

# Software Testing in DLT: Challenges and Use Cases in Financial Services

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# Agenda

- Introduction
- Exactpro test automation approach in pre-DLT era
- Adapting our testing framework for DLT platforms
- Case studies
- Q & As

# Exactpro Overview

Exactpro provides software testing services for mission critical technology that underpins global financial markets. The firm is experienced with trading and clearing and settlement platforms, market data systems, collateral management and risk management systems, central data warehouses, regulatory reporting, etc.



A specialist firm focused on functional and non-functional testing of exchanges, clearing houses, depositories, trade repositories and other financial market infrastructures.



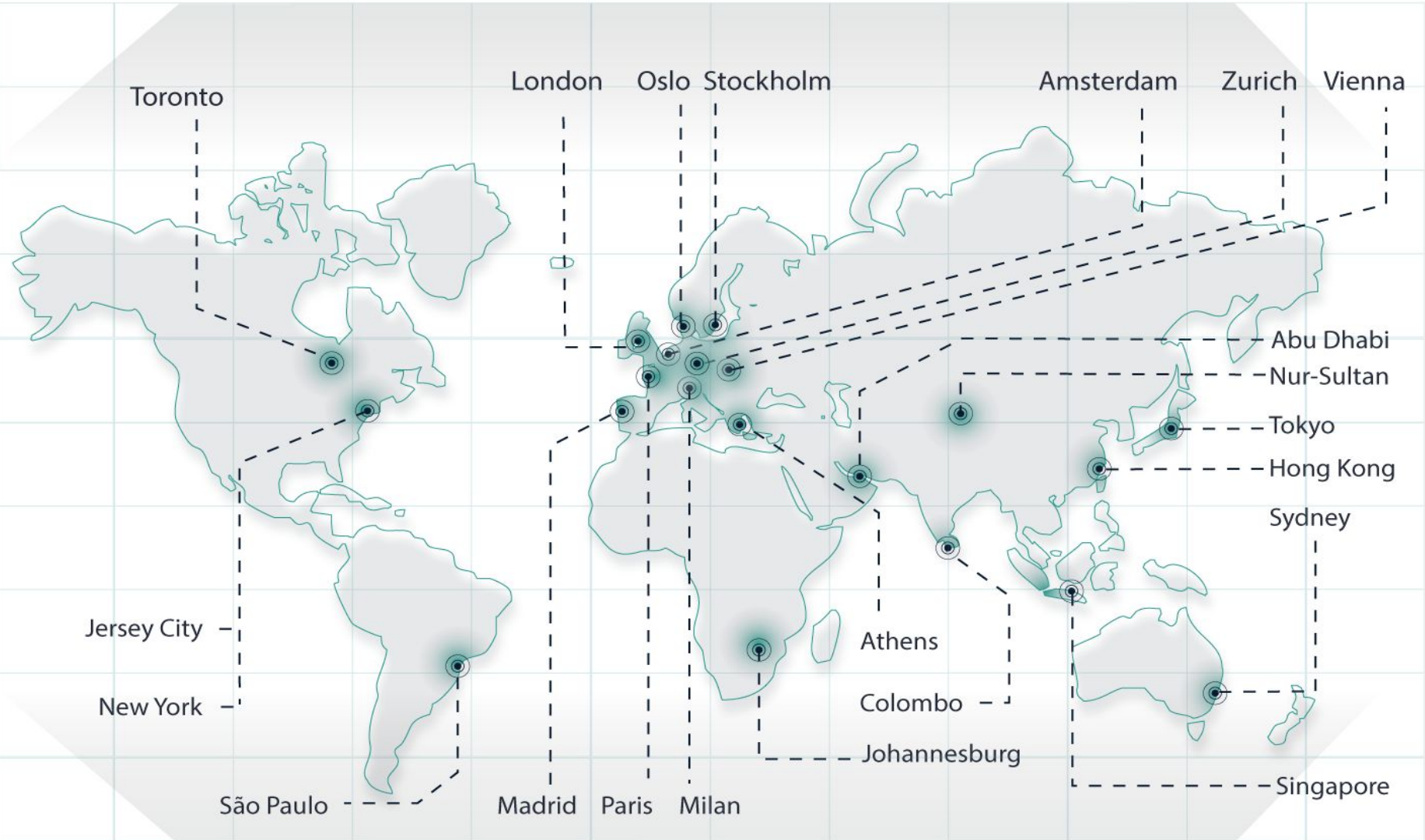
Headquartered in the UK with operations in the US and Eastern Europe. The clients are regulated by the FCA, Bank of England and their counterparts from other countries.



Part of the London Stock Exchange Group (LSEG) from May 2015 until January 2018, when the Exactpro management proceeded through the buyout of the company from LSEG.



Incorporated in 2009 with 10 people, Exactpro is now employing over 590 specialists.



# New space: Digital exchanges and DLT-based platforms

**DAML**

Exactpro Enables  
ClearTH Test Automation  
Framework for **DAML-BUILT  
APPLICATIONS**



**r3** **c-rda** exactpro

**EXACTPRO AWARDED  
INNOVATION ACCOLADE  
FOR BLOCKCHAIN PROJECT  
WITH R3**

QA Financial



CASE STUDY

**TESTING DISTRIBUTED  
LEDGER TECHNOLOGY  
(DLT) PLATFORMS  
AND INFRASTRUCTURES**



**DEX**

Exactpro Supports DEX with  
Institutional Grade  
Infrastructure



**ZUVR**

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**New Digital  
Derivatives  
Platform**

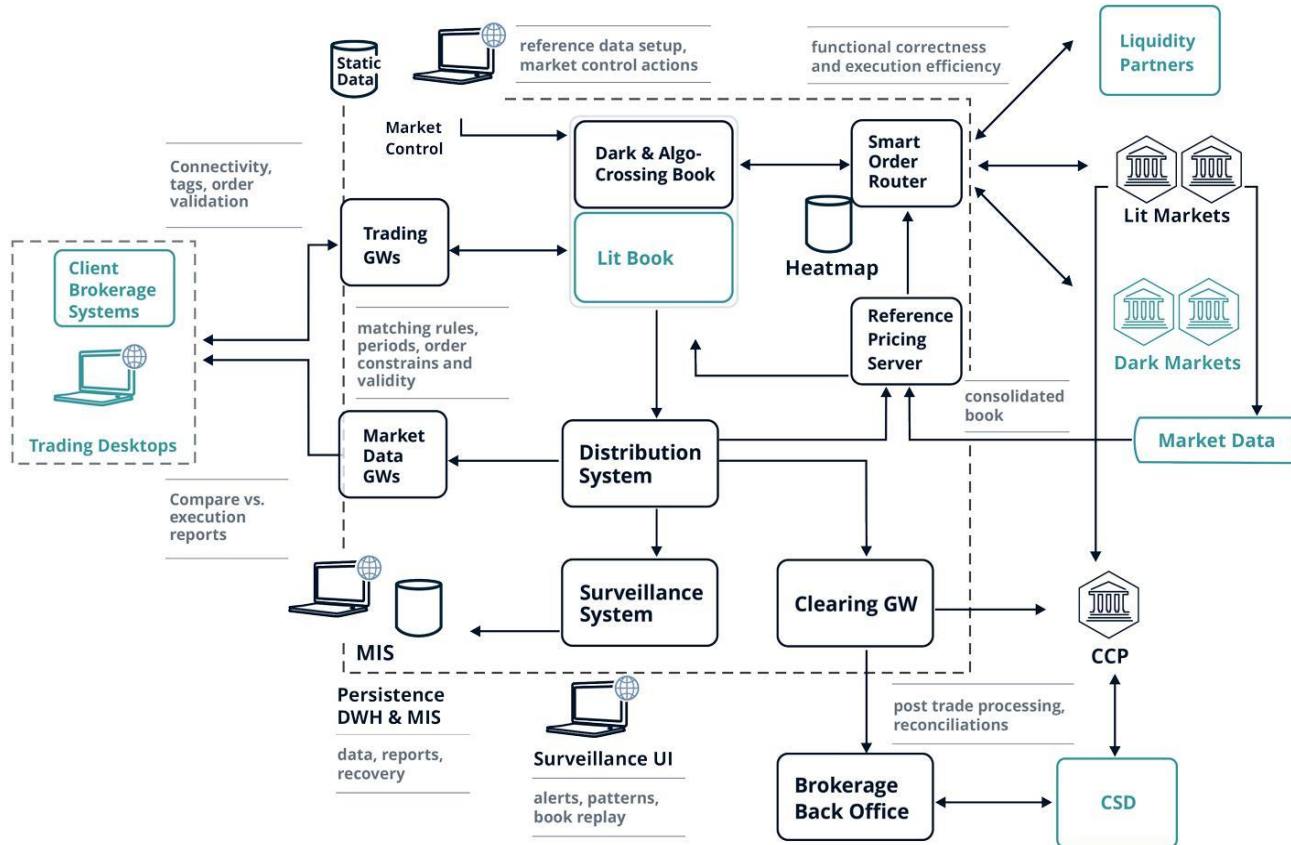


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**EXACTPRO'S APPROACH  
TO FUNCTIONAL TESTING  
OF DISTRIBUTED LEDGER  
TECHNOLOGY PLATFORMS**



# Complex financial platforms

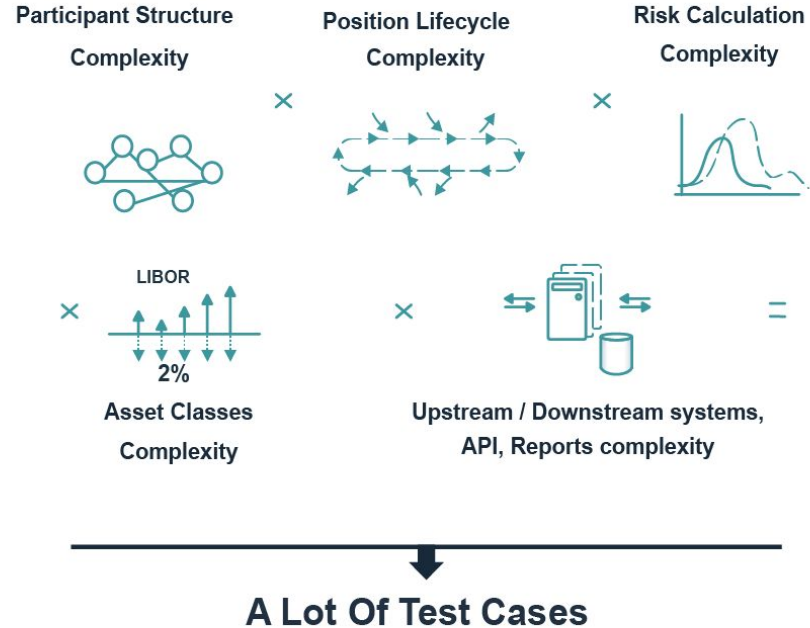


# Testing of Post Trade: Key Challenges

## Challenges:

- There is a multitude of components in modern complex post-trade infrastructures;
- Upstream and downstream system dependency;
- The participant structure is very complex;
- Trade/Xfer/Position/Account life cycle;
- The number of Asset Classes may vary;
- The complexity of the Risk calculation process;
- Access via a set of API endpoints.

The challenges and their parameterizations lead to a significant number of test scenarios.





**ClearTH** – a tool targeted at clearing, settlement and back-office systems.

- Verifies each stage of the DLC
- Has an integrated schedule
- Automatically runs test scripts
- Creates multiple-day test scenarios
- Performs multiple concurrent tests
- Has integrated simulators
- Supports SWIFT ISO protocol



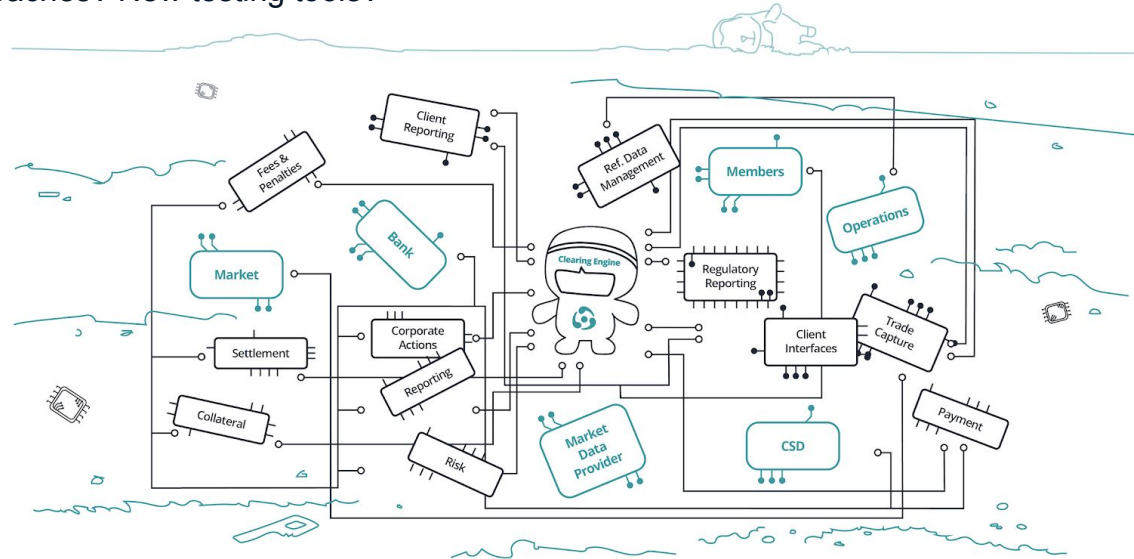
**Woodpecker** – a ClearTH extension acting as a platform for daemons combining functional and non-functional test approaches.

- Highly customizable (data source, data types, load, time, interface)
- Easy to transfer to different environments due to its ability to extract data right from the system under test
- Automatically generated test scenarios cover a vast majority of diverse conditions/data combinations
- A productive intersection of functional and non-functional testing approaches



# DLT and Technology Transformation

- ⇒ Many financial institutions adopt DLT;
- ⇒ Traditional platforms undergo transformation;
- ⇒ The changes are significant, so new infrastructures need thorough testing;
- ⇒ New platforms -> new test approaches? New testing tools?



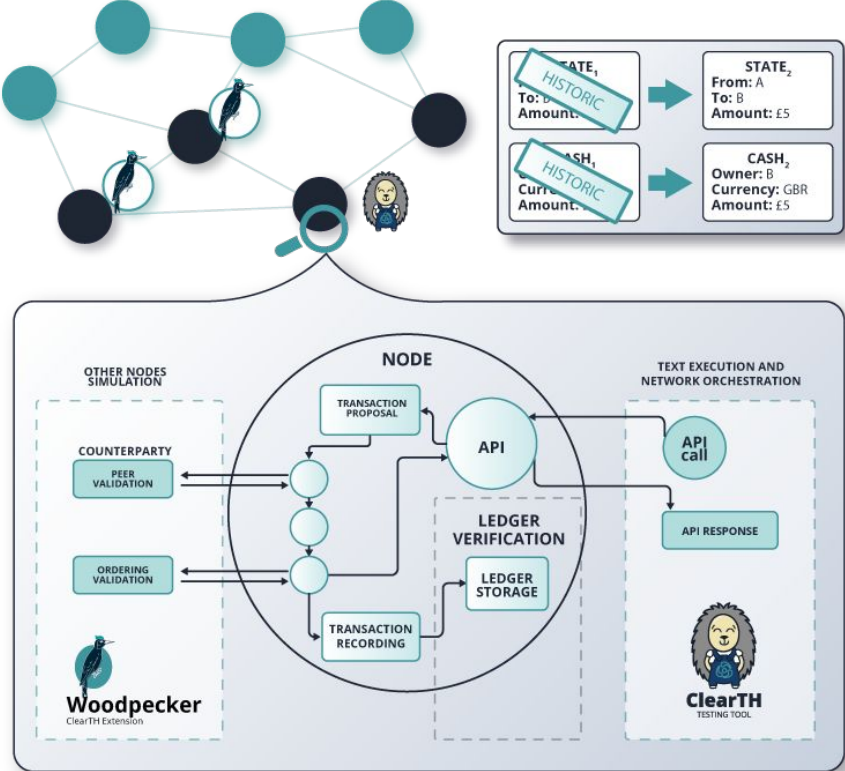
- **Complexity** – DLT-based infrastructures are complex and vary in their architecture. They can be extremely heterogeneous, i.e. it can be possible to deploy different versions of an application on different security devices, different databases, different Java machines and operating systems. This creates a combinatorial explosion when one tries to test them.
- **Interoperability** – A number of issues arise at the confluence between a distributed ledger and its connectivity to a non-DLT platform.
- **High transaction throughput** – such platforms are expected to be performant. So, it is necessary to do quite sophisticated performance tests.
- DLT-based infrastructures can be highly **distributed and multi-threaded**; that requires security, they need to be consistent (e.g. it becomes consistent after a certain delay).
- DLT platforms evolve because there are **continuous upgrades** to nodes, applications, networks.
- **High availability** (HA) is a must. The instruments ensuring there is no double-spend need to be highly resilient.

# Testing for Distributed Ledger Technology Platforms – Approach

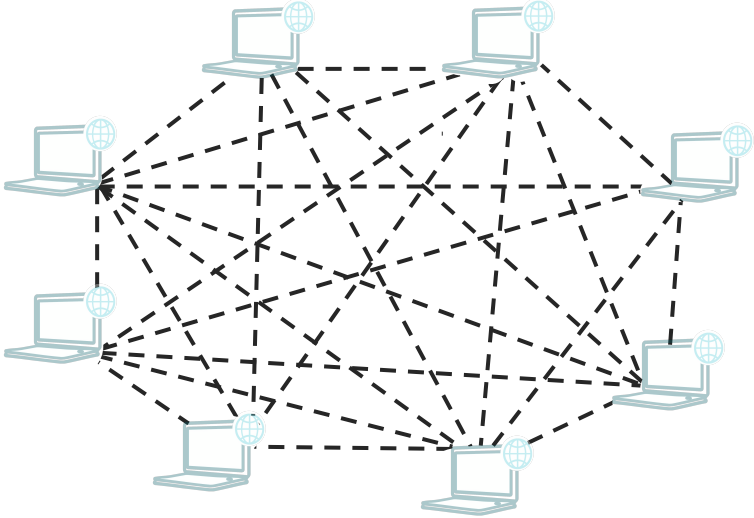
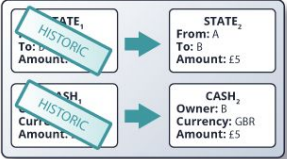
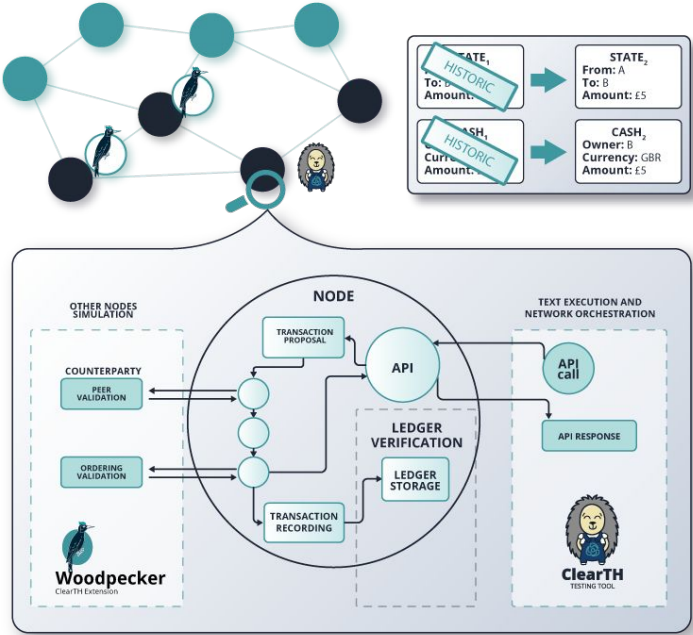


Functional testing

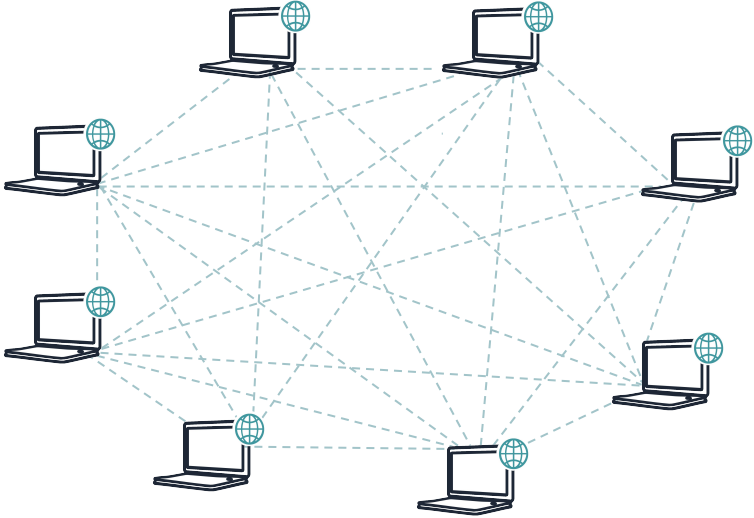
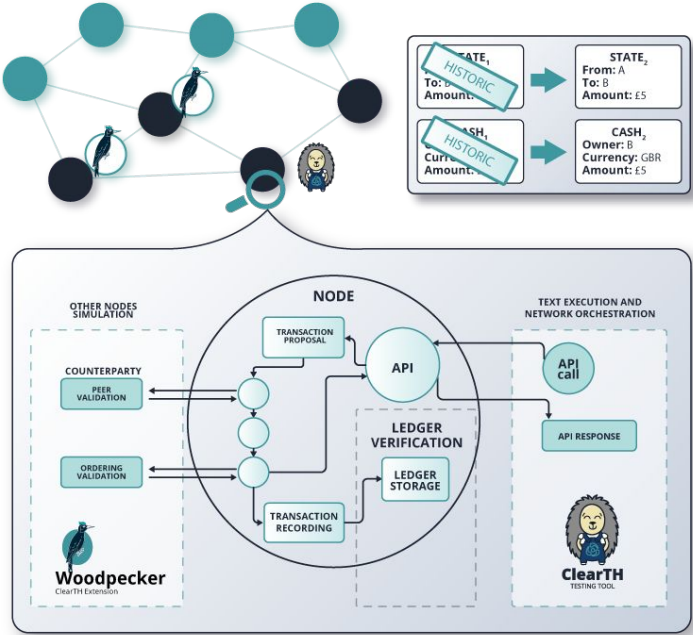
Non-functional testing



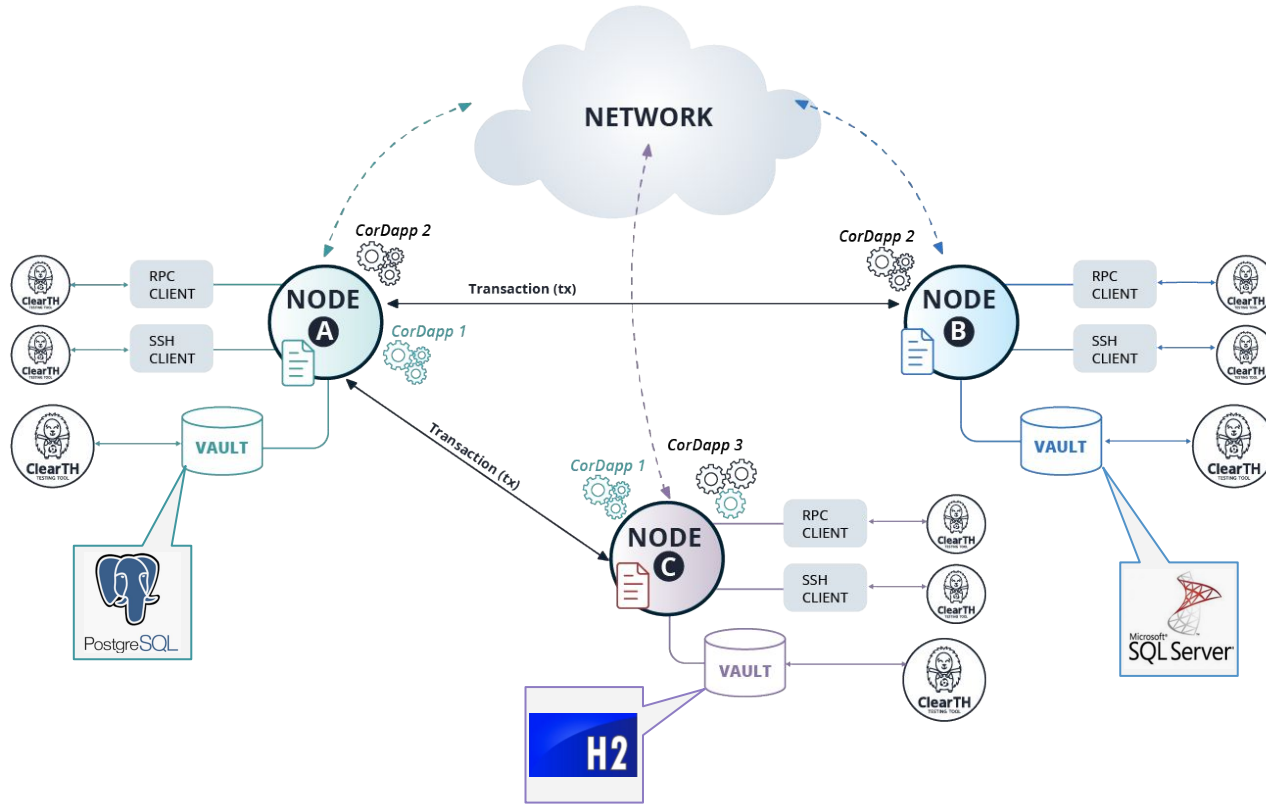
# Testing for Distributed Ledger Technology Platforms – Approach



# Testing for Distributed Ledger Technology Platforms – Approach



# Case study 1: Functional Testing for Distributed Ledger Technology Platform – Corda



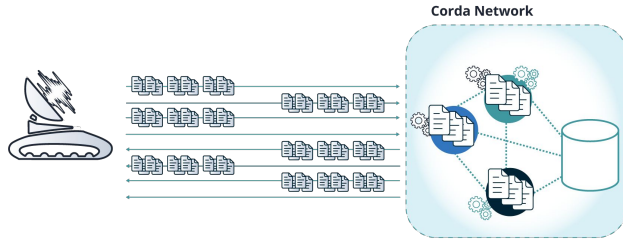
## ClearTH allows for:

- Nodes deployment with an ability to change the configuration
- CorDapps deployment
- Nodes Administration
- Nodes registration in the Network
- Trigger transactions generation, verification and distribution across the nodes
- JVM statistics gathering
- Log monitoring and analysis
- DB verification and monitoring (low-level ledger updates validation)

# Case study 2: Non-Functional Testing for DLT Platform – Corda

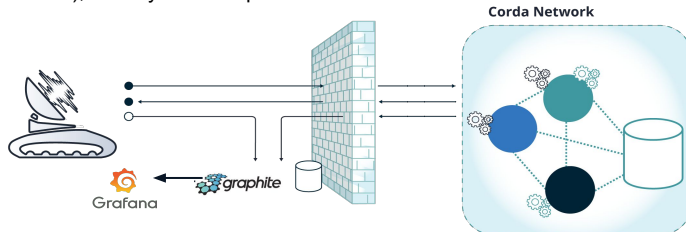
## Load & Stress Testing

Task: to determine the maximum throughput processing on the reference infrastructure with no chain history and one state per transaction. In a DLT Network, TPS is a function of many dimensions (attachments, chain length, number of input/output states).



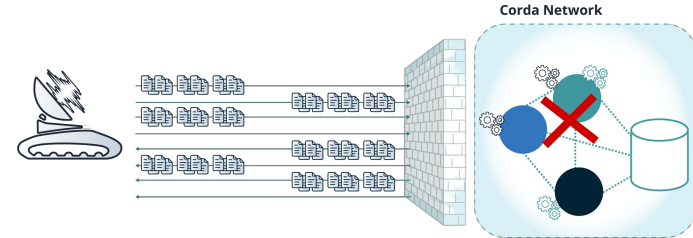
## Performance Testing

For a network with no chain history, the report was produced on latency values for input rates of 25, 50, 100, 150% of the maximum value, specifying average latency per transaction processing (mean and 99th percentile), average compute time (mean and 99th percentile), latency and compute time distribution charts.



## Failover

Here, we look to determine that there is no loss of service in transaction notarisation with a variety of test CorDapps. The Exactpro tool forced node failures within the network and ensured no loss in service or notarisation.

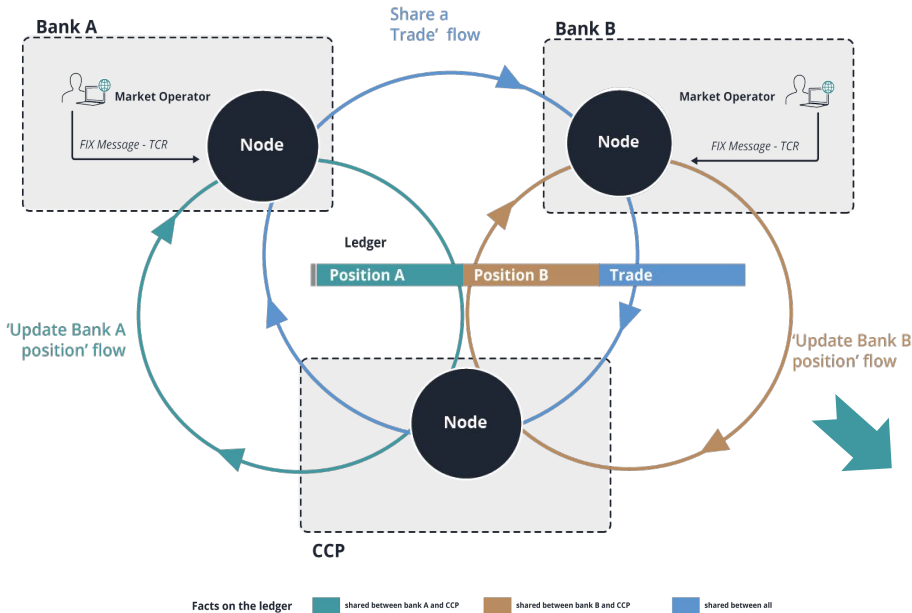


## Soak Testing

Soak testing evaluates the ability of a system to sustain load for long periods of time.

Test environment: a DLT framework on Microsoft Azure, with the multi-threaded RPC injector distributed across multiple global locations to initiate flows against a remote network of nodes outside of this framework. Docker images were configured to run specific Corda enterprise versions, CorDapps and RPC clients for the instantiation of test flows. System monitoring was performed using open-source tools DataDog, Graphite (for JMX stats), and bespoke scripts for additional memory monitoring. Analysis: memory usage of each node with a variety of test Apps, the change in memory usage of the node JVM over the time while processing tens of millions of transactions (e.g. does it grow, is memory released, do nodes fail and/or restart, etc.).

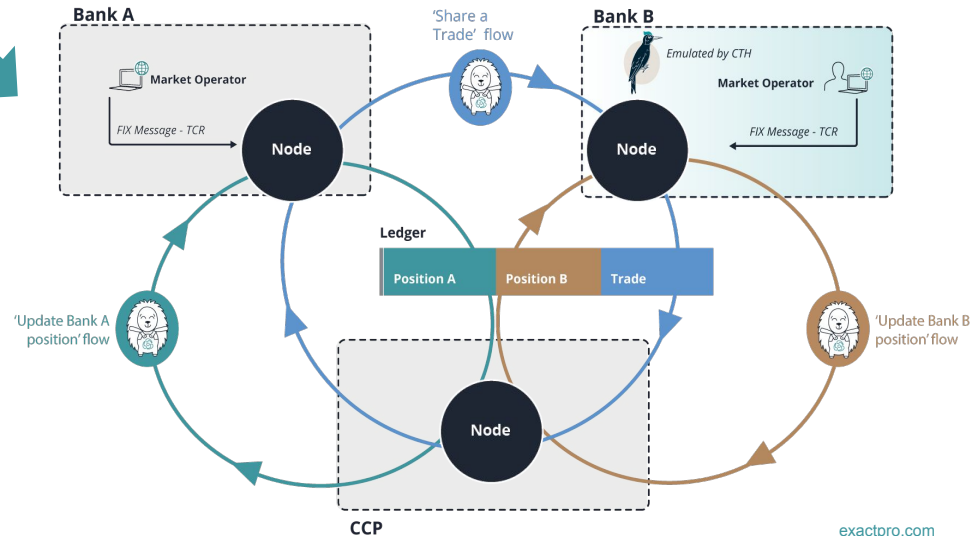
# Case Study 3: Distributed Ledger Technology in Position Update Business Flow



Across each and every step, the test framework provides different methods to validate the endpoints, inputs and outputs. The actual business flow steps and validation check items are transformed into the **ClearTH** matrix, after the execution of which the deviations from the expected behaviour can be analysed.

## 3 steps on the ledger side:

- 1st** Initialisation of positions
- 2nd** Trade creation and participant notification
- 3rd** Positions updates





# Case Study 4: PoC for IRS & CDS Swaps Lifecycle Module Based on CDM

<https://exactpro.com/news/exactpro/exactpro-enables-clearth-test-automation-framework-daml-built-applications>

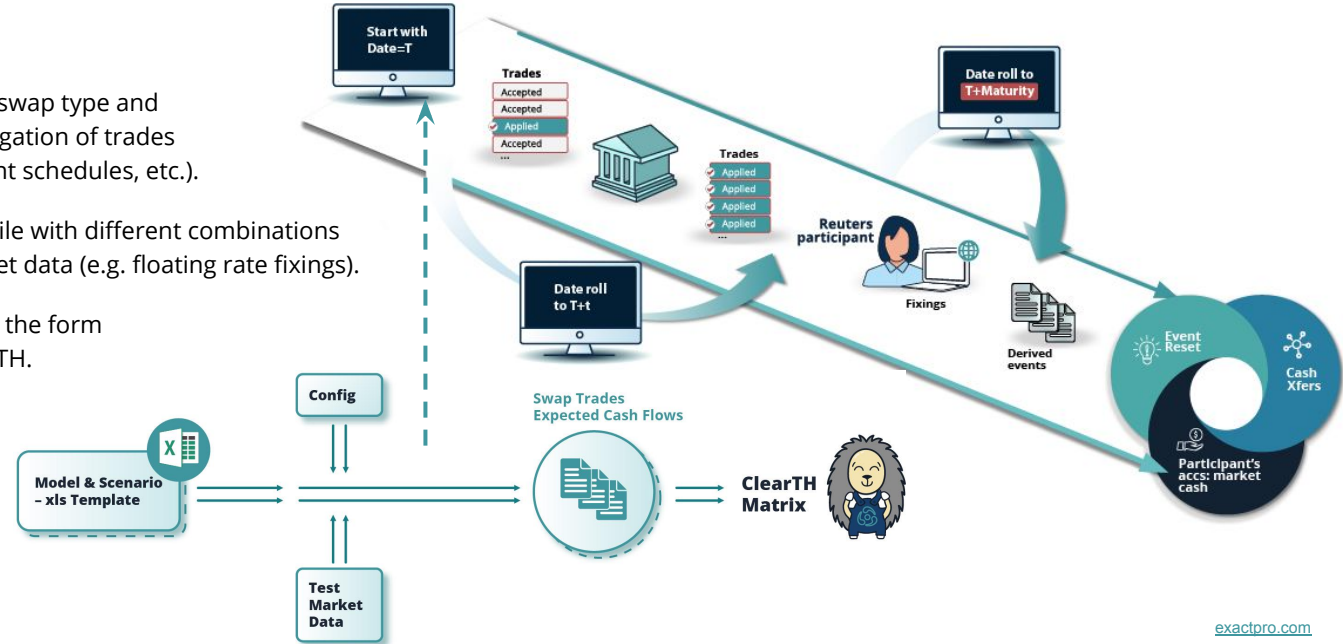


<https://github.com/digital-asset/ex-cdm-swaps>

ClearTH simulates a participant who submits a trade. The script sets the ledger time to the next fixing date and simulates floating rate fixings by the market data provider. Then it “time travels” to the next reset date (payment date) and generates derived events.

## Model for test automation:

- 1) A template with the swap contract info (swap type and structure) and lifecycle specifics (e.g. segregation of trades or multiple contracts by one member, event schedules, etc.).
- 2) Spreadsheets with Input data: a Config file with different combinations of parameters values; reference and market data (e.g. floating rate fixings).
- 3) Macros generating multiple scenarios in the form of csv matrices – scripts executed by ClearTH.



# Thank you!

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