ResilientDB

Nexres

The next generation of ResilientDB: a distributed blockchain platform

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UCDAVIS

Introduction

- What is Blockchain
- What is Nexres
- KV Server Example

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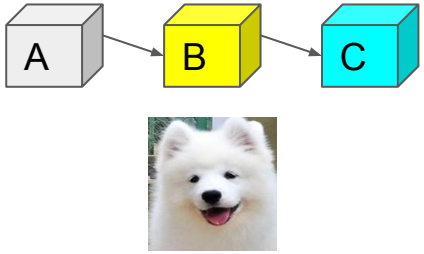
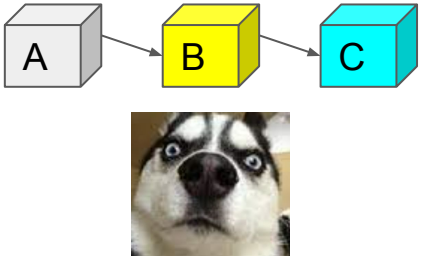
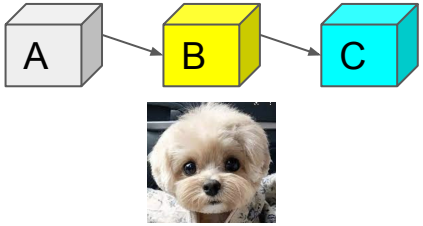
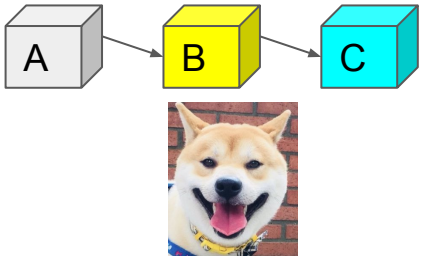
What is blockchain







- A distributed leger
- Users own their indivisual copies
- Consistent structure
- Idempotent (same input, same output)
- Can trace the histories
- Imutable
- Run in Byzantine Env



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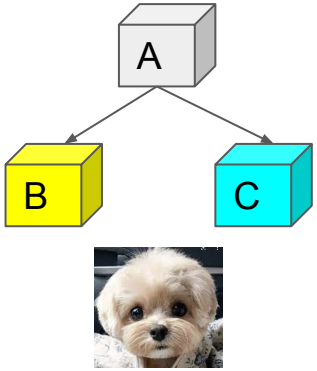
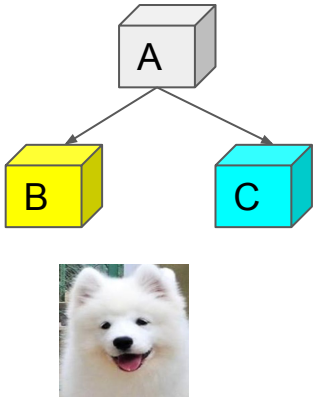
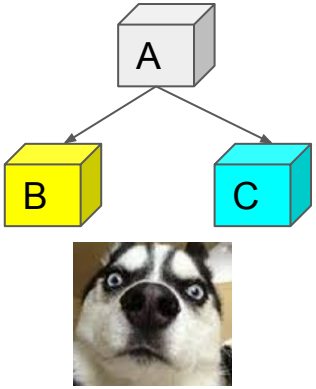
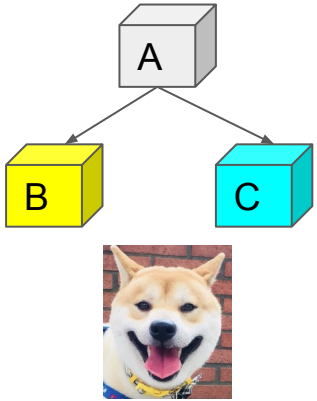
Is blockchain a single chain?









- Can be any DAG graph!!!

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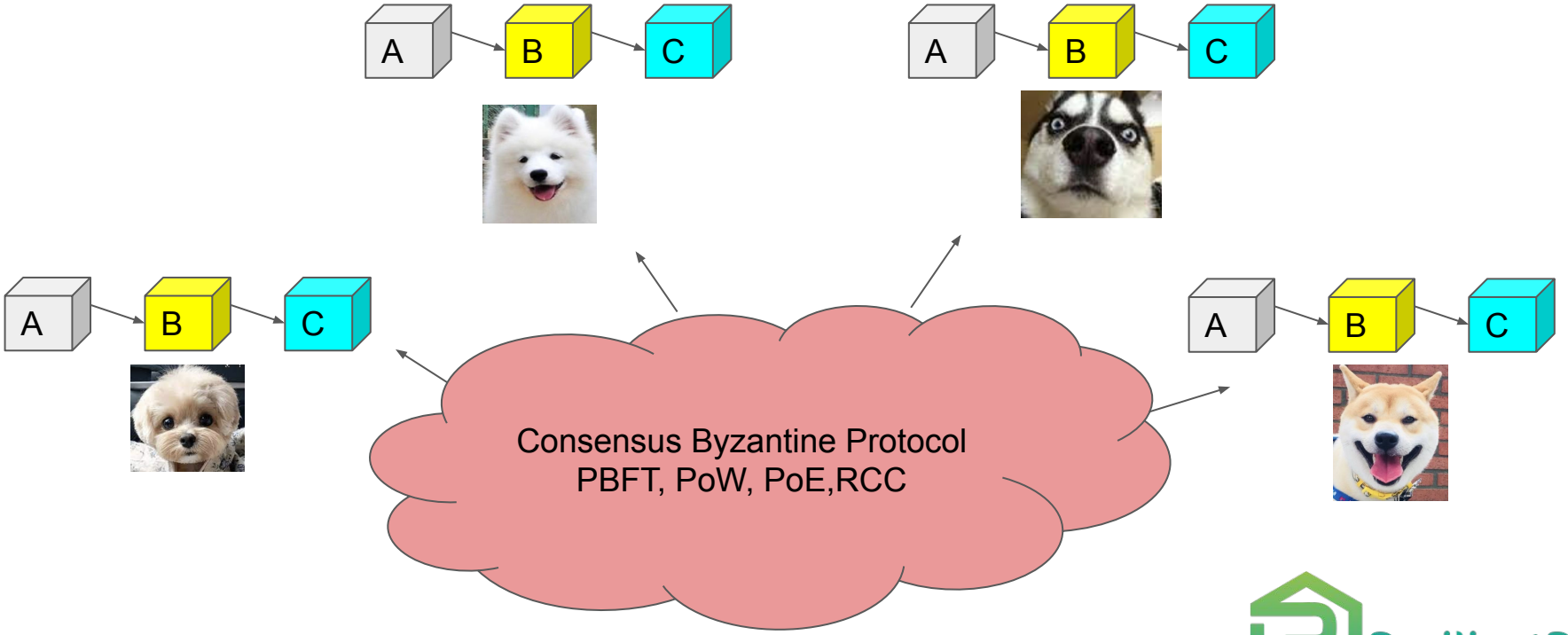
Behind blockchain



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Nexres

An open source high performance Remote Procedure Call (RPC) framework running in a byzantine environment.

A distributed platform helping people to develop an indivisual blockchain system.

- Easy to develop your own application or smart contract.
- Easy to develop your own consensus protocol

Using user kindly development suitekit.

- Written in C++: easy to access SDKs.
- Protobuf Message: easy to define a serialabe message
- Bazel Build: easy to build the system

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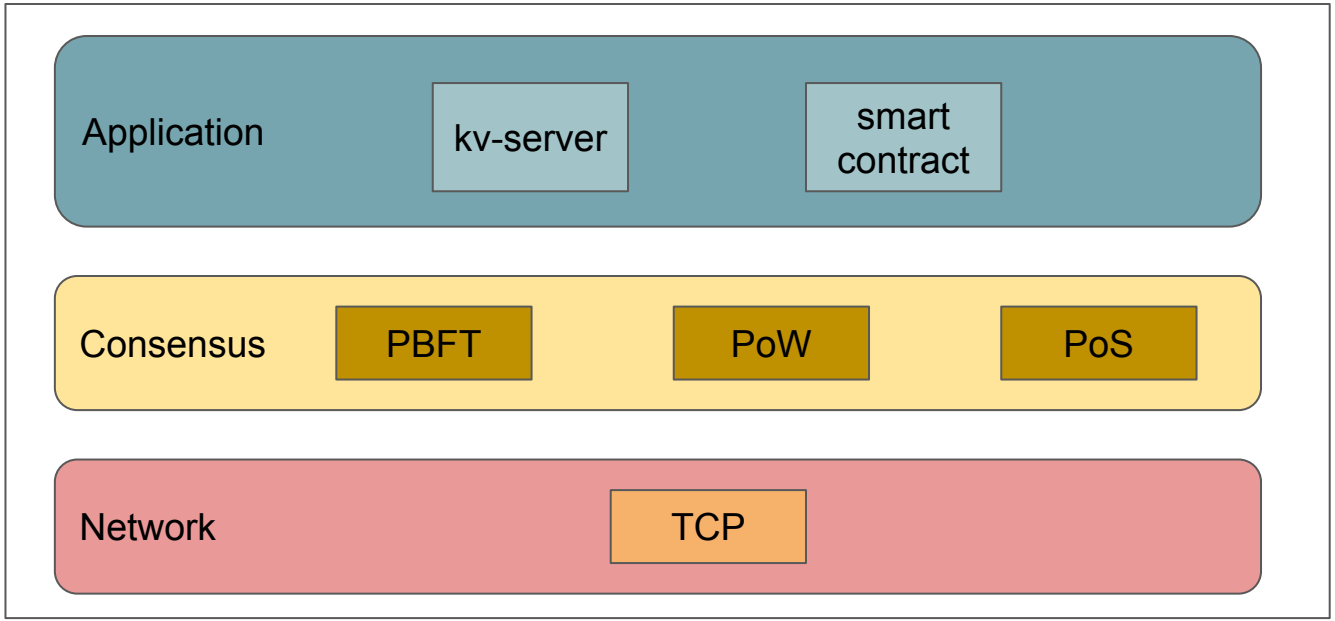
Nexres

Three Layers

1. Application
2. Consensus
3. Network



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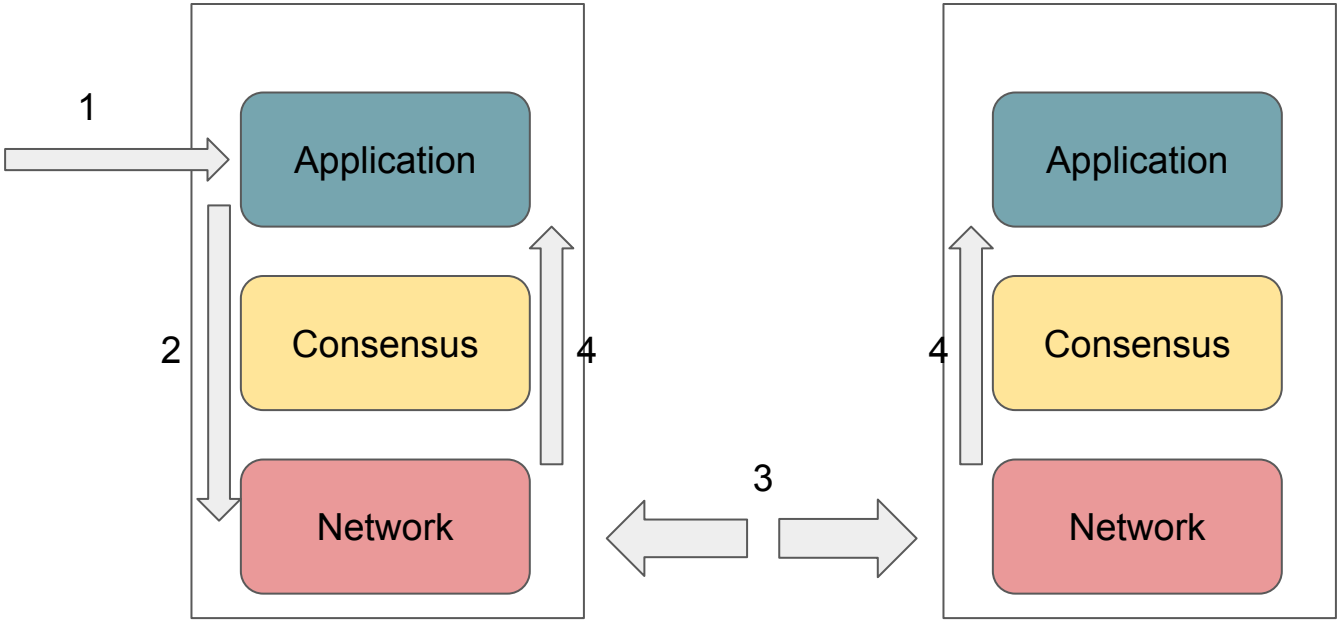
Nexres: Interact with Application SDK



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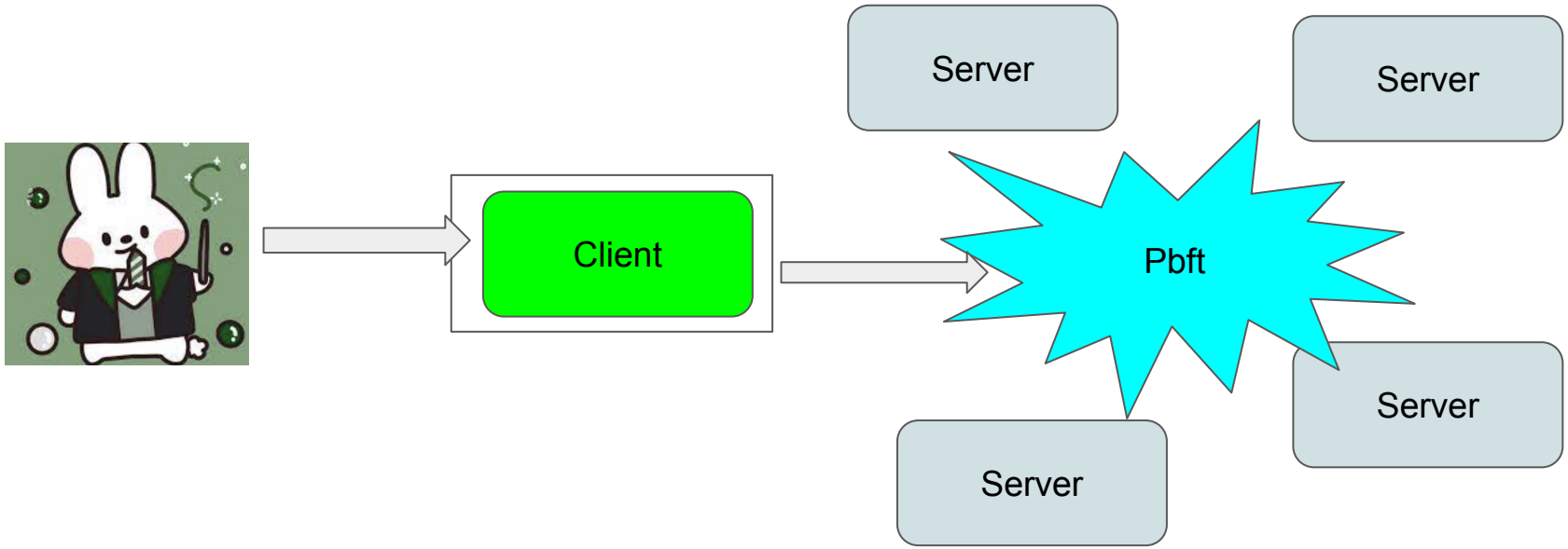
Example: Nexres - KVServer with Pbft



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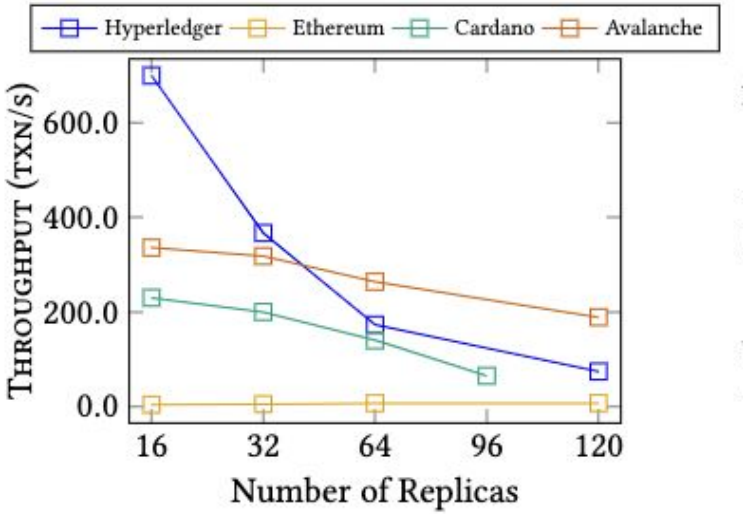
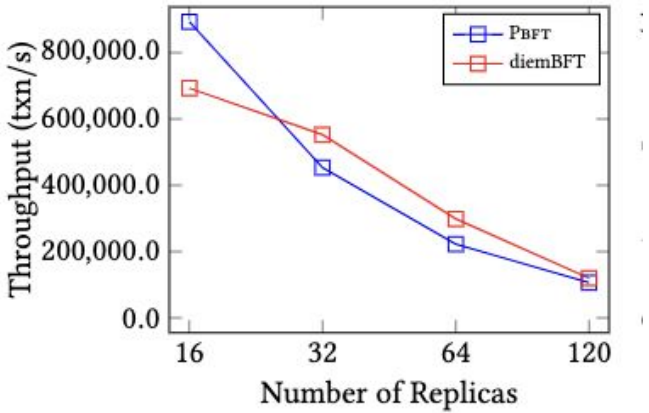
Performance



Nexres



How to run Nexres

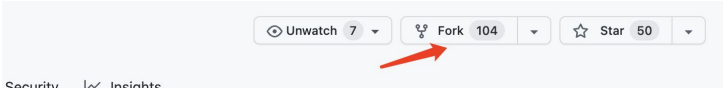
OS: UbUbuntu 20.04

Github:https://github.com/resilientdb/resilientdb/tree/nexres

ResilientDB

How to run Nexres

1. Clone the code: git clone https://github.com/resilientdb/resilientdb.git
   a. remember fork first.



2. Wwitch to nexres branch
   a. git checkout -b nexres remotes/origin/nexres
3. Run the initialization script to set up the environment
   a. sh INSTALL.sh
4. Start the kv server
   a. sh example/start_kv_server.sh (a few minutes to compile)
5. Run client request
   a. bazel-bin/example/kv_server_tools example/kv_client_config.config set cs 265
   b. bazel-bin/example/kv_server_tools example/kv_client_config.config get cs

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Thanks!

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GeoBFT

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Introduction

- Geo-scale Deployments
- What is Clustering
- GeoBFT Consensus

Geo-scale Deployment

GeoBFT is designed to deal with geographical scale deployments in which many replicas are spread across the world.

	Ping round-trip times (ms)						*Bandwidth* (Mbit/s)					
	O	I	M	B	T	S	O	I	M	B	T	S
Oregon (O)	≤ 1	38	65	136	118	161	7998	669	371	194	188	136
Iowa (I)		≤ 1	33	98	153	172		10004	752	243	144	120
Montreal (M)			≤ 1	82	186	202			7977	283	111	102
Belgium (B)				≤ 1	252	270				9728	79	66
Taiwan (T)					≤ 1	137					7998	160
Sydney (S)						≤ 1						7977

Data from Google Cloud experiment

Clustering

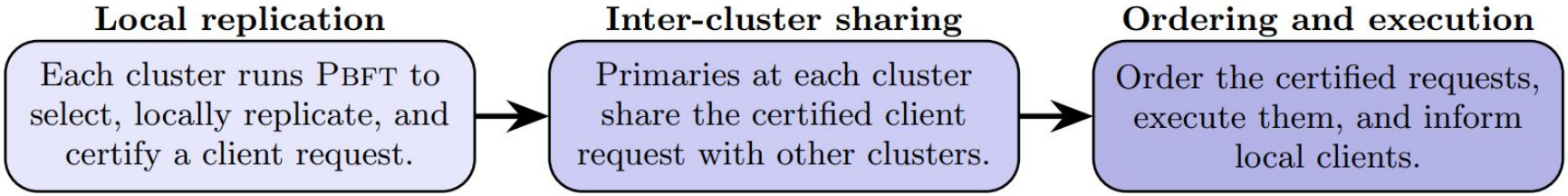
Clustering replicas in a region together, and favoring communication within such clusters over global inter-cluster communication.

Clustering

Clustering replicas in a region together, and favoring communication within such clusters over global inter-cluster communication.

- This makes sure that the protocol is aware of the network topology.
- The protocol is also decentralized, no single replica or cluster should be responsible for coordinating decisions, because centralized design can limit the outgoing bandwidth and latency of that particular replica/cluster.

GeoBFT Protocol

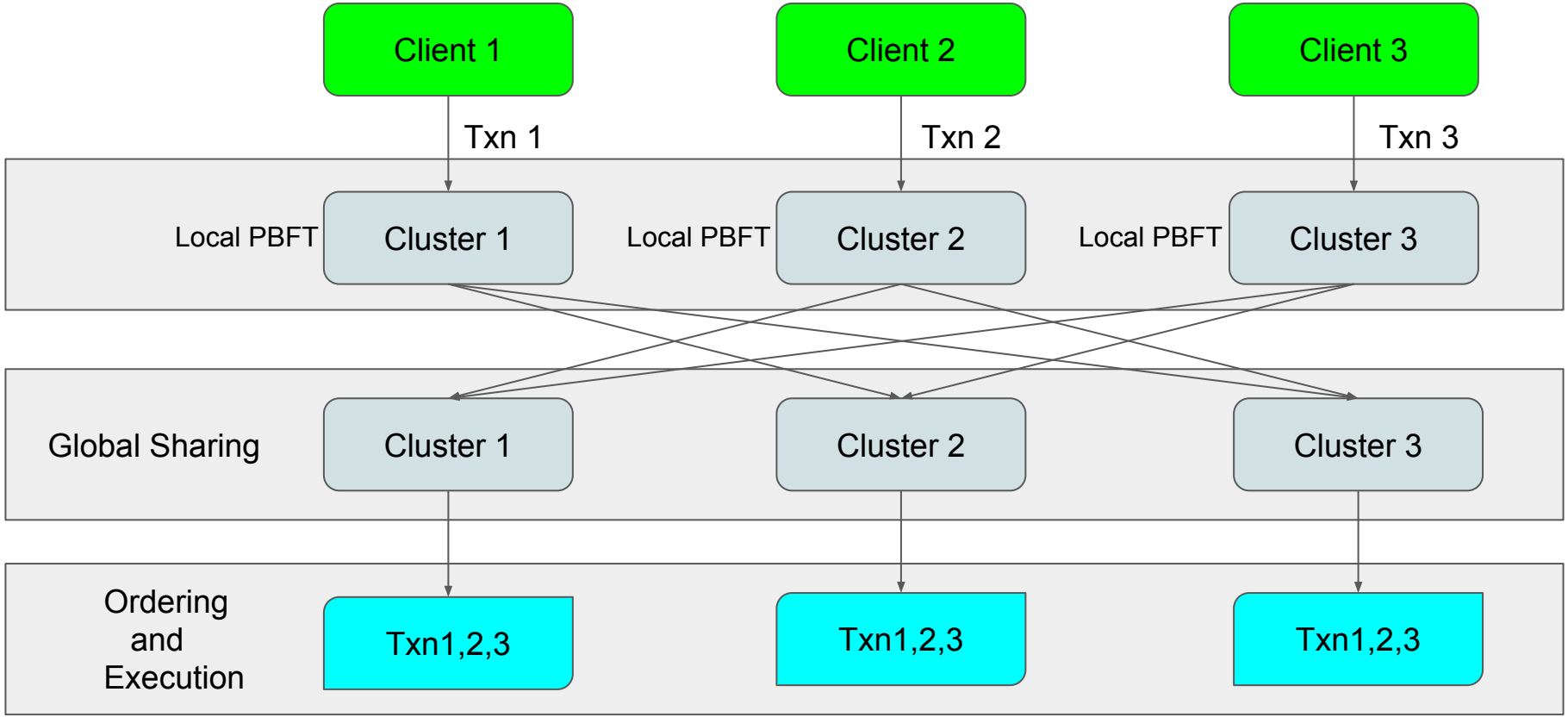


GeoBFT operates in rounds.

There are 3 main steps in each round:

1. Local replication
2. Inter-cluster sharing (Global sharing)
3. Ordering and execution

GeoBFT Protocol



Q & A

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NexRes In Action

@divjeet

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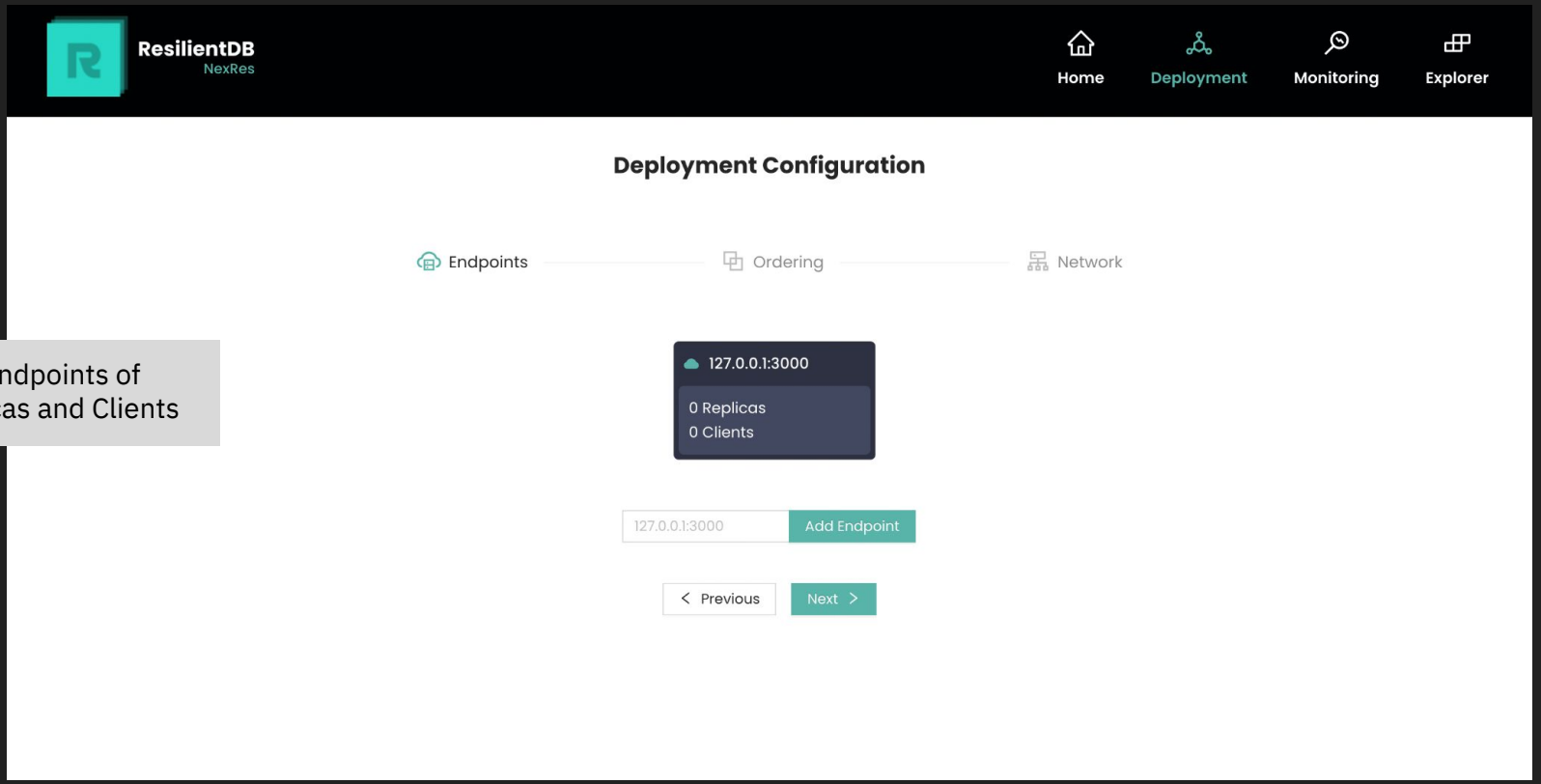
NexRes Application

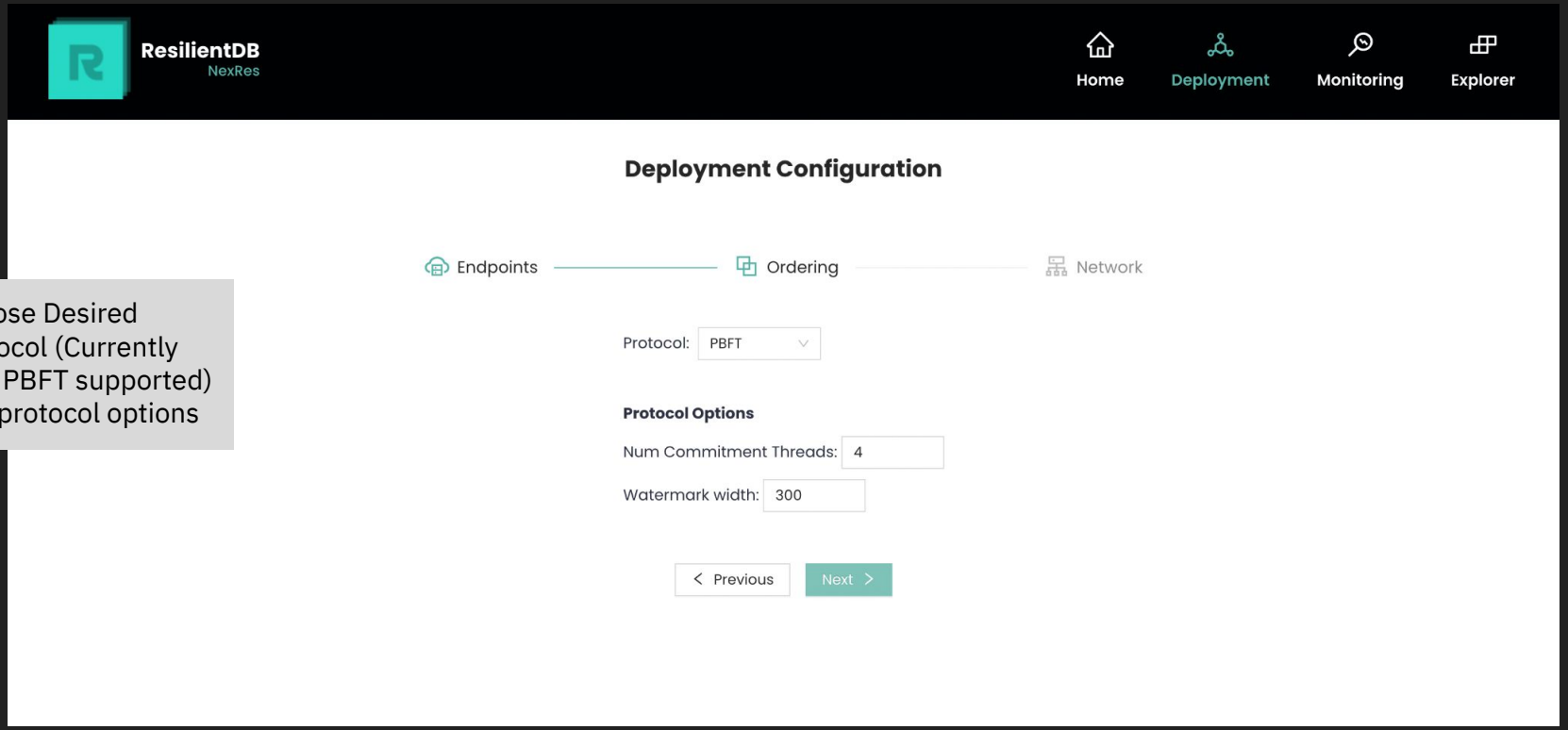
- Deployment Manager
- Block Explorer
- Monitoring Dashboard (Yet to be integrated with NexRes Webapp)
- NFT Marketplace

Deployment Manager (or Node Manager)



Add Endpoints of Replicas and Clients

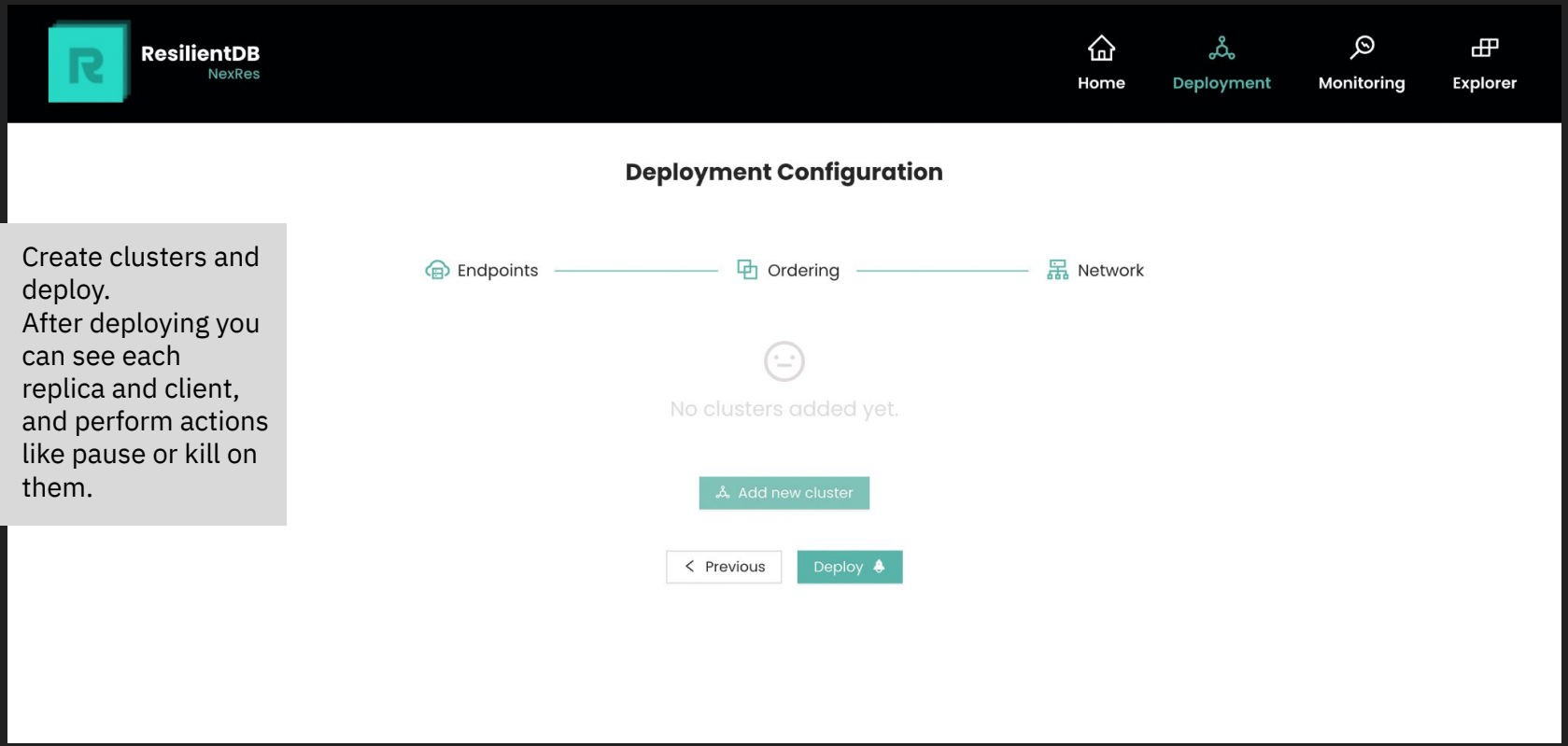
Deployment Manager (or Node Manager)



Choose Desired Protocol (Currently only PBFT supported) and protocol options

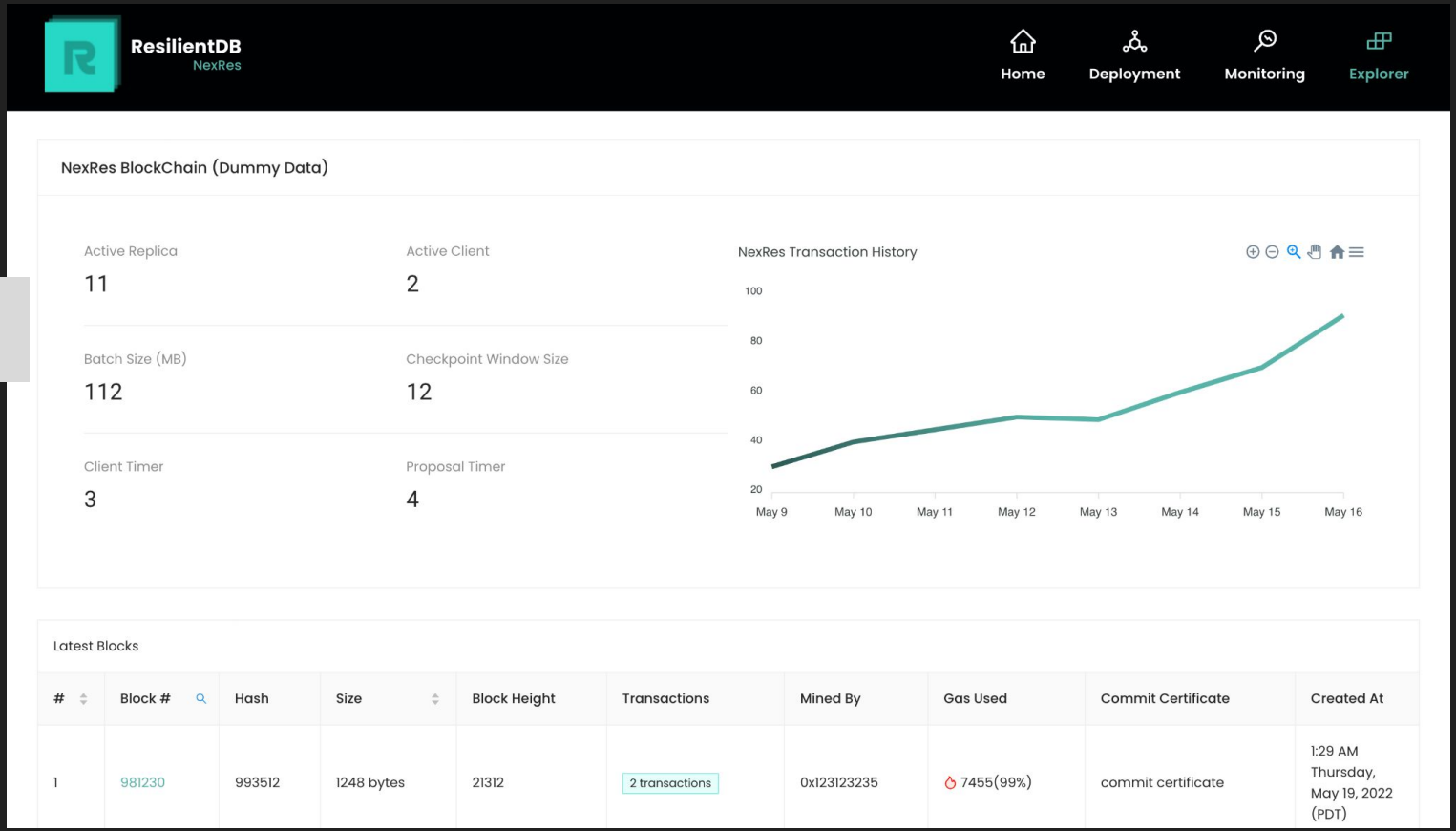
Deployment Manager (or Node Manager)

- Create clusters and deploy.
- After deploying you can see each replica and client, and perform actions like pause or kill on them.



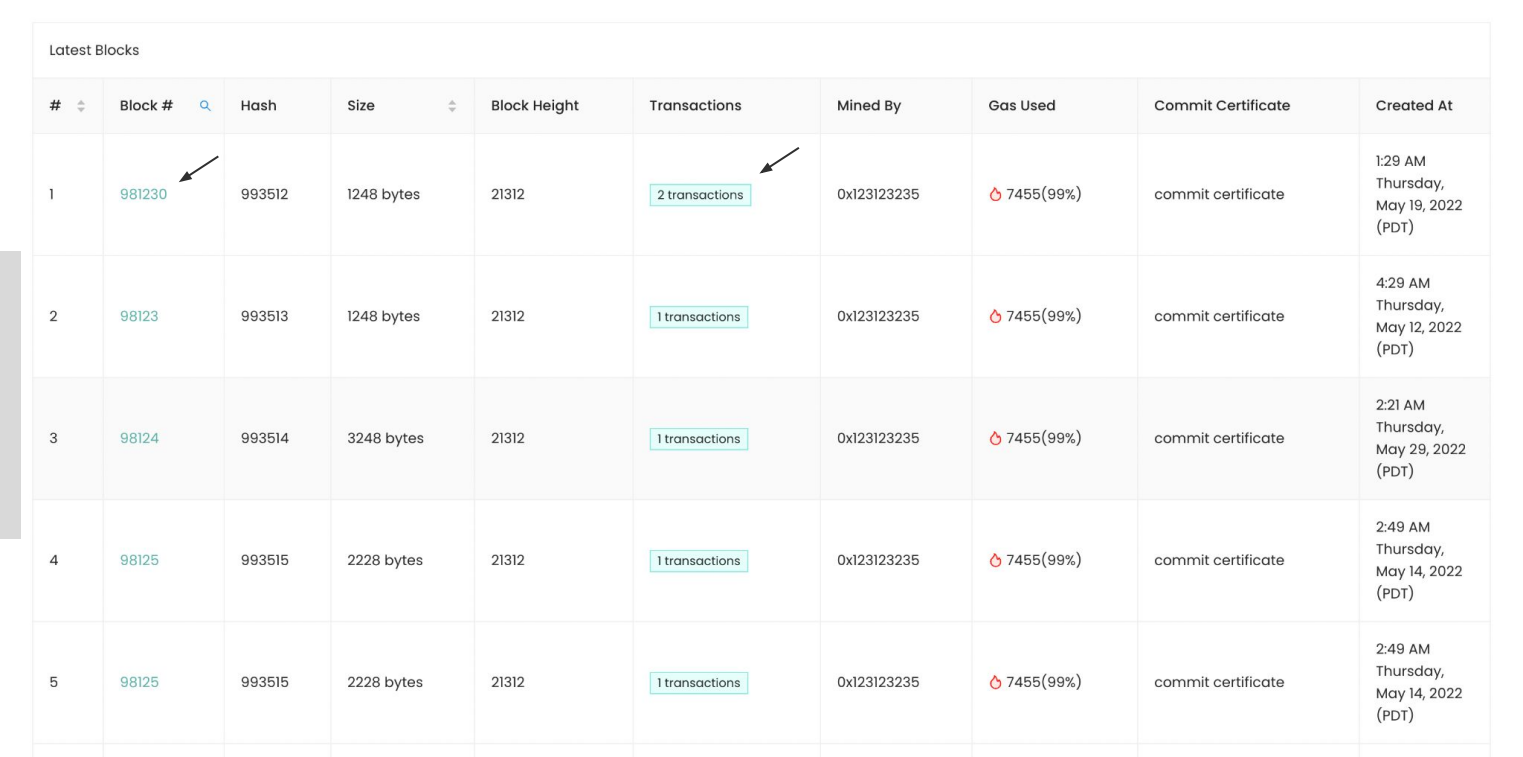
Block Explorer

Gives an overview of the blockchain



Block Explorer

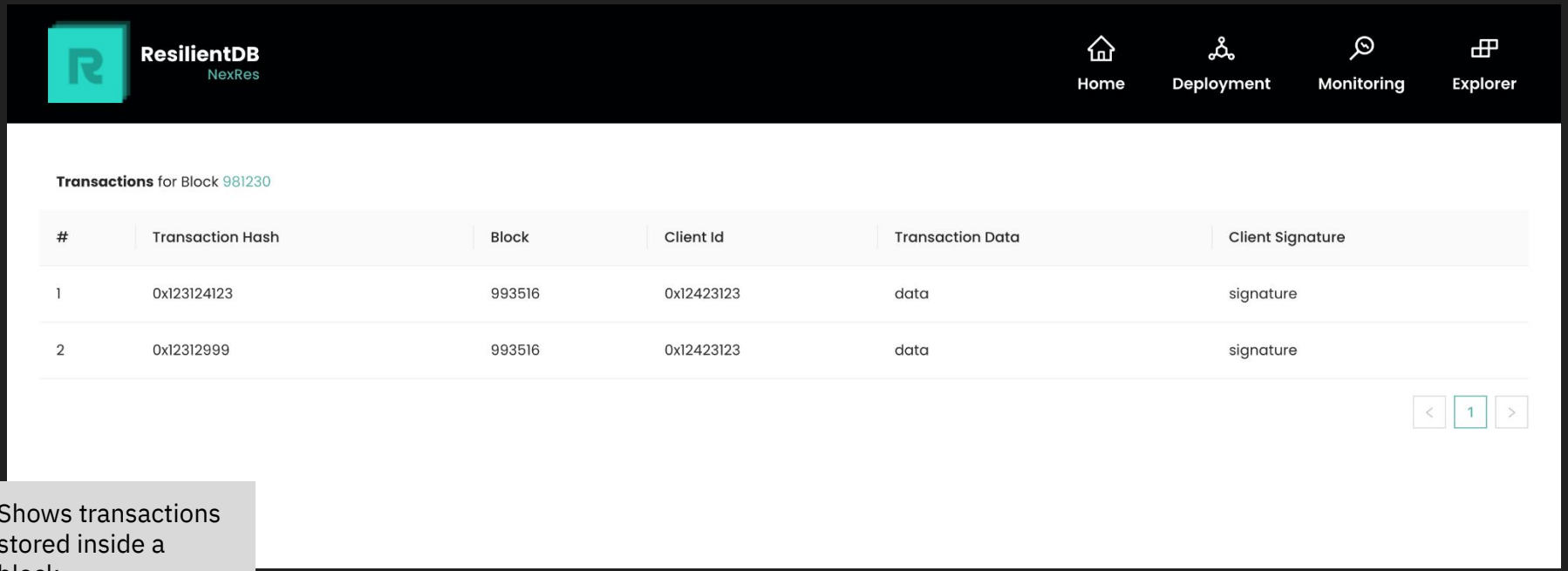
- Shows history of blockchain.
- User can select the block# or transactions to dive deeper as shown.



Latest Blocks

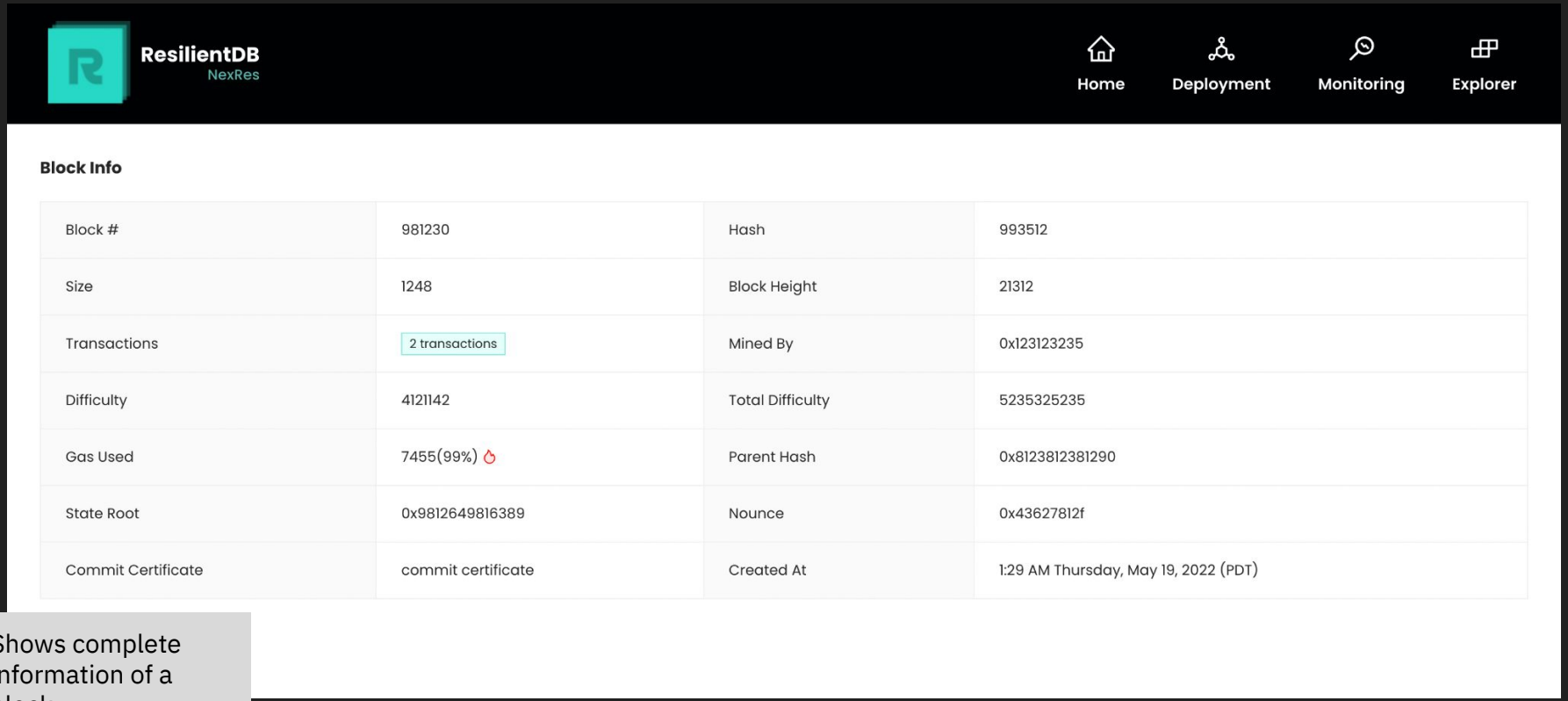
#	Block #	Hash	Size	Block Height	Transactions	Mined By	Gas Used	Commit Certificate	Created At
1	981230	993512	1248 bytes	21312	2 transactions	0x123123235	7455(99%)	commit certificate	1:29 AM Thursday, May 19, 2022 (PDT)
2	98123	993513	1248 bytes	21312	1 transactions	0x123123235	7455(99%)	commit certificate	4:29 AM Thursday, May 12, 2022 (PDT)
3	98124	993514	3248 bytes	21312	1 transactions	0x123123235	7455(99%)	commit certificate	2:21 AM Thursday, May 29, 2022 (PDT)
4	98125	993515	2228 bytes	21312	1 transactions	0x123123235	7455(99%)	commit certificate	2:49 AM Thursday, May 14, 2022 (PDT)
5	98125	993515	2228 bytes	21312	1 transactions	0x123123235	7455(99%)	commit certificate	2:49 AM Thursday, May 14, 2022 (PDT)

Block Explorer



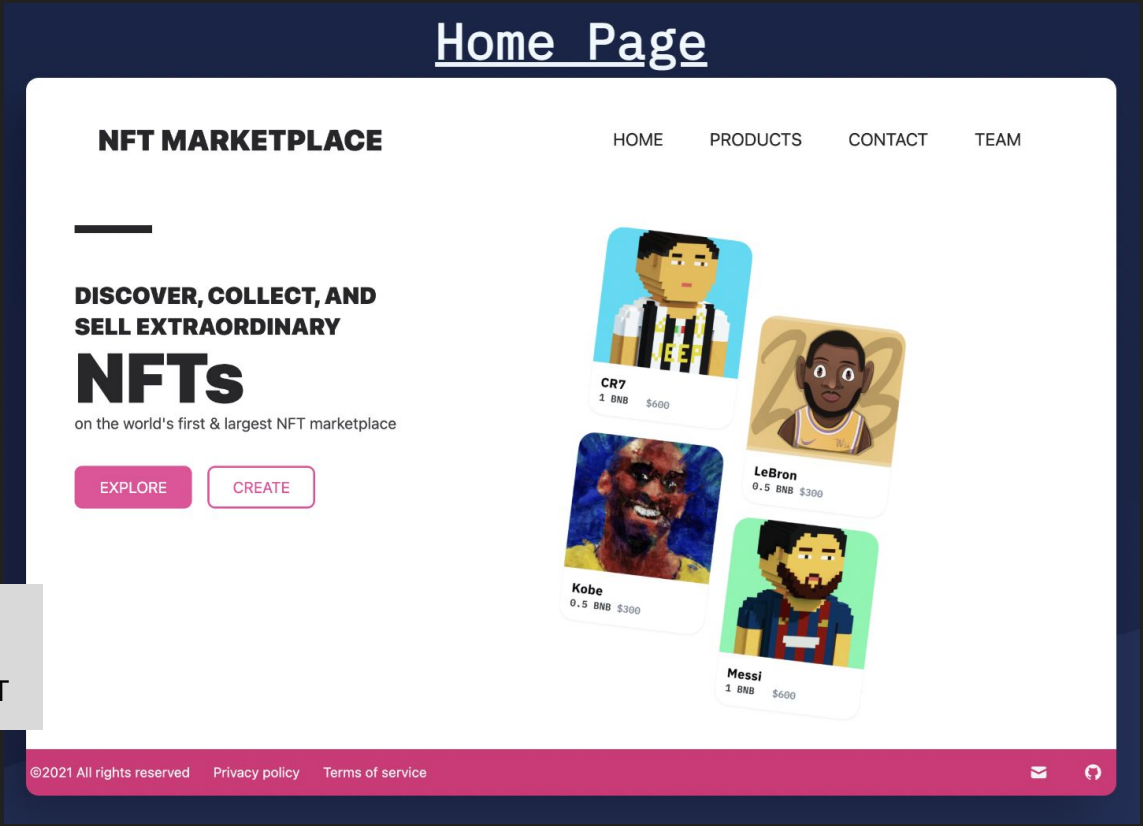
Shows transactions stored inside a block.

Block Explorer



Shows complete information of a block.

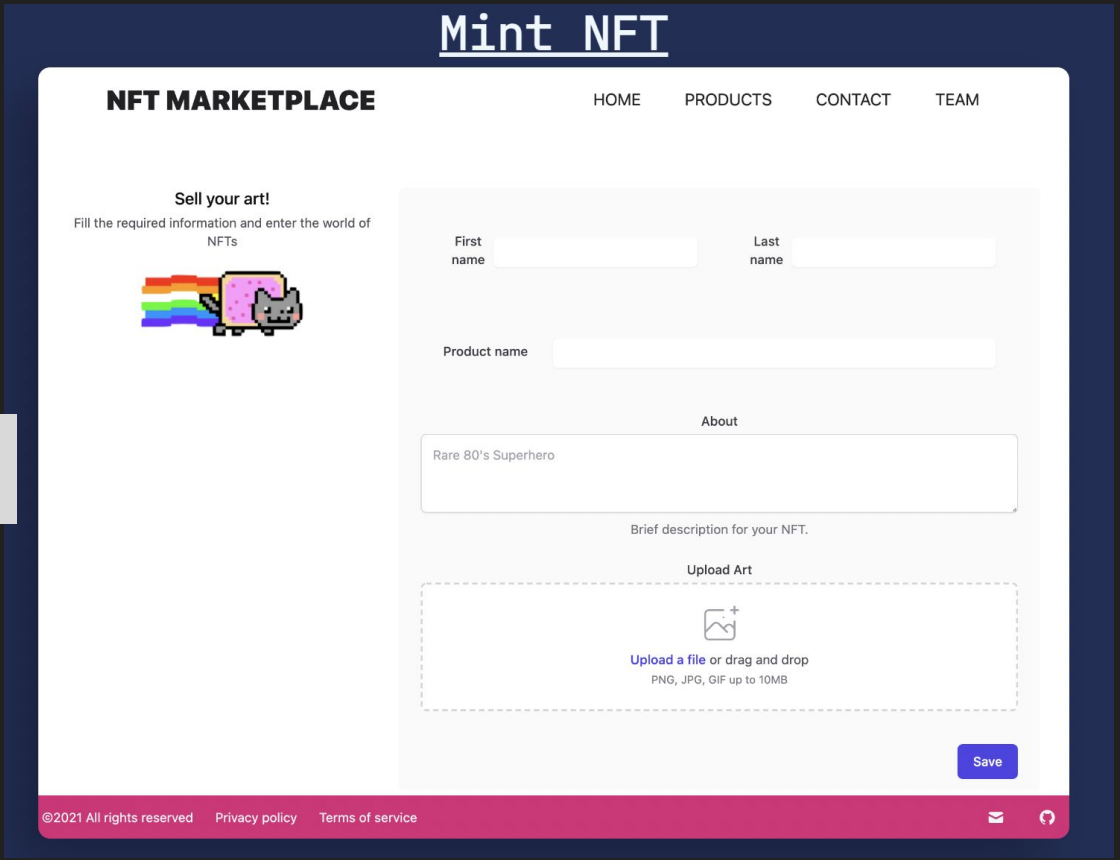
NFT Marketplace



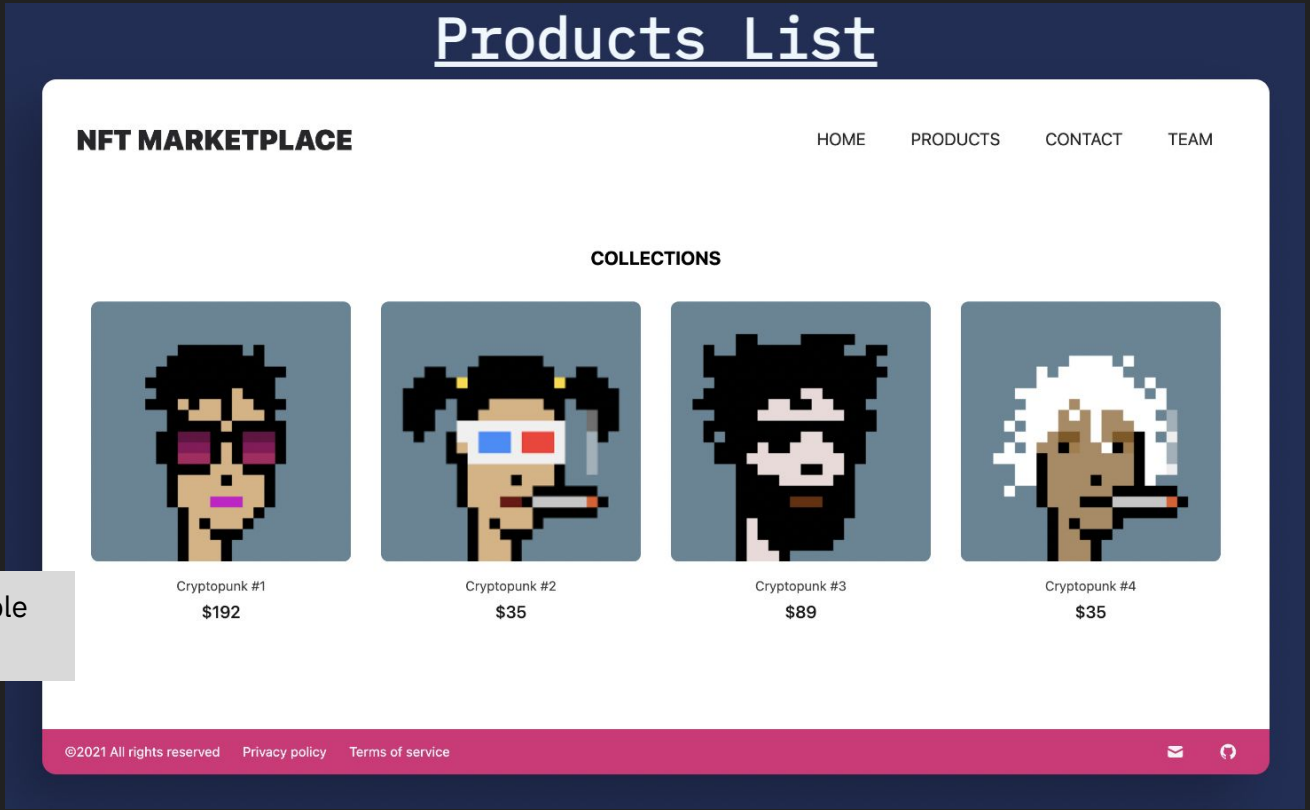
User can either explore or create(mint) an NFT

NFT Marketplace

User can upload a file to mint NFT

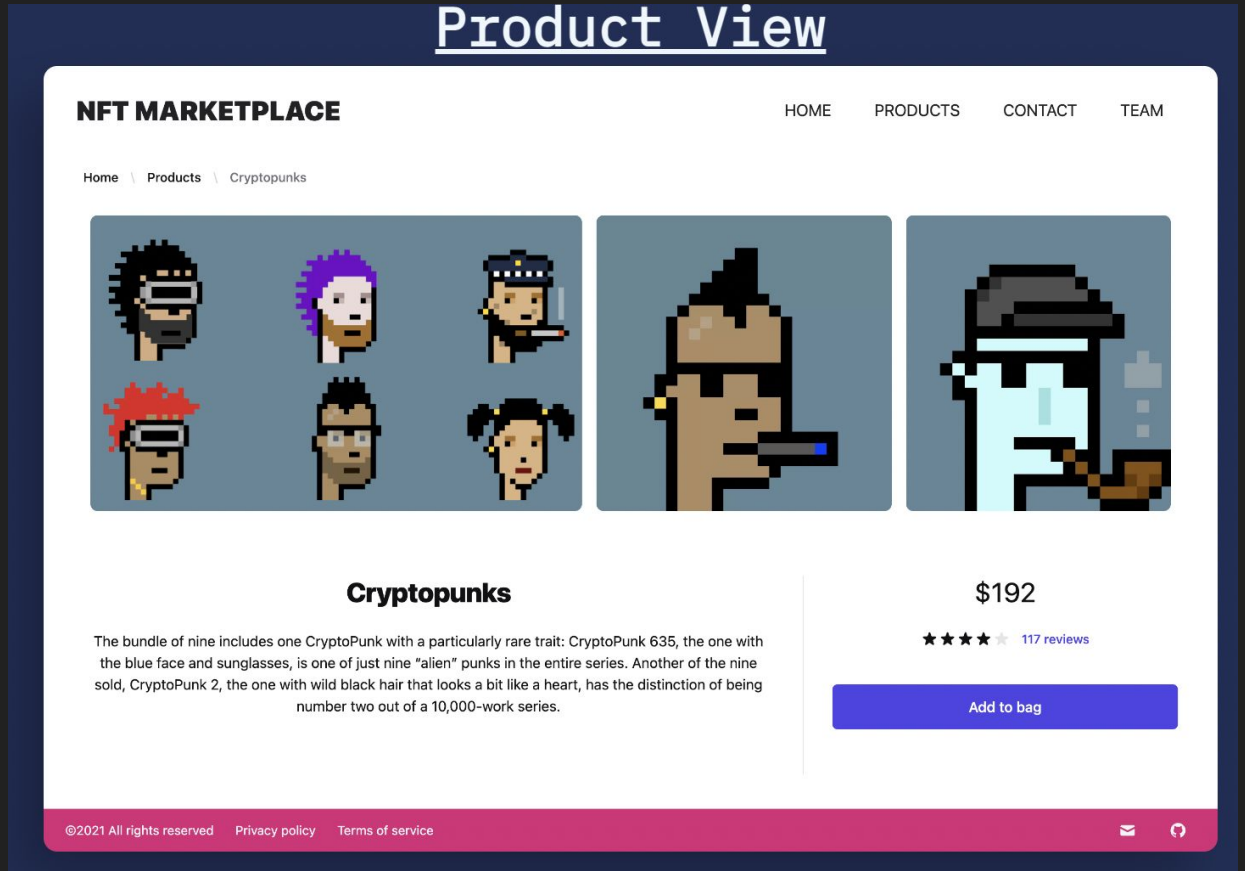


NFT Marketplace



Shows all available NFTs

NFT Marketplace



Project Ideas

- Implement the missing links
  - Connecting Block Explorer to NexRes using the new SDK
  - Connecting Monitoring Dashboard to NexRes Webapp
  - Connecting NFT Marketplace to NexRes using the new SDK
- Implement a crypto wallet on NexRes
  - Add this wallet to NFT Marketplace
- Adding smart contract capabilities to NexRes or more capabilities to the SDK.

Nexres Durability Layer

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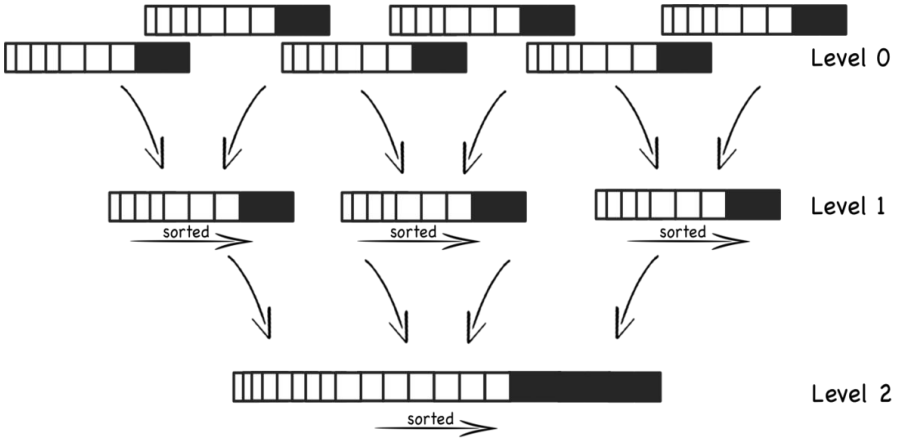
levelDB

- key-value storage library written at google
- data is sorted in key and value pairs
  - order can be changed by callers with custom comparison functions
- storage architecture is a log-structured merge tree (LSM)
  - write-optimized B-tree variant
  - optimized more for large sequential writes compared to small random writes
  - mutable MemTables in memory and immutable SSTables on disk
    - made up of blocks



Compaction continues creating fewer, larger and larger files

https://en.wikipedia.org/wiki/Log-structured_merge-tree

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Standalone LevelDB Performance Benchmarks

Keys: 16 bytes each **Values:** 100 bytes each (50 bytes after compression) **Entries:** 1,000,000

Write Performance

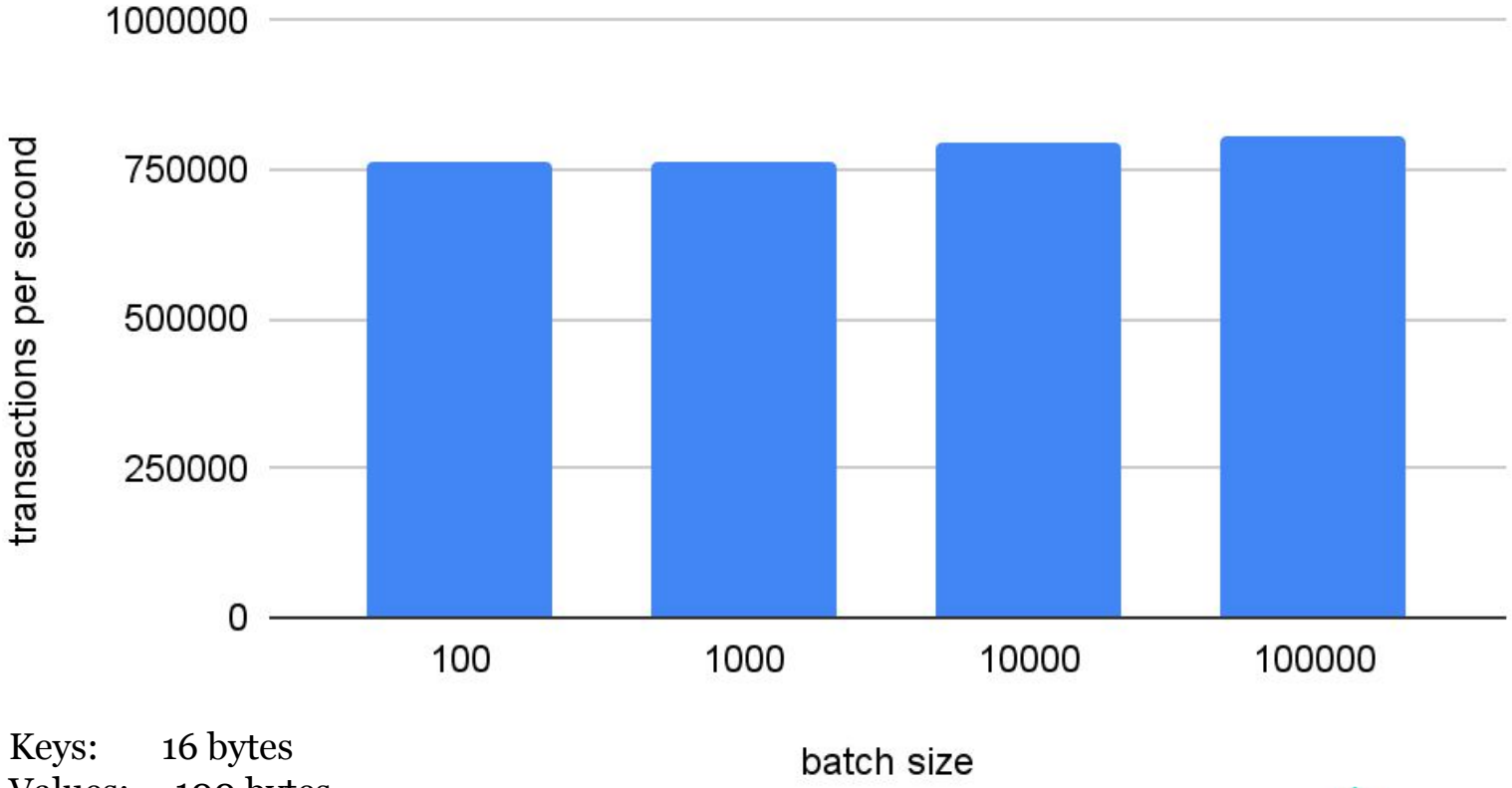
fillseq : 1.765 micros/op; 62.7 MB/s
fillsync : 268.409 micros/op; 0.4 MB/s
fillrandom : 2.460 micros/op; 45.0 MB/s (approx 400,000 writes per second)
overwrite : 2.380 micros/op; 46.5 MB/s

Read Performance

readrandom : 16.677 micros/op; (approximately 60,000 reads per second)
readseq : 0.476 micros/op; 232.3 MB/s
readreverse : 0.724 micros/op; 152.9 MB/s

After compactions:
readrandom : 11.602 micros/op; (approximately 85,000 reads per second)
readseq : 0.423 micros/op; 261.8 MB/s
readreverse : 0.663 micros/op; 166.9 MB/s

LevelDB Batched Writes



Keys: 16 bytes
Values: 100 bytes
Entries: 100,000,000

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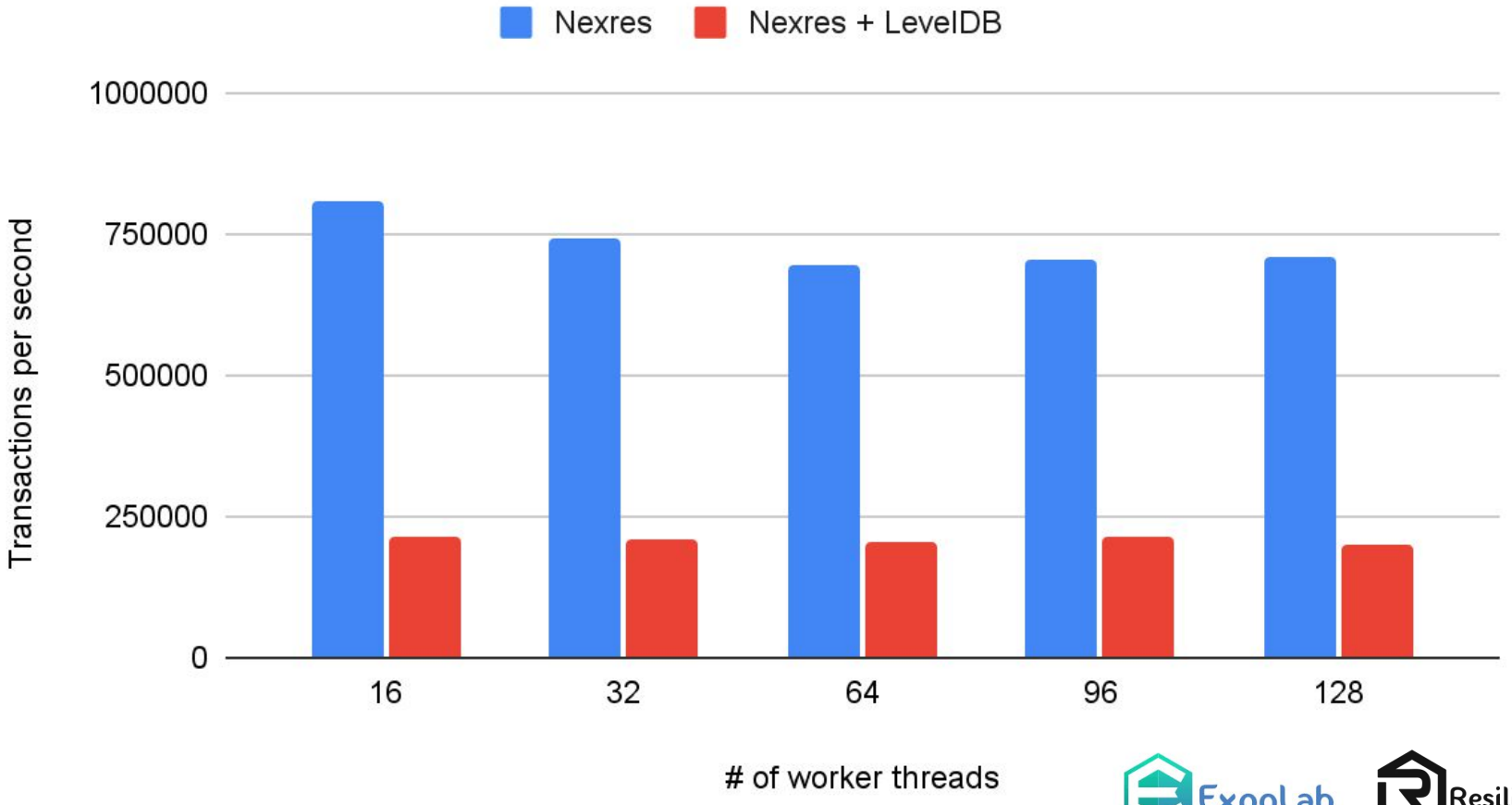
Durability Enabled vs. Disabled Comparison



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Nexres + LevelDB batched writes

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RocksDB

- key-value storage library made by Meta
- optimized for storing small to medium size key-values on flash drives and RAM
- uses log-structured merge-trees
  - consists of a memtable and multiple levels of files on disk
- offers more features than LevelDB, including multiple compaction styles

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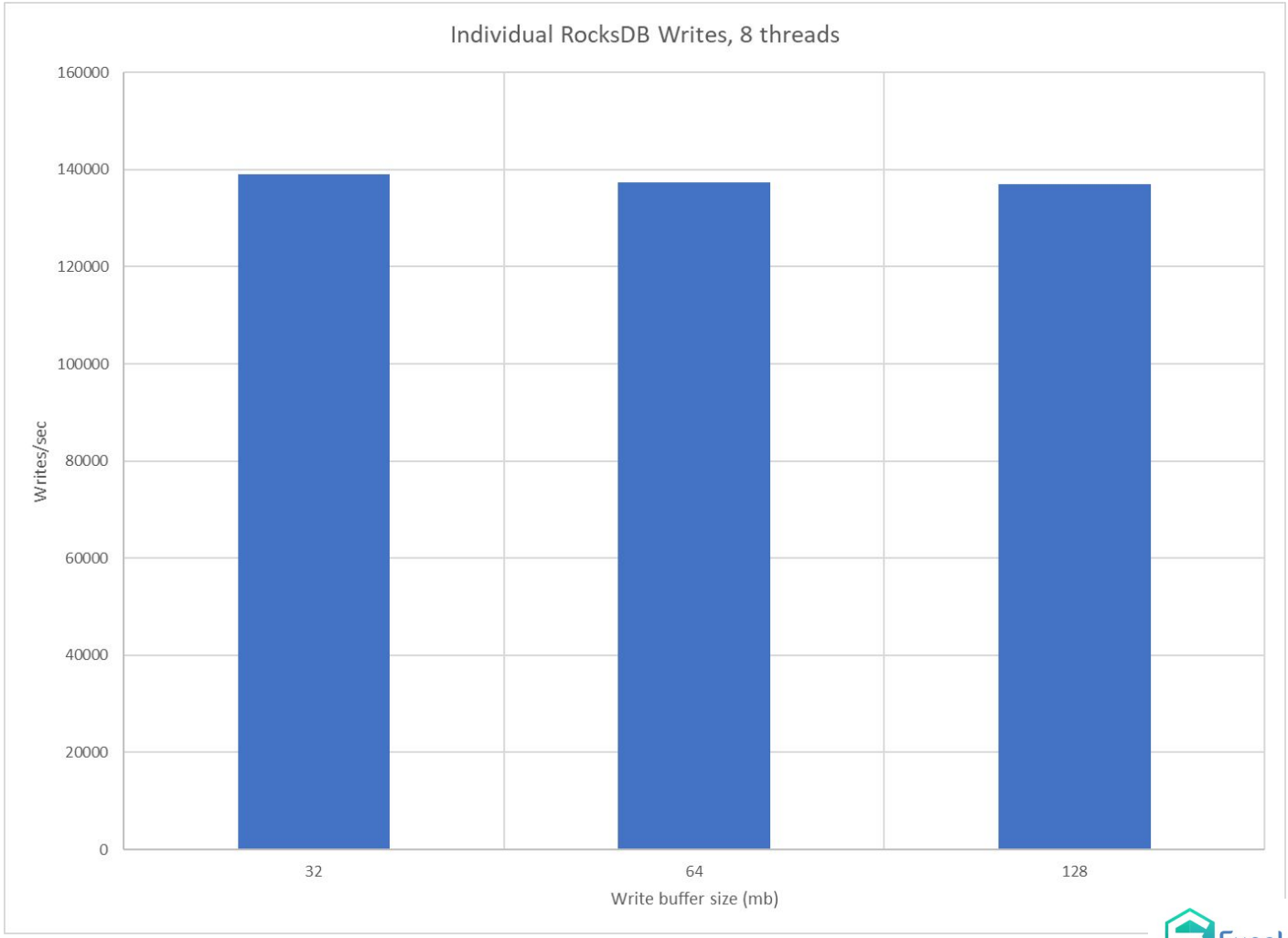
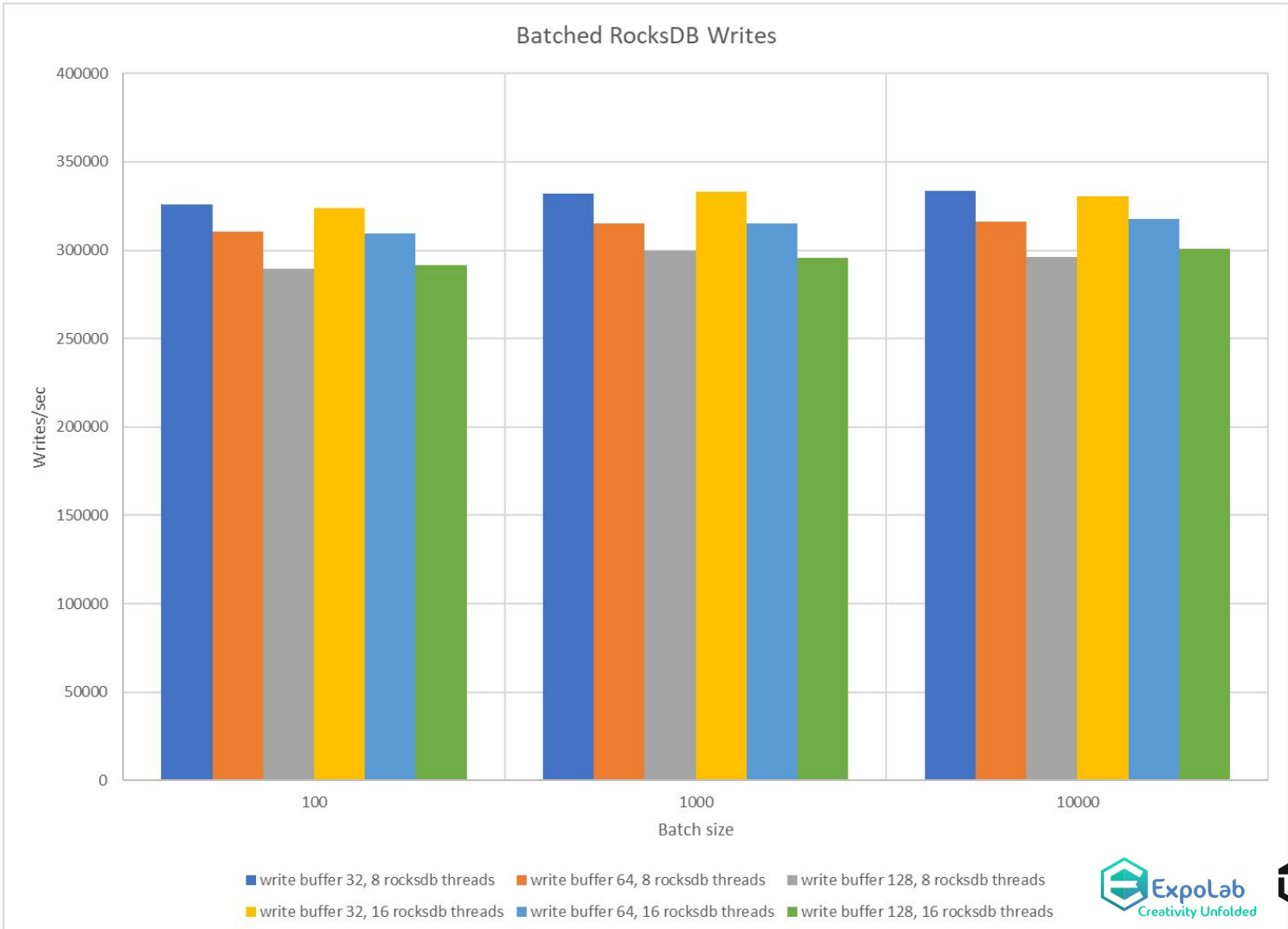
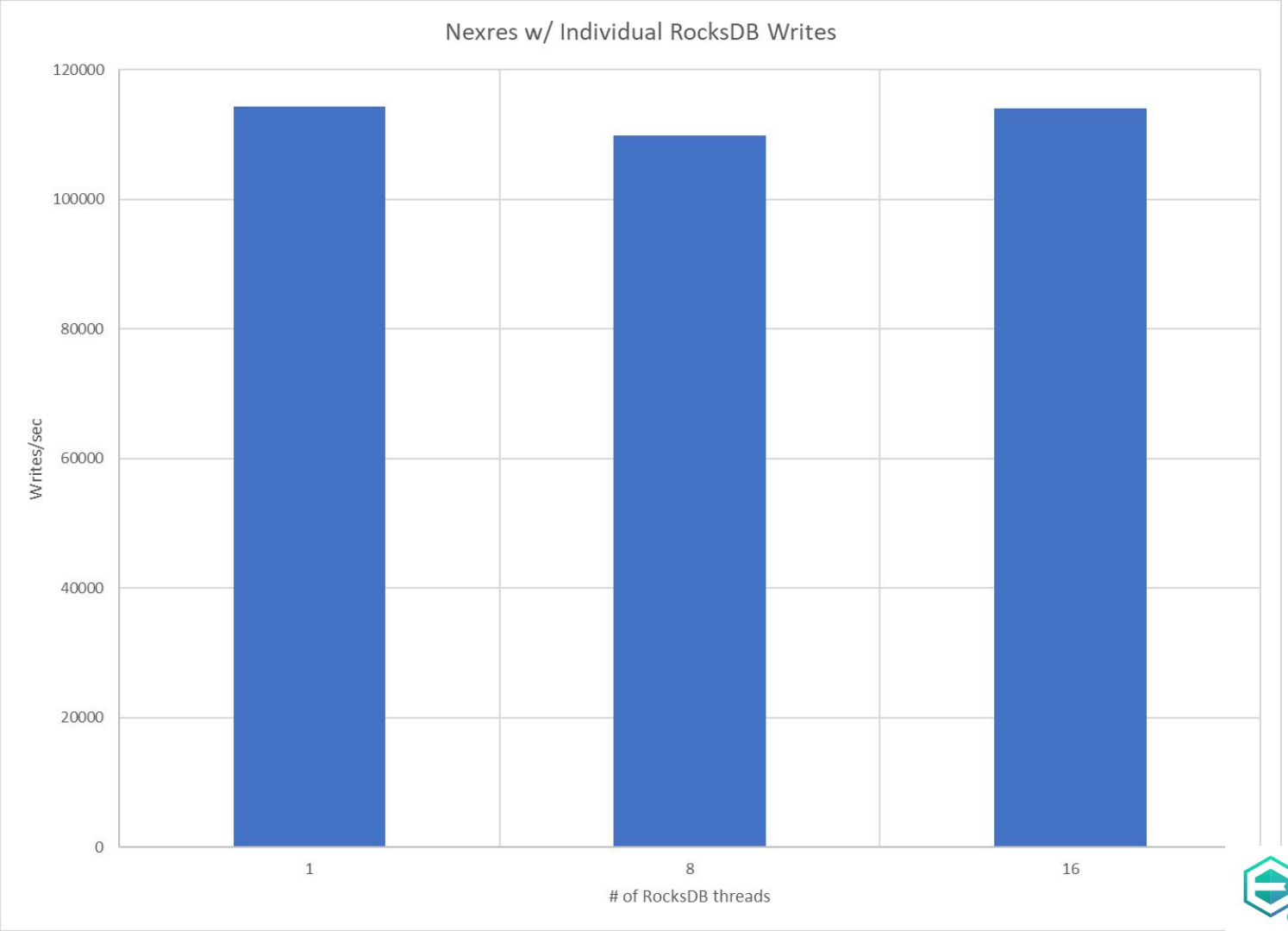
RocksDB Performance Testing

- Key size = 2, value size = 10
  - same as what is used in the provided kv_server_performance tester
- 32 cores, 240 gb RAM
- 4 nodes + client for Nexres







32 MB write buffer size

16 Nexres worker threads

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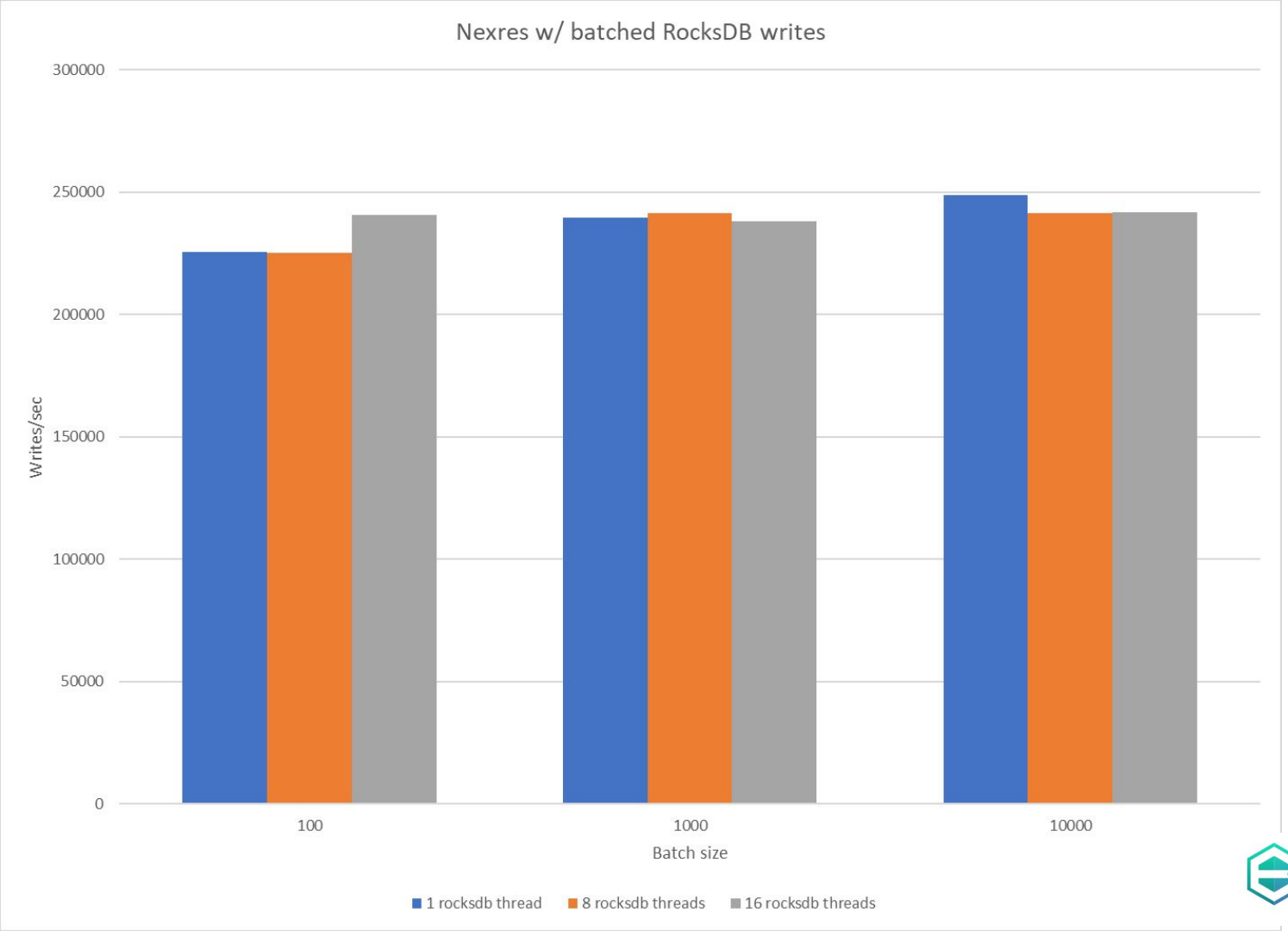

32 MB write buffer size

16 Nexres worker threads

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ResilientDB

Using Durability Options in NexRes

- NexRes uses protobufs to specify format of configuration options
  - similar to JSON format
- rocksdb_info and leveldb_info are optional
  - if they are missing, their enable flags will be set to false by default
- detailed instructions in README of durability_layer folder

Sample config settings that would be placed in a .config file

```
self_region_id:1,
 rocksdb_info : {
   enable_rocksdb:true,
   num_threads:1,
   write_buffer_size_mb:32,
   write_batch_size:1,
 },
 leveldb_info : {
   enable_leveldb:false,
   write_buffer_size_mb:128,
   write_batch_size:1,
 },
```

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NexRes SDK

@aroy @juduarte @gjjchen

Main goal of the sdk

- UTXO-based smart contracts

- Creation and Transfer of Assets

Background

Smart Contract

- Bitcoin script (Not Turing complete)
- Solidity (Turing complete)

Pros and Cons of Turing Completeness

- Any Turing complete programming language create **loops**
- Loops creates a possibility of infinite loops
- Malicious actor can halt the network with endless operation

Gas: Ethereum’s Way of Avoiding Infinite Loops

- A fee you pay for any operation on ethereum
- once all the gas is used up, the network stops processing the contract

What is Crypto-Conditions
Why do we need it

Crypto-Conditions

- A mechanism that allows smart contracts to be developed on top of Bitcoin-protocol-based blockchains
- Basically makes building smart contracts easier for any blockchain
- https://datatracker.ietf.org/doc/html/draft-thomas-crypto-conditions-04

Unspent Transaction Output (UTXO)

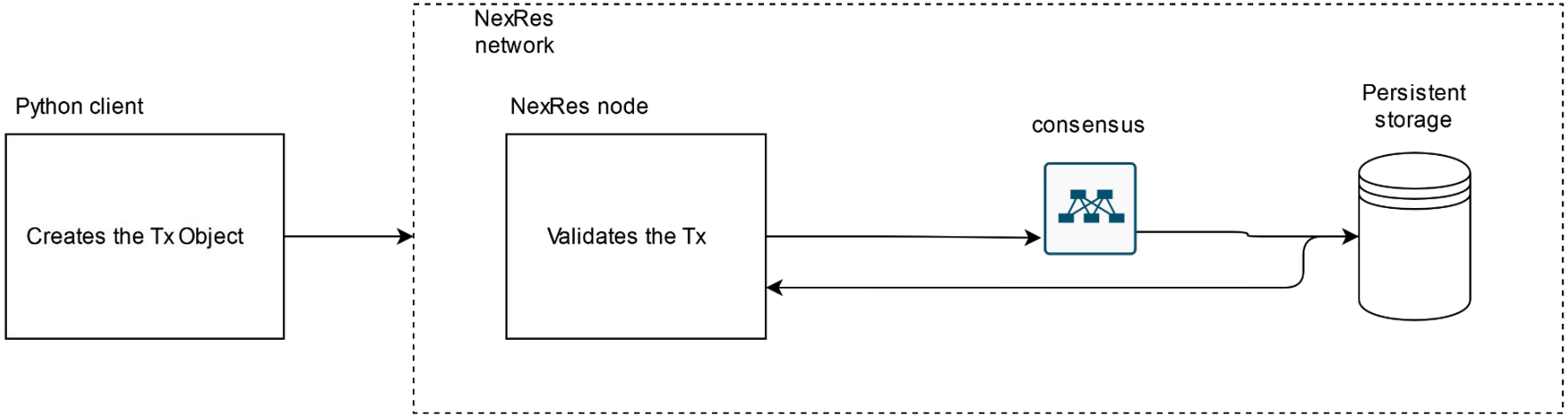
- Cryptocurrency transactions are made of **inputs** and **outputs**
- In a Tx, a user takes one or more UTXOs to serve as the input(s).
- The user provides their digital signature to confirm ownership over the inputs, which result in outputs
- The UTXOs consumed are now considered "spent," and can no longer be used
- Outputs from the transaction become new UTXOs
- Kind of similar to how cash works

UTXO-Based Smart Contracts

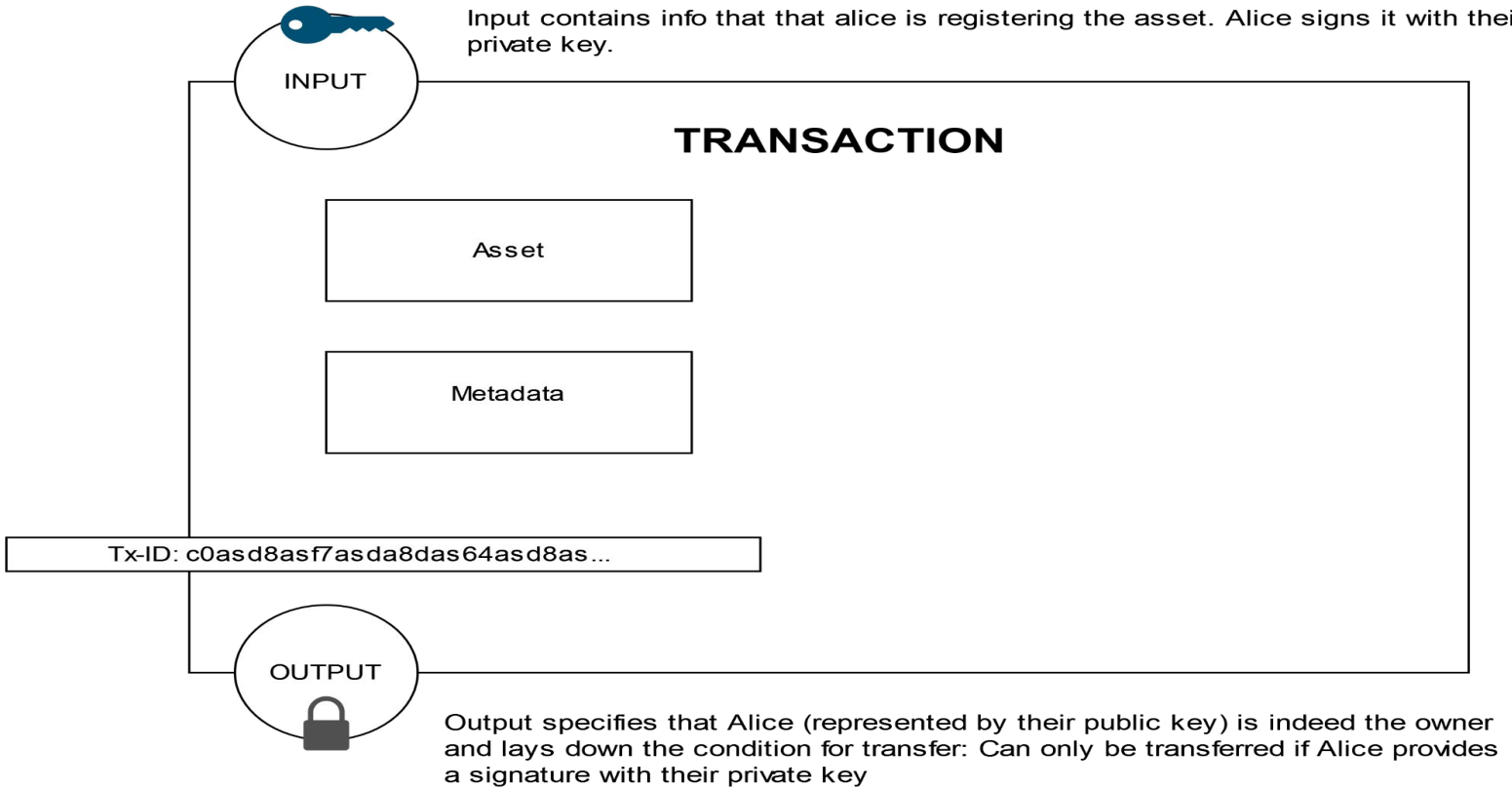
- Lock UTXO in a publicly-known address and prevent those UTXO from being spent until a certain set of conditions has been met
- conditions fulfilled → the UTXO are unlocked and sent to the appropriate address

High level overview of Tx

Architecture



Transaction per BEP-13 specification



Endpoints

- <ip>/v1/transactions/getAssets
  - GET request
  - returns a list of all transactions stored in Nexres
- <ip>/v1/transactions/getAssets/<txId>
  - GET request
  - returns a transaction corresponding to a specific txId
- <ip>/v1/transactions/commit
  - POST request
  - accepts a JSON transaction object and writes it to Nexres
- Available on servers using either Crow or Pistache REST APIs

Pistache vs Crow

HTTP and REST frameworks for C++

Pistache

- Slower than Crow except on local environments with smaller requests
- Hasn't yet hit the 1.0 release
  - might be unstable but should still be production ready

Crow

- Faster than Pistache in most situations, especially when clients and the server are on different machines
- Uses lambda expressions
  - may be slightly harder to learn if you’re planning to modify the endpoints

Demo

Creation and Transfer of assets