCommerce platform or NFT marketplace, the goal is similar:

- High number of transactions (potentially millions a second)
- Ability to read and write multiple records within one transaction
- prevent overwrite or updates of transactions
- comply with regulations (PCI, GDPR, ...)

Implementation:

immudb is typically scaled out using Hyperscaler (i. e. AWS, Google Cloud, Microsoft Azure) distributed across the Globe. Auditors are also distributed to track the verification proof over time. Additionally, the shop or marketplace applications store immudb cryptographic state information.

That high level of integrity and tamper-evidence while maintaining a very high transaction speed is key for companies to chose immudb.

INDIA URBAN DATA EXCHANGE – <https://iudx.org.in/>



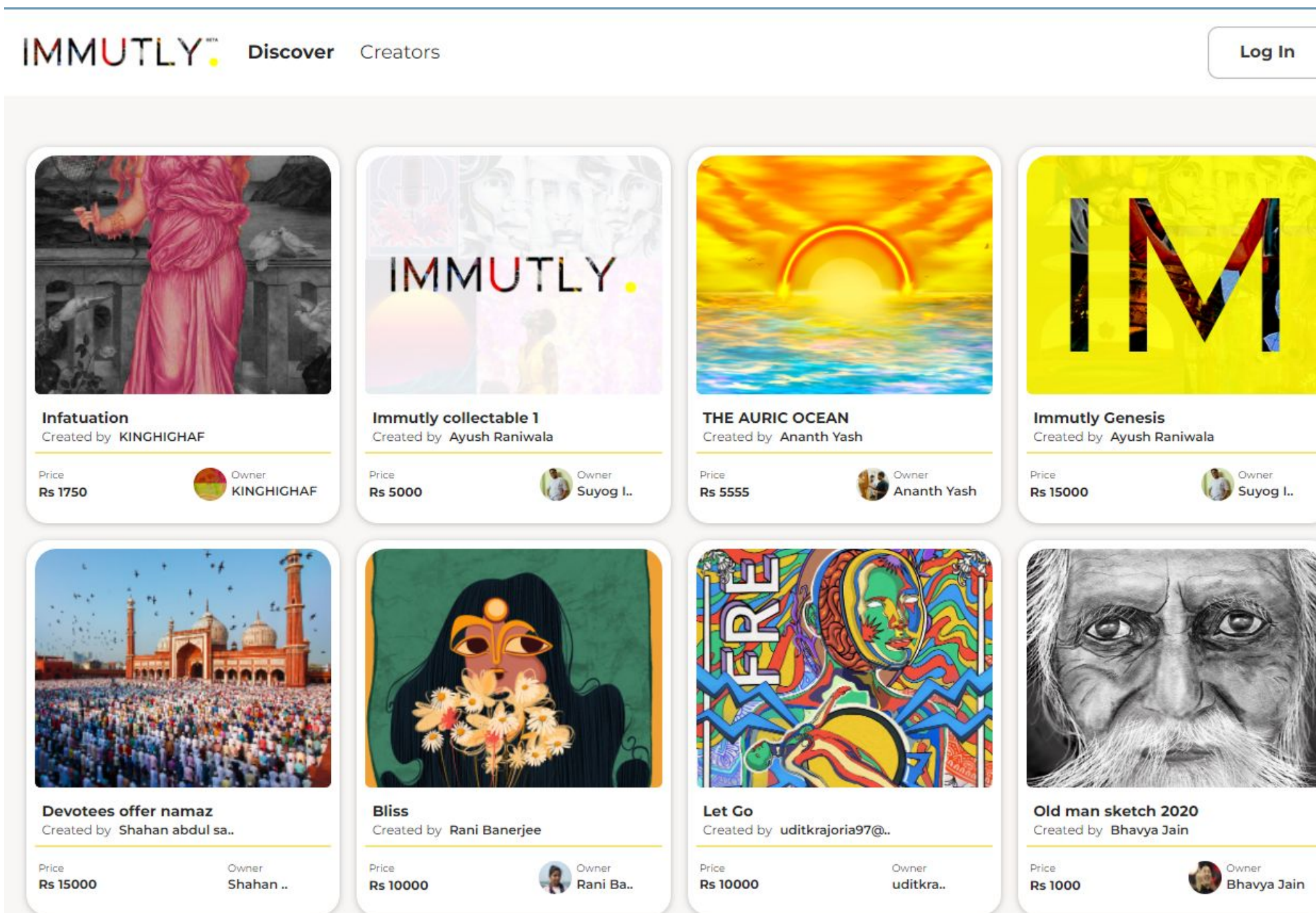
Indian Smart Cities Software

India Urban Data Exchange (IUDX) is a transformative initiative of the Ministry of Housing and Urban Affairs, Government of India to provide a data exchange platform to Indian cities.

IUDX enables data exchange between various city departments, government agencies, citizens and private sector.

IUDX helps the cities in using the data intelligently to address complex urban challenges, establish integrated development across various aspects of the urban sector and catapult them to the next stage of innovation.

NFT MARKETPLACE – <https://immutly.com>



<https://immutly.com>

What technology is used:

Our platform is an immutable digital ledger system, built on the concept of the blockchain.

Immutly's proprietary architecture makes use of immudb as the backbone for our NFT platform, providing the benefits of the blockchain architecture while removing the heavy gas fees and the dependency on cryptocurrency from the system all together.

One of a kind, next generation NFT marketplace, trade in FIAT currency with zero gas fee

Explore

Discover
Creators
Help

Legal

Privacy Policy
Terms & Conditions

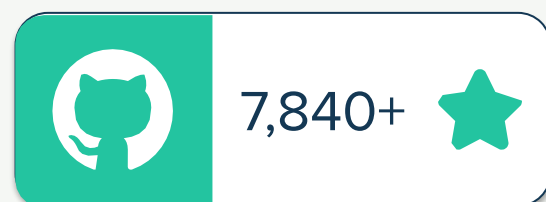
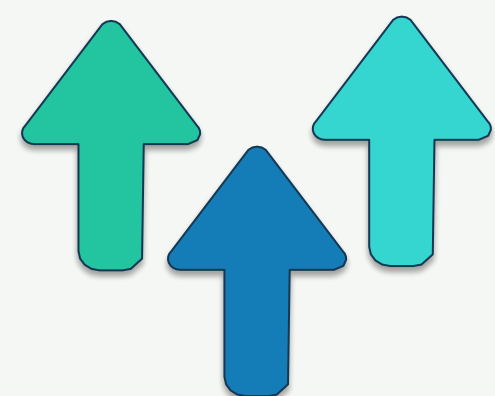
Follow Us



IMMUDB WORLD'S FASTEST IMMUTABLE DATABASE

BUILT IN IMMUTABILITY AND COMPLIANCE

OPEN SOURCE,
ENTHUSIASTIC
COMMUNITY
ADOPTION



INTEGRATES
WITH
LOTS OF
ENVIRONMENTS



ULTRA FAST,
LIGHT WEIGHT,
AND INSTALLS
IN SECONDS

```
brew install immudb
```

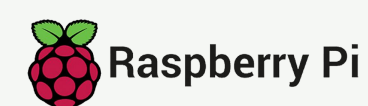
OR

```
apt install immudb
```

RUNS
EVERYWHERE,
CLOUD &
ON PREMISE

x 86 64 , z 390 x, ARM, RISC V

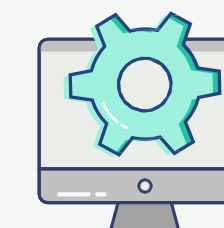
on premise or cloud



ENTERPRISE
GRADE



Many millions of
downloads



Hundreds of
software projects
based on immudb

IMMUDB CO-FOUNDER INTERVIEW



INTERVIEW WITH JERÓNIMO IRAZÁBAL

Chief Architect,
immudb - Cryptographically
verifiable database.



What is immudb? Why did you build it?

immudb is a cryptographically verifiable multilayer database. This is often assumed to mean immutable, but whilst immudb is indeed immutable, it's also important to highlight that everything that is written into immudb can be verified by a client application later on.

You can use immudb for logging events which can then be retrieved by the event identifier and verified, however, immudb can be used as a standard key-value store and as a relational SQL database, with the added benefit that everything is verifiable.

This allows client apps to check whether the data has been tampered with, even if someone has access to the file system or underlying storage. This can be detected.

The database is also intended to be run by a single owner, which is one of the differences when comparing immudb to blockchain. With blockchain, ownership is decentralized, whereas immudb can run on a single server. Clients do not need to trust the server because of the underlying verification capabilities.

<https://console.dev/interviews/immudb-jeronimo-irazabal/>

RESEARCH PAPER

SCIENTIFIC BOARD



PROF. ASSAF SCHUSTER

Technion – israel institute of technology



PROF. DR. MARTIN BOGDAN

Universität Leipzig

immudb: A Lightweight, Performant Immutable Database

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Abstract

More of the world's activity is being recorded by digital services, which has resulted both in an increasingly stringent compliance and regulatory environment for data storage and attacks on that storage that are growing in sophistication and subtlety. This paper describes immudb, an append-only general purpose database that, in concert with other security best practices, provides tamper evidence and irrefutable transactions while maintaining performance appropriate for high-volume applications.

immudb uses Merkle Hash Trees (MHTs) to create digests that represent the state of the entire database at any given time. Together with cryptographic proofs that demonstrate that 1) a given element has been successfully inserted into the database and 2) a database is consistent between two points in time, these provide robust guarantees about the validity of the state of the database.

Simultaneously, immudb provides data read access using versioned key-value and insertion order APIs that enable immudb to serve in a broad range of capacities that would otherwise use less secure alternatives.

of the Warsaw Pact. Rather than simply post new fraudulent articles, which would have been detected quickly due to the recency bias of the news cycle, the hackers replaced older articles which would not appear on the front pages, but would be returned in searches for, e.g. "NATO."

While this attack is significant in that it features a state-sponsored actor, it belongs to a larger group of threats in which attackers, whether internal or external to an organization, gain access to a data store and modify or delete data, instead of or in addition to exfiltrating it for other purposes. This can take myriad forms: modifying transaction histories to remove debits, tweaking clinical trial research data, deleting receipts or inflating invoices in support of theft, altering navigation waypoints, changing grades, etc.

Simultaneously, the burden of regulation for data retention is heavy. Major sets of regulations that impose data security rules include but are certainly not limited to HIPAA [5] (healthcare data), FERPA [12] (student records), FCRA [16] and its amendment FACTA [17] (consumer credit), SOX [13] (institutional accounting), and 21 CFR § 11 (pharmaceutical trial data), and so forth. The burden is also continuously increasing, with recent years seeing the European Union enact the General Data Protection Act [7], New York enact the SHIELD act [14], and California enact the California Consumer Privacy Act [4]. Many of these regulations levy specific rules requiring audit trails for data modifications.

Together, these two coinciding forces strongly indicate the need to create a new class of database that is auditable, irrefutable, and tamper-evident *by design* rather than attempting to retrofit existing database solutions with additional instrumentation¹.

1 Introduction and Motivation

In July 2020, Mandiant Solutions, a cybersecurity research company, released a report describing a Russian hacking campaign against targets in Poland, Lithuania, and Latvia that had been ongoing since at least March 2017 [27]. The hacking group(s) associated with this campaign, which Mandiant entitled "Ghostwriter", had, among other attack vectors, penetrated the content management systems that support various news outlets' web publications in the target nations. Subsequently, the attackers had posted fabricated news articles intended to sway public opinion against the North Atlantic Treaty Organization (NATO), in an apparent bid to weaken its geopolitical influence in three nations that were either former Soviet Socialist Republics or, in the case of Poland, a member

IMMUTABILITY



Cambridge dictionary definition

Meaning of **immutable** in English

immutable

adjective • formalUK  /ɪˈmjuː.tə.bəl/ US  /ɪˈmjuː.tə.bəl/**not changing, or unable to be changed:**

- *an immutable law*
- *Some people regard grammar as an immutable set of rules.*

Synonymchangeless literary**Opposites**changeablemutable formal

IMMUTABILITY OF DATA - APPROACHES



No immutability



Full immutability - frozen dataset



Entry-level immutability



History immutability



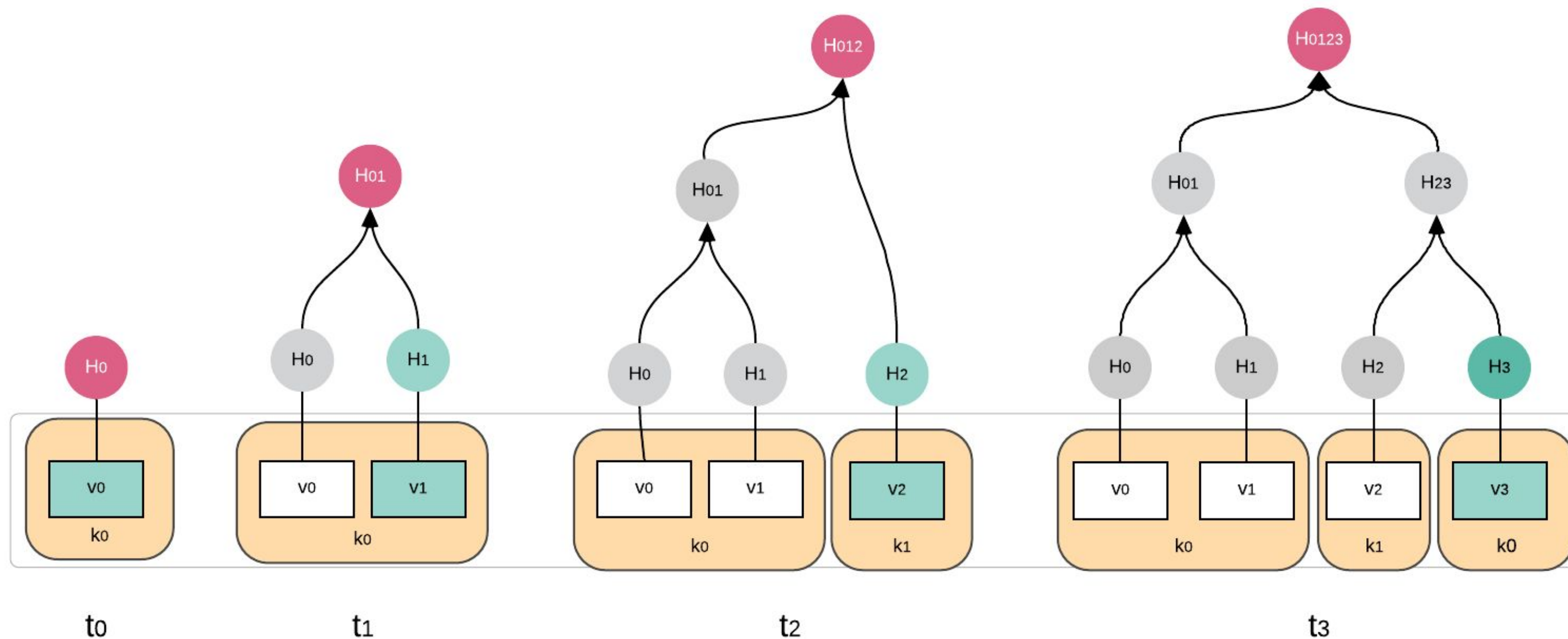
IMMUDB DATA MANAGEMENT

Append-only data structure

Multiple Merkle-trees are combined for cryptographic-client-verification

No entry is ever overwritten, and the history remains intact

Client-verification instead of Backend Consensus allows for high-speed without losing integrity



SCHRÖDINGER'S CAT DATABASE



The cat

We don't know what's the state of the cat as long as the box is not opened

We only know what the state is on the first contact with the interior of the box.

SCHRÖDINGER'S ~~eat~~ DATABASE



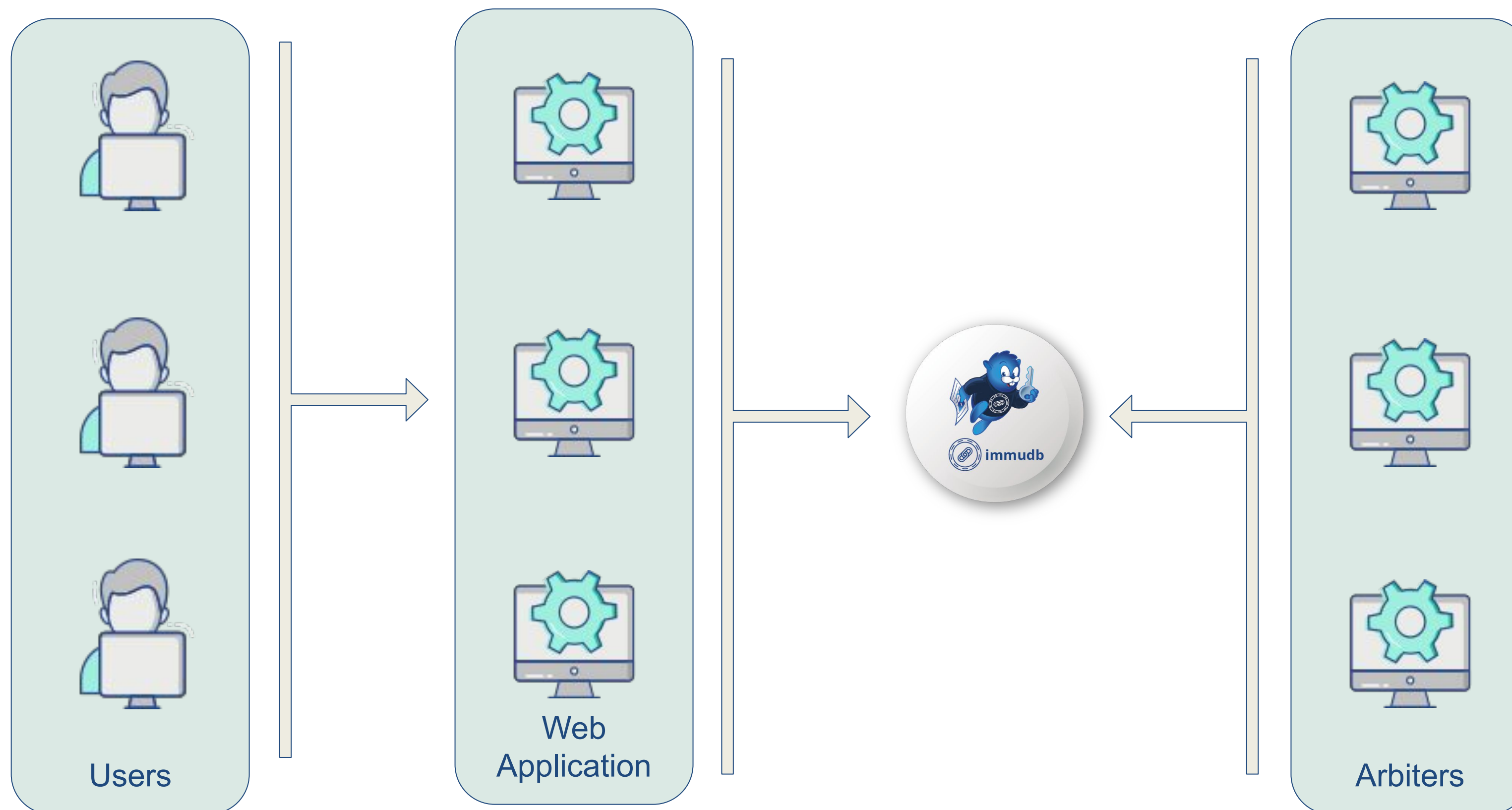
The Database

We don't know what's the state of the ~~eat~~ Database as long as the ~~box~~ connection is not opened

Without any prior communication knowledge about the database the client can accept that the Database could be in any state.

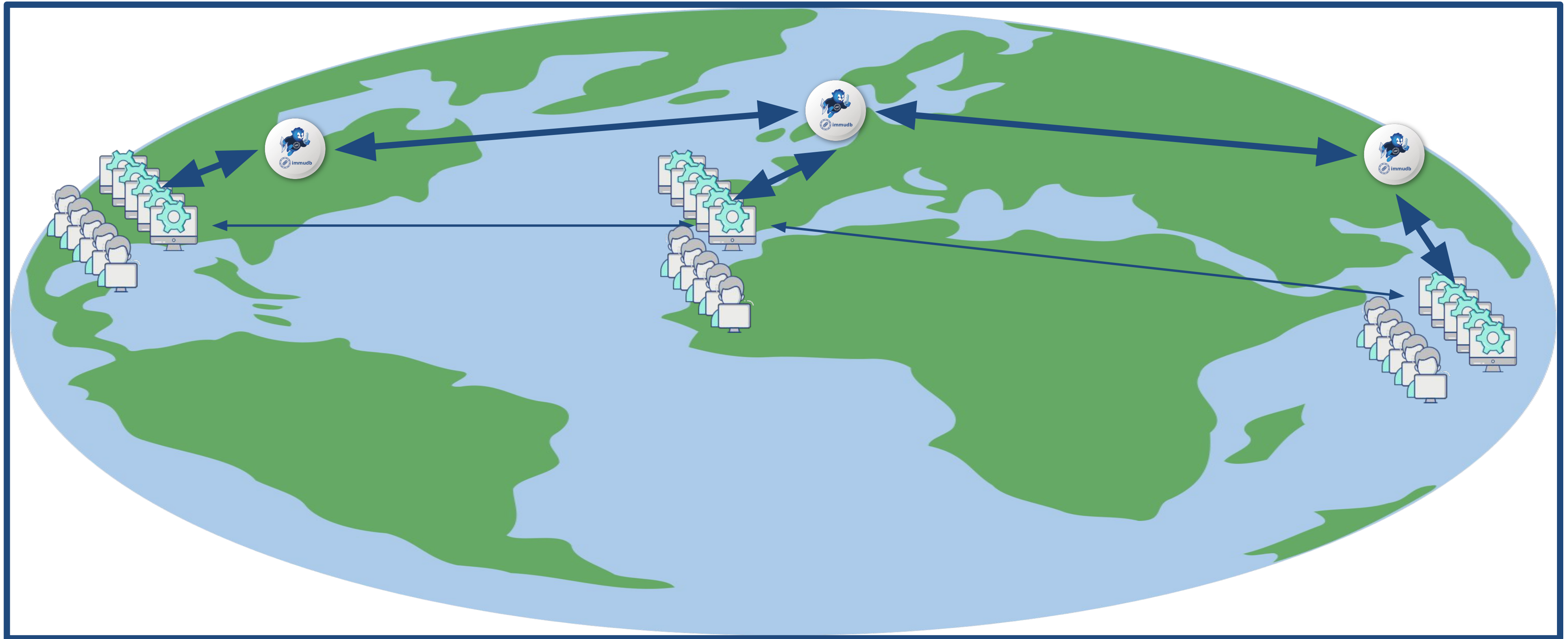
Client has to keep some information about the database to validate that it is consistent on subsequent calls.

IMMUDB SETUP



Distrust between components == trustworthy system

IMMUDB COMPLEX SETUP



LIVE DEMO



Codenotary



THANK YOU



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