BUILD SOFTWARE TO TEST SOFTWARE

The Deliberate Practice of Software Testing
EXACTPRO AT A GLANCE

- Exactpro is a leading provider of software testing and related software development services with a focus on test automation for financial market infrastructures worldwide.

- Exactpro was a part of the London Stock Exchange Group (LSEG) from May 2015 to January 2018. The company then went back to being an independent firm, following a successful buyout by its management.

- Incorporated in 2009 with 10 people, Exactpro now employs over 700 specialists.

- Headquartered in the UK with operations in the US, Georgia, Russia, Lithuania and Sri Lanka. Most of our clients are regulated market infrastructures.

- Since Exactpro’s foundation, the company’s client network has expanded to over 20 countries around the world.

- To ensure the continuity of operations for all our clients, and keeping in mind the continued global efforts to slow down the spread of COVID-19, most Exactpro teams have been working from their homes using secure VPNs since 17 March 2020.

- We maintain orderly operations and a full workload across all Exactpro business lines.

- We encourage everyone to take all the necessary precautions.
MEET THE GLOBAL TEAM

Iosif Itkin
CEO and co-founder, Malta

Alexey Zverev
CEO and co-founder, UK

Kirill Zagorouiko
Chief Operating Officer, Canada

Thomas Toller
Managing Director, USA

Jagath de Silva
CEO, Sri Lanka

Natia Sirbiladze
CEO, Georgia

Hiroshi Matsubara
Director, Business Development, Japan

Maxim Rudovsky
Chief Technology Officer, UK

Alyona Lamash
Director, Head of Risk Management Practice, UK

Ian Salmon
Business Development, UK

Michael Smith
Head of Sales, UK

Hirosi Matsubara
Director, Business Development, Japan

Lilia Tira
Business Development, UK

Victoria Leonchik
Technology, Data Warehouse, Georgia

Boris Rabinovich
Technology, Derivatives, Israel

Alyona Buda
Head of Global Exchanges, SVP, Russia

Elena Trescheva
Program Manager, USA

Dmitry Kolpakov
Chief Financial Officer, Russia

Asya Legotina
Technology, Big Data, UK
EXACTPRO EXPANDS INTO LITHUANIA AND SRI LANKA

LITHUANIA

SRI LANKA

EASE OF DOING BUSINESS
11th out of 190 countries*

ECONOMIC FREEDOM
15th out of 178 countries**

LOCATION ASSESSMENT
23rd out of 60***

FINANCIAL ATTRACTIONNESS
1st out of 60***

* Doing Business 2020
** The Heritage Foundation in its 2021 Index of Economic Freedom
*** The 2021 Kearney Global Services Location Index

• Young and talented labour pool
• Business-friendly environment
• Great quality-to-cost ratio
• World-class infrastructure

Lithuania’s focus on tech education helps it to further build its reputation as a highly attractive location for global tech businesses.

Read more about Exactpro’s expansion into Sri Lanka and Lithuania.

SRI LANKA

Sri Lanka’s sophisticated and transparent regulatory and legal framework offers safety of foreign investments. Several open-market free economic and trade policies as well as bilateral investment protection agreements with many countries makes Sri Lanka’s economy one of the most liberalised in South Asia.

• Pro-business environment
• Sophisticated and transparent regulatory framework
• Safety of foreign investments
EXACTPRO APPOINTS JAGATH DE SILVA AS CEO TO LEAD OPERATIONS IN SRI LANKA

• Jagath De Silva to spearhead development of Sri Lankan office

• New delivery center to take advantage of local talent to support global clients

London/NewYork/Colombo, 7 October 2021 – Exactpro, a leading software testing services provider for financial market infrastructures, is pleased to announce the appointment of Jagath De Silva as CEO of its new subsidiary in Sri Lanka.

In his new role with Exactpro, Jagath De Silva will spearhead the company’s growth in Sri Lanka with the aim of making use of the leading local talent and harnessing the potential of the new market.

Jagath brings over two decades of fintech and delivery experience to Exactpro, having previously held a number of senior executive and technological engineering roles throughout his 20+ years at the Virtusa Corporation. He was a founding member of the Quality Assurance practice of Virtusa, and also held the position of Software Quality Engineering Head of Sri Lanka from 2014, where he led a team of 800+ Software Quality engineers until his most recent role as head of the Global Tech Factory, an extended engineering arm of their Global Technology Office.

Jagath De Silva sits on the advisory committees of both the Sri Lanka Association for Software Services Companies (SLASSCOM) Technology forum and Sri Lanka Institute of Information Technology (SLIIT) Business School.

De Silva’s appointment follows the announcement of Exactpro’s expansion into Sri Lanka in July, enabling Exactpro to continue strengthening support for global clients, including major exchanges and firms in the UK and US. Exactpro will also bring new capabilities to the local market, including the ability for specialised testing and engineering quality into software systems. By engaging at the grassroots level with universities and youth programmes, Exactpro aims to acquire, build and nurture world-leading talent.

Iosif Itkin, CEO and co-founder of Exactpro, said: “We’re thrilled to welcome Jagath to the expanding global Exactpro team. Jagath will be able to utilise his impressive industry and leadership experience to spearhead Exactpro’s new delivery centre in Sri Lanka to the benefit of our international clients and the local business community.”

Commenting on his appointment, Jagath De Silva, CEO, Exactpro Systems – Sri Lanka, said: “I look forward to leading Exactpro’s expansion into Sri Lanka and providing a great opportunity for over 100 local software testing specialists. As the financial sector undergoes further transformation and faces new challenges, ensuring system quality has become a boardroom issue, and Exactpro is well placed to meet this challenge being the industry leader in testing services in the global financial market.”

Jagath De Silva, CEO, Exactpro Systems – Sri Lanka
ADDRESSING THE NEW LEVELS OF COMPLEXITY IN FINANCIAL SYSTEMS

**th2** offers stock exchanges, clearing houses, central securities depositories (CSDs), and other financial infrastructures a comprehensive technology agnostic AI-driven test automation solution. It aims to help regulated capital markets participants stay compliant and resilient to disruption, while focusing on innovation and having the freedom to embrace emerging technologies in response to their clients’ needs. Built with these goals in mind, th2 provides unprecedented flexibility, breadth and depth of software testing to the financial industry.

Tackling the ever-increasing complexity of financial platforms, th2 is a next-generation toolkit for automated functional and non-functional testing of distributed transaction processing systems. These include securities trading systems and exchanges, banking and broker systems, post-trade (e.g. clearing, settlement, custody) and payments platforms, and many more. th2 is a Kubernetes-driven microservices solution tailor-made to deliver efficient machine-driven end-to-end test libraries with comprehensive coverage of your system. th2 consolidates the power of the entire Exactpro test tool suite in a single solution.

The th2 source code has been released on GitHub and is open for contributions from the software testing and development community.

Professionals working with th2 are Software Development Engineers in Test who combine the roles of programmers, testers and data analysts equally well.
EXACTPRO CASE STUDIES

Exactpro teams have worked with various market infrastructure participants, creating comprehensive end-to-end test libraries to expose critical issues and enhance the resilience of the underlying systems. On this page, you will find our case studies on the specific technology implementations.

Trading: Exactpro – JSE collaboration to test the Millennium Exchange™ platform
The case study highlights the Exactpro deliverables in setting up automated functional and non-functional testing of the Millennium Exchange™ trading platform for the Johannesburg Stock Exchange (JSE) conducted ahead of JSE’s release of the Integrated Trading and Clearing (ITaC) programme of implementing world-class, multi-product solutions to enhance the exchange’s trading and clearing functions.

Collateral Management
The case study discusses the development of new techniques for the functional and non-functional testing of Distributed Ledger Technologies (DLT) such as Corda, Hyperledger and DAML, in particular, for their application to mission-critical Financial Market Infrastructures.

Post Trade: A Case Study on Functional And Non-functional Testing
In times of high market volatility, CCPs are one of the finance infrastructure links that are hit the hardest. This case study focuses on the Exactpro approach to testing large-scale post-trade infrastructures with emphasis on enhancing system resilience and increasing the level of process automation. The latter is achieved via leveraging the latest data mining and machine learning techniques.

Collateral Management
The case study highlights the challenges and the complexity of testing market surveillance systems connected to trading platforms, market data providers, involving various data mining processes, alerting mechanisms, and having different degrees of process distribution complexity. The case study is based on the expertise Exactpro has acquired by testing a number of market surveillance systems across different markets and locations.

Risk Management
The case study focuses on the challenges of testing risk management systems and Exactpro’s test automation and testing approach developed and implemented for our client, a central counterparty responsible for clearing and risk management of CCP-eligible transactions on a leading European exchange.

MEMX-Exactpro Collaboration on Exchange Quality Assurance
Members Exchange (MEMX) is a US exchange operator founded in 2019 by the largest U.S. online retail broker-dealers, global banks, financial services firms, and market makers to benefit all investors. MEMX was established to bring new competition into the market to drive three effects: lower fees, provide its members a voice in market dialogue and decisions, and foster innovation.
EXACTPRO ANNOUNCED RUNNER-UP IN SWIFT HACKATHON 2021

The organisers of SWIFT Hackathon 2021 have announced the winners and runners-up of two hackathon challenges launched in early September this year. Exactpro is recognised as runner-up in Challenge 2 – Building ‘synthetic’ data-sets required for AI-based product development, whilst protecting privacy.

Exactpro’s solution submitted in Challenge 2 is based on years of experience of growing in-house test data development capabilities.

Iosif Itkin, Exactpro CEO and co-founder, comments: “Leveraging the in-house expertise and deep domain knowledge of our team that included business analysts, software testing engineers, developers, researchers and data scientists, Exactpro has been able to produce a scalable solution that can serve the industry in so many ways, from improving anti-money laundering (AML) and fraud detection mechanisms to building a variety of personalised payments products.”

Rostislav Yavorsky, Head of Research, Exactpro, says: “Challenge 1 is where the contestants had to be most pedantic about their solutions and relentless about reaching the desired metrics. Challenge 2 is where they had to apply utmost ingenuity and creativity in solving the task at hand. In both cases, the teams had to demonstrate painstaking attention to detail, work hard within a limited timeframe and coordinate exceptionally well, while being miles away from each other. I’m really proud of the results we’ve achieved. The value of reliable GDPR-compliant solutions for generating synthetic data-sets for market infrastructure institutions and fintechs is indisputable.”

The announcement came as part of the Sibos 2021 premiere financial services event program that has been taking place this week. From the official kick-off session on 7 September to the wrap-up hours on 24 September, 25 teams from across the industry worked hard to apply their unique expertise, industry’s latest research and best practices to be able to present their solutions to the SWIFT community at this year’s Sibos.

The hackathon challenges aim to reflect the increasingly important role artificial intelligence (AI) and machine learning (ML) are playing in financial services, with both tracks serving the purpose of facilitating the adoption of ML and AI technology in the banking space. The two challenges featured were:

Challenge 1: Enhancing the accuracy of anomaly detection in payments

Challenge 2: Building ‘synthetic’ data-sets required for AI-based product development, whilst protecting privacy
THE VALUE OF UNDERSTANDING YOUR TECHNOLOGY ASSETS

"Never invest in a business you cannot understand," – the famous quote attributed to Warren Buffett also holds true for fintech innovation and may suggest that lack of knowledge about your technology assets can put your digital transformation budgets at substantial risk.

The healthy way to own an asset is to know what is inside and what governs it. If this is the case, you will be able to put this asset to work and get returns on your investment.

Imagine you decide to renovate your own home. This may play out as a nice demonstration of your craft skills and, at the same time, help you save on costs. However, if you choose to pour your creativity onto the walls without knowing where exactly the electrical wiring runs, the outcome of hammering a nail into the wire is likely to spoil both perceived benefits.

Similarly, the feasibility of investing in a technology transformation project depends on the depth of your understanding of the platform in question.

The financial benefits of knowing what you own

Consider two examples. The first example is around large-scale technology migration within a market infrastructure being handed over to a new parent entity. The current technology is thoroughly tested, its functionality is exhaustively modelled through an end-to-end regression test library equipped with automated execution capabilities. What is more, the team has extensive knowledge of the technology platform, as well as an understanding of its correct and incorrect behavior. The migration is planned with this knowledge in mind.

The second example features a financial institution who started their technology replacement efforts by engaging a third party to create a requirements specification for a new system based on the organization's business need and then asking them to develop one. The resulting system, though impeccable from the functional specification point of view, however, turns out to be unable to function through multiple interfaces connecting it to the surrounding infrastructure components. In this case, the organization has only a few people familiar with the original system from performing superficial manual tests against it.

Given the two situations, it will not come as a surprise that the first project proved to be a much better investment than the second one, which achieved the only transformational goal of turning an impressive budget into a waste of time and human effort.

Let us try to understand what is involved in “knowing what you own”.

Understanding: the process of knowledge acquisition

What is knowledge from an epistemological point of view? Knowledge is different from just an opinion in that it requires evidence to support it. In other words, the process of understanding deals with building a model of reality and subsequent assessment of this model against the reality itself.

Any technology platform is a fragment of the world designed to perform specific meaningful functions. To understand how it works means to build its model and challenge it.

From the knowledge acquisition perspective, this approach is implemented through rigorous testing as opposed to a box-checking exercise, which in the financial technology world is a very common activity accompanying regulatory reporting tasks. The main difference between the two lies in the mindset: to get a good understanding of the system under test we need to challenge our assumptions about it rather than try to prove that they simply comply with the requirements and stakeholders’ expectations.

Models: reflecting the reality

An important point about understanding is that it is a process rather than a static snapshot of current reality.

To make this process effective, mere mind power is not enough – it is important to support knowledge acquisition with tools. The deeper the needed degree of confidence in the system under test is, the more complexity would be required from the tool that we use to assess it.

A tool that is fit to the task is essentially a model of the system under test, which rivals it in terms of complexity and degrees of freedom. Such a tool is capable of modelling all of its possible interactions, both internal and external, and capturing the data flow. Analysis of this data can be leveraged for the model improvement.

Test oracles vs. human judgement

As any technology project evolves, the accompanying testing activities result in building a comprehensive model of the system under test in the form of a large regression testing library. This is a valuable artifact per se, as it significantly improves our knowledge acquisition capabilities.

However, if not subjected to constant improvement, such a model will inevitably decline, losing the ability to serve its main purpose – to drive the evolution of what we know about our technology platform.

According to common understanding, the ability to tell right from wrong, correct from incorrect is considered to be the essence of the test oracle concept. However, when this reasoning capability is cast in stone (i.e., built into a finalized test library) it means that we are delegating our judgement functions to the machine.

An alternative view on the test oracle suggests that its purpose is to serve as an alert mechanism prompting humans to intervene rather than taking over their decision-making responsibility. This perspective is in line with the principle of constant model evolution: to ensure it, we need the people component to be a part of the equation. Moreover, knowledge by its essence is a social concept, so the understanding of the system under test cannot evolve without humans: people act as a collective distributed database used to shape judgements about reality.

To be justified in terms of time/money investment, any transformational initiative needs to be assessed in terms of understanding of one’s own technology assets. The knowledge about them rests on three pillars – processes, platforms and people, with all three being part of any rigorous software testing approach. Invest in software testing. Build a more resilient future.
EXACTPRO APPOINTS HIROSHI MATSUBARA AS DIRECTOR OF BUSINESS DEVELOPMENT IN JAPAN AND ENTIRE APAC REGION

This is an exciting time to be joining Exactpro’s global team. As financial markets transform and face further digitalisation challenges, with the evolution of DLT and digital assets, it is now more critical than ever to ensure the highest levels of system quality assurance. I look forward to working with the team to drive Exactpro’s growth into Japan and the wider Asia-Pacific region.

Hiroshi Matsubara, Director of Business Development (APAC), Exactpro

Modern exchange platforms are highly sophisticated by design and require continuous testing to ensure their resilience.

Our Deliberate Practice of Software Testing approach is based on modelling the system under test, which allows us to create test libraries that serve as an executable specification for such highly complex platforms. This is a deliberate practice, meaning that it is systematic and focused on achieving the specific goal of improving performance.

Instead of relying on a fixed data subset, we constantly strive to widen the testing scope. Instead of confining the test scope to a limited number of requirements, we have learned to see the system under test as something that evolves and changes over time, and is not a static sum of its parts.

Software testing is relentless learning. The best software testing instrument is the human brain.

We create a mental model of the system (the Theory of Everything), implement it in the code (Build Software to Test Software) and use it to produce a multitude of relevant test scenarios and their expected outcomes.

THE DELIBERATE PRACTICE OF SOFTWARE TESTING

The test libraries and tools we have developed over the years apply to various business contexts, from regulated markets to MTFs, from dark pools to clearing houses and brokerage systems. They have been successfully implemented in a wide range of technical and middleware infrastructures.

London/Tokyo/New York, 18 May 2021 – Exactpro, a leading software testing services provider for financial market infrastructures, is pleased to announce the appointment of Hiroshi Matsubara (Matsu) as Director of Business Development for Asia-Pacific (APAC), with responsibility for leading the firm’s expansion in the region effective from 17 May 2021.

In his new role with Exactpro, Matsu will spearhead the company’s expansion through serving the company’s clients in Japan and the entire APAC region.

Matsu joins Exactpro after establishing earlier this year his own consultancy firm – Pine Grove Research – focused on new technologies in financial markets. Since 2007, Matsu has also been serving as Co-Chair of the Japan regional committee of the FIX Trading Community and has been taking an industrial thought leadership role.

Previously, he spent 15 years overseeing product marketing and communication activities in Fidessa (now ION Group) in Asia after holding various product marketing positions both in Japan and overseas (UK and US) for 17 years by originally joining the firm as a graduate management trainee in 1987.

Iosif Itkin, CEO and co-founder of Exactpro, said: “We are very pleased to welcome Matsu to the global Exactpro team. Matsu will be able to draw on his extensive industry experience to build on the success of Exactpro as we look towards growing our presence and expand our offering to clients in APAC.”

Matsu’s extensive career experience, spanning over three decades, started in the marketing of financial information and electronic transaction products at Reuters (now Refinitiv, part of LSEG) holding various product marketing positions both in Japan and overseas (UK and US).

Iosif Itkin, CEO and co-founder of Exactpro, said: “We are very pleased to welcome Matsu to the global Exactpro team. Matsu will be able to draw on his extensive industry experience to build on the success of Exactpro as we look towards growing our presence and expand our offering to clients in APAC.”
The process of migrating the Exactpro test tools suite that we have built over the years to th2 – a single next-generation test automation solution for complex transaction processing systems – is nearly complete now.

As of December 2020, half of the Exactpro top management team are UK-based. I can’t say that moving away from home has been easy, but it’s definitely beneficial for being fully synced up with some of our major clients and being even more responsive to their needs.

The process of migrating the Exactpro test tools suite that we have built over the years to th2 – a single next-generation test automation solution for complex transaction processing systems – is nearly complete now. th2 has successfully been made available to many clients in our network in the first half of this year. During the time of the transition, we have been providing extra support to all our clients, as our Chief Technology Officer Maxim Rudovsky and I are in London on a more permanent basis now.

Like all other firms in the financial services industry, we should keep moving forward, aligning our strategies and uniting our efforts to support the operational resilience of our clients’ systems under the conditions of uncertainty.

Our ultimate goal is to help our clients stay operational and compliant, and future-proof our clients’ systems from the standpoint of their quality. This requires tireless work and comprehensive testing, as opposed to having a ‘box ticking’ attitude.

Despite the events of the past two years, we have prevailed and come out stronger. Our Deliberate Practice of Software Testing approach has proven to be the right one for software quality assurance. Our ultimate goal is to help our clients stay operational and compliant, and future-proof our clients’ systems from the standpoint of their quality. This requires tireless work and comprehensive testing, as opposed to having a “box ticking” attitude.

Our software development and testing teams officially launched th2 and released it as open source software last December. We are now rolling th2 out across all our projects. With a single data-driven platform-agnostic end-to-end test automation solution for testing modern complex financial market infrastructures in place, the opportunities are abundant, and I’m happy to be here in the UK to facilitate the transition.

Like all other firms in the financial services industry, we should keep moving forward, aligning our strategies and uniting our efforts to support the operational resilience of our clients’ systems under the conditions of uncertainty.

Our ultimate goal is to help our clients stay operational and compliant, and future-proof our clients’ systems from the standpoint of their quality. This requires tireless work and comprehensive testing, as opposed to having a “box ticking” attitude.
IS YOUR DAPP REGULATORY-GRADE?

By Alexey Zverev, CEO and co-founder, Exactpro

Distributed ledger technology (DLT) innovation is an important trend shaping the financial services industry. It's no surprise that under the pressure of ongoing overall digital transformation, many financial institutions are keen to adopt DLT in development of their platforms. However, when the innovation is introduced on a scale of a major capital market participant, its potential impact is likely to be shared by a larger financial services community. To facilitate the smooth transition towards the emerging technologies, the regulatory bodies require systematically important financial market infrastructures to ensure that while innovating, they also stay operationally resilient.

Operational resilience: regulatory perspective

Following last year's disruptive events, the regulators continue to increase their focus on the financial sector's operational resilience, i.e. the ability to prevent, adapt and respond to, recover and learn from operational disruption [1].

In the UK, the ‘Building operational resilience’ Policy Statement, produced by the FCA, PRA and Bank of England in March 2021[2], introduces new rules to go into effect early next year. In the preceding discussion paper dated July 2018 [1], the regulatory bodies outline the main challenges to the operational resilience and provide guidance on identifying important business services and assessing the impact of potential disruptions.

The European regulatory framework is consistent with its UK counterpart in terms of these challenges and sees emerging technologies along with growing dependency on data as generating a need for stronger operational resilience [3].

As outlined in the EC's regulation on a pilot regime for FMIs based on DLT, the operators of market infrastructures are expected to "ensure that the overall IT and cyber arrangements related to the use of their DLT are proportionate to the nature, scale and complexity of their business" [4]. To fully comply with this requirement, regulated entities need to establish adequate software testing procedures for their core platforms. But what sort of testing would be considered regulatory-grade?

Achieving regulatory standard in software testing

Regulatory-grade testing is software testing that helps the firms ensure “continued transparency, availability, reliability and security of their services and activities, including the reliability of smart contracts used on the DLT” [4]. It also provides the information, sufficient for making robust decisions. In achieving this, it is crucial that testing activities generate regulatory-grade data, the data that satisfies the requirements of integrity, security and confidentiality, availability, and accessibility.

Speaking broadly, in order to meet regulatory requirements, you need to prove the ability to manage your application providing fair, consistent and uninterrupted transaction management service for all participants. The key for this ability is extensive knowledge of the system that you are going to manage. The only possible way of obtaining such knowledge is via experiments and observation, which is basically what software testing is. For those trying to develop and maintain complex financial systems, insufficient testing leads to inevitable failure.

Understanding the challenges

However, testing the systems based on distributed blockchains is not a trivial task. For comparison, in electronic trading, all transactions in modern stock exchanges are processed by matching, clearing and settlement engines hosted in fully controlled data centers managed by corresponding organizations. The key characteristics of a good testing process are:

• Focus on observation: aiming to discover new information rather than confirming the assumptions;
• Testing is relentless learning: meaningful testing demands sufficient time investment;
• Early testing: testing activities should start as early as possible during the requirement definition stage and continue throughout the whole duration of the project;
• Independent perspective: testing team has an ability to form objective judgements and a voice to advocate for proper governance;
• Test automation: efficient testing is impossible without employing test tools - not for the sake of automation per se but rather to augment testing capabilities of highly qualified software testing engineers.

Regulatory-grade testing requires a significant investment of time of highly skilled resources. It is important that this talent is providing an independent view: they are not the same people who built the platform in the first place, e.g. in-house developers or a software vendor.

Setting up software testing process

At Exactpro, we understand the software testing process as an empirical technical investigation conducted to provide stakeholders with the regulatory-grade information about the quality of the product or service under test.

Key ingredients to accommodate software testing of a regulatory grade are Processes, Platforms and People.

1 - As the first step, we must ensure that basic scenarios of the core functionality pass the tests in a semi-isolated controlled environment.
2 - The next step is end-to-end testing in a production or production-like network, consisting of an environment, a test version of your application, and test tools that will facilitate testing and collect important information.

Using this toolkit will enable you to:

- load the system with appropriate flow of transactions covering important scenarios;
- simulate outages in the network and test application;
- simulate complex conditions your application is required to sustain.

3 - Finally, all these activities you will need to collect data containing sufficient information to understand the outcome of the tests. This data must be processed and analyzed to extract the knowledge about the system behavior and draw insights needed to provide uninterrupted service.

**Building regulatory-grade platforms**

The processes should be supported by the platforms. To provide the regulatory-grade testing capabilities, a test automation framework should rely on the latest technology stack and support testing at the confluence of functional and non-functional approaches.

The extreme complexity of the task implies a set of requirements for the testing framework that are crucial to ensuring an appropriate level of quality assessment.

First of all, a technologically advanced testing tool fit for the task of testing distributed apps on a regulatory grade requires the ability to invoke tests through a variety of platforms and APIs along with the potential to run many different tests many times. Another important requirement is the possibility to simulate important conditions by deploying the test code into the network. To enable its users to draw insights from system behavior, the testing harness should be able to process high volumes of data. On top of that, the ability to invoke and analyze the outcome of chaotic scenarios as well as to deal with non-deterministic responses entails the requirement of a tool being enhanced with a strong analytics module.

To meet the complexity level of the present-day distributed non-deterministic platforms, we developed a software testing framework satisfying these requirements.

th2 [5] is an open source toolkit providing end-to-end functional and non-functional test automation for complex distributed transaction processing systems. Built as a cloud native Kubernetes-driven solution, it aims to help regulated entities stay compliant and resilient to disruption, while focusing on innovation and having the freedom to embrace emerging technologies:

- it is a multi-platform framework with a powerful API, enabling intelligent interaction with many widely adopted network protocols as well as API, UI, DLT and cloud endpoints;
- its microservices architecture allows building complex test instruments and execute sophisticated test algorithms;
- it supports GitOps paradigm, enabling CI/CD pipeline integration;
- it is designed to perform autonomous test execution;
- ready for implementation of AI-driven test libraries for machine learning and advanced data analytics.

Though this set of test automation capabilities may seem comprehensive all by itself, it is still not enough to establish a robust software testing approach of a regulatory scale without highly-skilled professionals to make processes and platforms work together.

**Supporting processes and platforms with people**

If asked to outline core qualities of the people who are apt for the task of testing of complex distributed systems, the following key characteristics can be suggested:

- a software tester's mindset - to actively pursue exploring of the system they test;
- software developer's skills - to be able to create code for tests that adequately cover complex behavior of the systems under test;
- deep understanding of business logic and technology behind the platform being tested.

Hard and soft competencies that are needed to operate technologically advanced platforms and implement the required processes are outlined under the umbrella of the Zero Outage Industry Standard (ZOIS) [6], an industry association developing best practices to ensure the highest quality of IT platforms.

Conclusion

The regulators expect the financial institutions operating complex distributed platforms to be able to maintain high availability and resilience to disruption, even in a chaotic environment. This can only be achieved by intelligent end-to-end testing of a distributed application in both business-as-usual and disruption scenarios under production-like conditions and in a full-scale network. That requires an investment of the time of highly technical resources and advanced test tools.

With DLT projects being implemented on a greater scale, the financial services industry is rapidly transforming adopting new technology and, then, regulatory standards. In such a context, it is very important to establish the practice of DLT innovation that is supported by extensive regulatory-grade quality assessment.

**REFERENCES**

Join the Exactpro Systems YouTube channel for regular updates on the applications of AI and Machine Learning, DLT, cloud computing, and many other technologies and solutions to software testing and development. This channel is for chief technology, information and compliance professionals, product owners and software Quality Assurance and development specialists of all levels.

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The complexity of software systems is continuously increasing. This tendency is caused not only by non-determinism introduced by AI algorithms, but also by the technology stack supporting intelligent systems. This complexity makes the task of testing AI-based platforms especially challenging: the task is not likely to be approached without test automation, in addition, the testing tool itself needs to satisfy a whole range of technologically-advanced requirements to provide reliable assessment. For the third year in a row, the IEEE International Conference On Artificial Intelligence Testing explores new ways of addressing the demand that AI-based systems present to software testing.

For these three years, Exactpro has been delighted to have the chance to contribute to this important scientific and industry event, with our internal research being deeply focused on both finding applications of AI techniques to software testing and improving ways to test AI-based solutions.

In 2021, Exactpro has also supported the IEEE Autonomous Driving AI Test Challenge as organiser. Our research team has also created a course on Software Testing for Complex Intelligent Systems and Autonomous Vehicles. The course is available on the Exactpro Systems YouTube channel. 
ELENA RUSAKOVA — WOMEN IN TECHNOLOGY AND DATA AWARDS WINNER

Exactpro is proud to announce that the company’s HR Director Elena Rusakova received the prestigious ‘Women in Technology and Data’ Award held by WatersTechnology, the premier global financial technology news and analysis provider. Elena was recognized as a leader in the inaugural “Wellness/Work-Life Balance” category.

Elena Rusakova has held a position of Exactpro’s Human Resources Director for over six years, having joined the firm as Human Resources Manager in 2011. For almost a decade, Elena has spearheaded the development and the implementation of HR initiatives for the fast-growing and agile company servicing the world’s critical market infrastructures and market participants.

From 2011 to 2020 Exactpro’s headcount experienced a 10-fold increase (under her stewardship the firm hired 1000+ specialists), with Elena devising and executing comprehensive HR programmes to ensure the right balance in terms of staff skills and experience, as well as ensuring staff training and development opportunities helping to enhance their performance and achieve Exactpro’s business goals. Under Elena’s HR leadership, the company went through an extensive HR transformation evolving from a startup, to the LSEG technology division, and then to a growing independent company with low staff turnover levels, especially among the key personnel.

Elena has also been involved in promoting Exactpro’s brand to local talent and ensuring legal compliance of the firm’s offices in London, New York, and Tbilisi.

When it comes to helping employees balance their personal and professional responsibilities there is no one suited better to help than Elena. During the exceptional year in 2020, with the majority of Exactpro’s staff working remotely due to the COVID-19 pandemic, she led a wide range of initiatives promoting health and well-being, companionship, fundraising events and knowledge-sharing sessions, among others. In the beginning of the pandemic, not only was she able to handle the shift to the remote work over the short period of just several days, but she also supported the staff increasing the focus on interpersonal communication across the team, which was of extreme significance at those challenging times.

As a company, we are proud of this achievement and thankful to Elena Rusakova who goes above and beyond in making life at Exactpro so much better.

EXACTPRO WINS “BEST IN OPERATIONAL RESILIENCY” MARKETS CHOICE AWARD

Exactpro is honoured to be recognized as “Best in Operational Resiliency” in the 2021 Markets Choice Awards held by Markets Media Group.

Exactpro’s next-generation test automation platform — th2 — offers financial infrastructures a comprehensive end-to-end technology agnostic AI-driven test automation solution which aims to help regulated capital market participants stay compliant and resilient to disruption, while focusing on innovation and having the freedom to embrace emerging technologies, most relevant to their clients’ needs. Built with these goals in mind, th2 brings unprecedented flexibility, breadth and depth of software testing to the financial industry in the drive for improved operational resilience.

The th2 toolkit is designed to enable automation in functional and non-functional testing for complex distributed transaction processing systems, such as securities trading systems and exchanges, banking, brokerage, post-trade (e.g. clearing, settlement, custody), and payments platforms. With the aim to increase the tool’s accessibility across Exactpro’s international client base, the th2 source code was released to GitHub in December 2020.

Natalia Kryukova, th2 platform Manager, Exactpro, said: “Considering that the subject of operational resiliency has been at the forefront of financial technology for the past year, the award is an immensely valuable recognition of Exactpro’s continuous effort to address the increased industry demand. This award is an important achievement as our strategic focus remains on the assessment of the clients’ financial technology for robustness and reliability.”

About Markets Media
Markets Media was launched in 2007 to provide sophisticated, in-depth content spanning all sectors of the securities industry, delivered across a synergistic platform of print, online and events. Learn more: www.marketsmedia.com
EXACTPRO NORTH AMERICAN COVERAGE: EXPANDING GEOGRAPHICALLY AND INTO COMPLEMENTARY VERTICALS

Exactpro works with many leading stock exchanges and market infrastructures around the world, providing them with independent quality assurance and testing.

Expanding the local team to focus on North America – which is home to some of the world’s largest equities and futures exchange groups, banks, brokers, liquidity providers, and infrastructure providers – is a strategic priority.

I have a background in management and compliance at both brokers and proprietary trading firms in the equities and futures space in both the US and Europe. Over this time with Exactpro, my experience has proven useful in expanding our independent testing and quality assurance offering to areas like market surveillance and market access systems, as well as other heavily regulated areas.

I am happy to have come on board nearly three years ago to help Exactpro increase its capacity to engage with clients, prospects, regulators, and the trade organizations in the region. Increasing our headcount here has allowed us to build on our market structure knowledge and become more available for supporting our clients locally.

I am also excited to explore the sustainability aspect of the Exactpro business and work on the framework of defining people, processes and platforms which can pave the way towards software testing for the public good in the context of ESG initiatives undertaken by financial institutions in the US.

Over this time with Exactpro, my experience has proven useful in expanding our independent testing and quality assurance offering to areas like market surveillance and market access systems, as well as other heavily regulated areas.

Thomas Toller
Managing Director of Exactpro Systems LLC, USA

RELYING ON THE CONTEXT – SCIENCE, TECHNOLOGY, SUSTAINABILITY

I am lucky to be part of an experienced team focusing on research around innovations and aligning the corporate strategy with the unique regulatory space and diverse technological landscape characteristic of the North American financial markets.

Ensuring resilience of systemically important financial market infrastructures worldwide, Exactpro is known for its comprehensive knowledge of the financial services business domain. It has always been an imperative for us to support our software testing practice with research activities.

Here in the US, with many leading research centers and innovative technology firms around us, we witness new technologies emerging and being adopted by the financial services industry. We need to keep up with that pace. One of the areas requiring extensive research is artificial intelligence: how we can leverage AI to enhance our test automation solutions and how we can test AI leveraged by our clients in their financial technology platforms. I am lucky to be part of an experienced team focusing on research around innovations and aligning the corporate strategy with the unique regulatory space and diverse technological landscape characteristic of the North American financial markets.

Elena Treshcheva
Program Manager, Exactpro Systems LLC, USA

We look forward to a time when we can host our first EXTENT event in New York City. EXTENT is a forum for sharing views on technology innovation and ways to increase efficiency, quality assurance levels, and due diligence standards with the ultimate goal of improving the industry’s risk management approaches and regulatory compliance.
MEMX-EXACTPRO COLLABORATION ON EXCHANGE QUALITY ASSURANCE

Introduction
Members Exchange (MEMX) is a US exchange operator founded in 2019 by the largest U.S. online retail broker-dealers, global banks, financial services firms, and market makers to benefit all investors. MEMX was established to bring new competition into the market to drive three effects: lower fees, provide its members a voice in market dialogue and decisions, and foster innovation.

MEMX Platform Requirements
From the start, MEMX committed to building an exchange that allowed for continuous enhancement and improvement. MEMX’s goal is to use innovation to break free from the past, while maintaining system quality, reliability and customer trust to operate a thriving exchange. Below is a review of MEMX exchange functionalities available today.

MEMX provides its members with a set of connectivity options based on common methods and semantics to type, define, encode and decode data using the FIX Protocol Standard and Simple Binary Encoding (SBE). The table below outlines the interfaces exposed to the members:

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMX-TCP</td>
<td>A Session Level TCP-based transport protocol for reliable delivery of business messages.</td>
</tr>
<tr>
<td>MEMX-UDP</td>
<td>A Session Level UDP-based transport protocol for best-effort delivery of business messages.</td>
</tr>
<tr>
<td>MEMO SBE</td>
<td>The native binary protocol used for order submission.</td>
</tr>
<tr>
<td>MEMO FIX</td>
<td>The Classic FIX (ASCII Tag/Value) protocol used for the exchange of information related to securities transactions.</td>
</tr>
<tr>
<td>MOIR Depth</td>
<td>A real-time full depth-of-book feed offered directly from MEMX.</td>
</tr>
<tr>
<td>MOIR Top</td>
<td>A real-time top-of-book feed offered directly from MEMX that provides reporting, cancellation and correction of exchange executions.</td>
</tr>
<tr>
<td>MOIR Last Sale</td>
<td>A real-time trade feed offered directly from MEMX that provides reporting, cancellation and correction of exchange executions.</td>
</tr>
<tr>
<td>Drop Copy</td>
<td>A Drop Copy in Classic FIX protocol providing information related to trades executed on MEMX with the option to include order related information.</td>
</tr>
</tbody>
</table>

MEMX supports Pre-Market, Market and Post-Market trading sessions. Both the SBE and FIX MEMO order entry protocols contain an integrated pre-trade risk management service, which includes a mandatory set of configurable controls.

They are designed to protect investors and ensure market integrity by preventing erroneous orders from passing through to the matching engine for execution. Additionally, MEMX offers a configurable batch cancel function allowing participants to cancel all or a subset of orders in one or more symbols with a single command to the exchange over any active session, irrespective of the session(s) over which the original order(s) was submitted. MEMX also supports cancel on disconnect.

Based on industry feedback to reduce complexity and promote fair, transparent, and efficient client interactions, MEMX accepts three order types:

- Market (for time-sensitive traders),
- Limit (for price-sensitive traders), and
- Pegged (including Midpoint Peg and Primary Peg orders that will automatically adjust with changes in the National Best Bid and Offer for traders sensitive to periods of market volatility).

MEMX supports a set of modifiers, including:

- Intermarket Sweep Orders,
- Reserve Quantity (with multiple replenishment options including randomized size and time),
- Re-Pricing to comply with Reg NMS, Reg SHO, and Limit-Up/Limit-Down,
- Non-Displayed,
- Minimum Quantity,
- Post Only,
- Book Only.

MEMX routes orders to away markets displaying protected quotations to comply with Reg NMS. A combination of exchange proprietary data feeds and CQS/UQDF data feeds from the Securities Information Processors (SIPs) are used for the handling, execution, and routing of orders. MEMX required a test solution to properly cover all these areas to ensure proper behavior and function.

The Implemented Solution
To achieve the objective and facilitate the delivery of the exchange, MEMX’s testing team was enhanced with the assistance of the established professional testing services provider – Exactpro – known for its long-term partnerships with some of the leading global exchange groups and a thorough test approach leveraging a bespoke automation test tool suite.

Processes: the MEMX-Exactpro Operating Model
Being a customer-centric market operator, MEMX engaged Exactpro at the early stages of the program for review of the client-facing specifications in order to deliver clear and transparent documentation to the participants.

Exactpro worked in close collaboration with the MEMX team starting from the initial analysis of the test scenarios and specifications, through the test design, to the model-based and the discovery-based implementation, test planning and monitoring.

We have been delighted to partner with MEMX on such an ambitious and innovative project, a natural fit for Exactpro’s services and our continued expansion into North America.

Thomas Toller, Managing Director, Exactpro USA
Basic building blocks used by MEMX are of several types:

1. **conn** components represent connections to the respective MEMX endpoints and are responsible for active communication with the system under test (SUT) in accordance with the available specifications.

2. **read** components acquire data as passive subscribers. They are needed to apply data consistency and reconciliation checks across different data streams, irrespective of the inbound traffic. Examples of such checks include MEMO FIX/Drop copy.

3. **codec** blocks process transactional data from conn and read components. They are responsible for encoding and decoding the messages. Multiple blocks allow support for different protocols and their versions.

4. **check** contains simple verifications.

**Custom logic components were configured to reflect the specifics of the MEMX platform:**

1. **act** is responsible for the active test scenario logic.

2. **check** contains advanced verifications such as:
   a) **Reconciliation** which is used to widen the test coverage age of the executed transactional tests by reconciling the data streams coming into and going out of the SUT.
   b) **Book checker** which builds order books based on market data output and checks the.

3. **simulator** was designed for the emulation of the away exchange for MEMX and was configured based on the specific business logic. The aim of the sim component is to support the designed test library of routed orders.

   The platform enables the implementation, execution and analysis of a wide variety of test concepts.

**Working with MEMX, the fastest-growing US equities exchange, has proved to be an invaluable experience as we continue to deploy our next-generation test automation framework, th2. With this new offering, Exactpro was able to support MEMX’s rapid deployment schedule whilst simultaneously providing the highest levels of system quality assurance.**

Josif Itkin, CEO and co-founder of Exactpro

**People: Human Competencies for Delivering Mission Critical Systems**

Exactpro builds software to test software to be able to verify complex systems that underpin global financial markets. To ensure the required level of services is being met, the company follows the Zero Outage Industry Standard in its human capital development strategy. The standard is a collection of best practices enabling IT professionals to plan, build, deliver and run end-to-end IT solutions suited for the most critical business functions and processes. Exactpro shares the Standard’s holistic view on going beyond technology and emphasizing that not only are platforms, processes, and security essential to IT services, but that people are the backbone of every organization and every project (please refer to the picture).

**Conclusion**

The extensive functional testing and test automation delivered by the Exactpro team contributed to the successful launch of the MEMX U.S. equity market in September 2020, followed by trading of all NMS symbols in October 2020.

Today, MEMX continues to be the fastest growing U.S. equities exchange. Its success is a testament to the participants’ desire for an exchange focused on fostering innovation and competition, as well as on the quality and efficiency of its platform.

**MEMX’s close collaboration with Exactpro provided additional operational resilience and contributed to the exchange’s successful launch, rollout and, ultimately, live trading in all NMS symbols. We greatly appreciate Exactpro’s partnership in working to ensure the exchange’s technology was ready to perform at full capacity from day one.**

MEMX Chief Technology Officer
Dominick Paniscotti
EXACTPRO IN GEORGIA: INVESTING IN THE BRIDGE BETWEEN EUROPE AND ASIA

Georgia is one of the three Deep and Comprehensive Free Trade Areas (DCFTA) established by the European Union under the EU Association Agreement that entered into force in 2016. Georgia has ranked 7th among 190 states in the World Bank Doing Business 2020 ranking. It also ranks 12th in the 2020 Index of Economic Freedom tracking the impact of liberty and free markets across 180 countries. Our course towards eventual NATO membership is very strong.

Information and Communication Technology has been one of the key focus areas for us as a country, with much attention being paid to education, innovation and expanding the IT infrastructure. Foreign companies are willing to invest here for the transparent and favourable tax regime, cost-effective and yet skilled and talented labour force, and the high-quality standard of living.

The first Exactpro office opened in Tbilisi, Georgia in the fall of 2018. It expanded fast and now occupies the space of two co-located offices. The branch employs Quality Assurance (QA) engineers and developers, both in senior and junior positions, as well as Software Engineers in Test – a new job description for specialists working with our next-generation test automation platform th2. We are also proud to have become a second home to eight Exactpro managers and team leads who have relocated to Tbilisi from their home cities to spearhead the knowledge transfer.

“Exactpro has successfully promoted professional excellence in Georgia, built a QA community, created GeoSTQB, established links with universities and shown support for local IT students.”

Information and Communication Technology has been one of the key focus areas for us as a country, with much attention being paid to education, innovation and expanding the IT infrastructure. Foreign companies are willing to invest here for the transparent and favourable tax regime, cost-effective and yet skilled and talented labour force, and the high-quality standard of living.

As a leader in software testing and related software development, Exactpro has successfully focused on promoting professional excellence in Georgia, building and nurturing a local QA community, creating GeoSTQB – a Georgian representation of the International Software Testing Qualifications Board (ISTQB), establishing links with universities and actively showing support for IT students from across the country who study in Tbilisi.

Natia Sirbiladze
CEO, Exactpro, Georgia
President, GeoSTQB

Exactpro has successfully promoted professional excellence in Georgia, built a QA community, created GeoSTQB, established links with universities and shown support for local IT students.
This case study highlights the Exactpro deliverables in testing the Millennium Exchange™ trading platform for the Johannesburg Stock Exchange (JSE). The testing activities were part of JSE’s Integrated Trading and Clearing (ITaC) multi-year programme focused on the implementation of world-class, multi-product solutions to enhance the exchange’s trading and clearing functions. To emulate JSE’s client activity and the system responses, Exactpro used its bespoke test tools: EXACTPRO — JSE COLLABORATION TO TEST THE MILLENNIUM EXCHANGE™ PLATFORM

Within the JSE ITaC programme, Exactpro also successfully delivered a high frequency Order Generation Tool. The JSE business analysts needed the ability to generate a versatile and flexible load of messages and had specific requirements for trades/order ratio, order/quote types, instruments, markets and rates.

To meet these requirements, the Load Injector tool was enhanced with the following features:

- **Support of message templates and functions in templates to generate all required types of messages with specific values**
- **Support of different rates for different markets (Equities and Derivatives)**
- **Support of multiple order types for different types of instruments**
- **Support of multiple order/trade ratio across different segments**
- **The option to shuffle the generated messages and send them into the system according to a predefined load profile**

The Order Generation Tool allowed us to create a complex load for the trading system and execute a comprehensive set of non-functional tests.

The test automation tools (Sailfish, Shsha, Load Injector – for test automation of trading, and ClearTH – for test automation of clearing) delivered to the JSE by Exactpro as part of our collaboration in the trading test automation area were successfully used by the JSE team and helped with the successful implementation of the multi-year ITaC programme into production on 29 April 2019. The introduction of new, internationally recognised systems means the JSE will strengthen its position as a global market player providing more stable and efficient trading and clearing services to its clients.

“I have been receiving very positive feedback from my JSE teams about their work with Exactpro. The automated testing solutions allow us to perform in-depth testing to ensure software quality before deploying into live service,” says Hendrik Kotze, Chief Information Officer, JSE.

“We will continue our collaboration with Exactpro who help us with quality deliverables to ensure that the JSE continues offering reliable, secure and efficient capital markets across a diverse range of instruments, supported by cost-effective services.”

Hendrik Kotze,
Chief Information Officer, JSE

Exactpro’s clients innovate. With testing services provided by us, they can adopt innovative technology with confidence and improve the resiliency, performance and quality of their systems and platforms. Our company achieves this through deep testing performed by our teams using our innovative tools developed in accordance with our test automation principles. We are empowered by experience gained over the years and embrace a culture of relentless learning and dedication to our clients.
In this interview to Best Execution, Alyona Bulda, Head of the Global Exchanges Division at Exactpro and winner of the Rising Star Award in the inaugural European Women in Finance Awards 2020, talks about staying the distance, keeping calm and helping clients navigate.

"Navigating through the difficulties of the pandemic required the understanding that people are a crucial component of what we do, so I started to pay more attention to the overall well-being of the team, while making sure the client gets all the thoroughness they had before and even more – given the dramatic increase in market transaction flows."

Right after graduating from university, I joined Exactpro at an entry-level position of a junior QA Analyst. Shortly after that, I was given the responsibility to lead a team, and later – a project. While successful projects have led to progression in the company, I’ve also experienced an evolution in terms of expertise. Exactpro is a software testing business targeted at technologically and functionally diverse market infrastructures. Today my team may work with low-latency trading platforms, and tomorrow we may deal with sophisticated post-trade systems. Along with the business areas, technology is yet another dimension, and over the years I have become an expert in more domains.

What is your role at Exactpro and how has it evolved over the past ten years?

I am responsible for the Global Exchange Division at Exactpro. Exchanges, clearinghouses and other financial market institutions using our software testing services are located in more than 20 countries on all six continents. The geography of the division projects spans from London to Johannesburg, from Abu Dhabi to Sydney, from Osaka to Jersey City.
What has been the impact of Covid-19 on your company and what skillsets have you needed to navigate through the current environment?

The lockdown did not bring a dramatic change to our way of operation – our pre-pandemic model was to have 1-2 people on client premises organising the remote work of the offshore development and testing teams. The only change was that it is now performed from home rather than from offshore offices.

Navigating through the difficulties of the pandemic required the understanding that people are a crucial component of what we do, so I started to pay more attention to the overall well-being of the team, while making sure the client gets all the thoroughness they had before and even more – given the dramatic increase in market transaction flows. From the skillset perspective, it is just the ability to stay calm, be agile and tolerant as everyone is adapting to the new environment in their own way, and just being there to help whenever it is needed.

How has the pandemic impacted the industry and what trends do you think has accelerated?

The pandemic brought a better understanding of the inevitability of disruptions in face of uncertainty. This accentuated the importance of what we do to help our clients prepare for the unexpected – simulating heavy transactional load and outages to identify points of failure in critical financial services infrastructures.

How did the firm cope with remote working or was that part of the culture already?

Agility is among the core principles that we follow at Exactpro. As the financial institutions incorporate the Agile approach, it is necessary to follow its essence rather than mimic the procedures. Strategically, we do not overestimate the benefits of co-location. Instead, we foster system analysis skills in our people and value software testing specialists with critical and independent thinking. This mindset helps us to stay operational and efficient throughout the times of the ‘new normal’.

Aside from Covid, what are some of the other key challenges that the industry faces and what do you think will be the solutions?

As the world becomes more complex and unpredictable, technology-dependent industries reflect this through a substantial increase in systems’ complexity, data volumes and automation. Enhancing the platforms with strong data analytics capabilities raises the question of finding a legitimate way to harness the data and streamline the innovation without overly relying on automation and delegating decision-making to algorithms.

To address this challenge, the industry needs to critically assess the implications of new technologies and set its mind to always prepare for the worst scenario, use and re-use data, and apply smart analytics to help humans make responsible decisions.

For over a year, the Monitoring, Onboarding and Software Testing (MOST) working group within the FIX Trading Community has been meeting regularly to grow a community focused on standardization and innovation in technology processes leveraging the FIX protocol. The group is co-chaired by Ievgenii Storozhuk, Trade Desk, CBOE Global Markets and Iosif Itkin, co-CEO and co-founder of Exactpro.

The group’s mission is to raise the quality and reliability of platforms operated by the FIX Trading Community Members. This is being implemented via developing a set of recommended practices for monitoring, client onboarding and software testing of FIX-related financial applications as well as creating technical guidelines for the assessment of their quality and reliability. The group has presented a detailed mind map of such a set of best practices and guidelines, and continues working on the content of the document. The MOST members meet on a monthly basis and also collaborate with the FIX Orchestra and the Cybersecurity working groups to ensure alignment across a number of related topics.

Exactpro partners
EXACTPRO CLIENTS

THE JOHANNESBURG STOCK EXCHANGE (JSE) — EXACTPRO COLLABORATION TO TEST THE MILLENNIUM EXCHANGE™ TRADING PLATFORM

"I have been receiving very positive feedback from my JSE teams about their work with Exactpro. The automated testing solutions allow us to perform in-depth testing to ensure software quality before deploying into live service," says Hendrik Kotze, Chief Information Officer, JSE. "We will continue our collaboration with Exactpro who help us with quality deliverables to ensure that the JSE continues offering reliable, secure and efficient capital markets across a diverse range of instruments, supported by cost-effective services."


SKYTRA SELCTS EXACTPRO TO TEST ITS NEW DERIVATIVES TRADING SOFTWARE

Jeremy Norwood, CIO of Skytra: "Our timescales for launch are challenging, and we needed an experienced IT partner who could help us ensure that the delivered software works as per our business, operational and regulatory requirements. Exactpro will conduct a number of independent, unbiased functional and regression test cycles as part of our overall delivery programme. I am confident that Exactpro, with its proven track record of successful delivery of quality assurance projects for the financial services industry, will provide exceptional service for Skytra."


EXACTPRO ANNOUNCES MANAGEMENT BUYOUT FROM LONDON STOCK EXCHANGE GROUP

As per a multi-year services agreement, LSEG will remain a significant customer of Exactpro that will continue providing independent software quality assessment of LSEG’s core platforms.


EXACTPRO COLLABORATES WITH AUSTRALIAN SECURITIES EXCHANGE (ASX) TO CONDUCT FUNCTIONAL, NON-FUNCTIONAL TESTING AND TEST AUTOMATION FOR ASX’S NEW TRADING PLATFORM.

Timothy Hogben, COO, ASX
Interview: Disruptive Technologies and Blockchain


EXACTPRO DELIVERS TEST STRATEGY FOR HONG KONG EXCHANGES AND CLEARING LIMITED (HKEX) NEXTGEN POST TRADE PROGRAMME

"Thorough testing is important for a smooth launch of our new platform, and we are delighted to have engaged Exactpro to provide their expert advice on how we can utilise current best practices," said Christian Sjøberg, HKEX Managing Director and Head of Platform Development.


EXACTPRO’S TH2 ALLOWS QUOD FINANCIAL’S MULTI-ASSET TRADING PLATFORM TO PERFORM 4,000 REAL-TIME END-TO-END TESTS PER SECOND, PER RELEASE.

Mickael Rouillere, Chief Data Science Officer, Quod Financial: "th2 and our collaboration with Exactpro is the first use of AI/ML-driven test automation for an execution and algo trading software provider. With these tools, our clients can upgrade more frequently, develop algos more confidently, and focus more on innovation."

TEST AUTOMATION FOR CCPs AND EXCHANGES – OPERATIONAL DAY REPLAY LIMITATIONS

INTRODUCTION

As regulated entities vital for the financial markets ecosystem, CCPs and exchanges recognise the importance of quality and resilience of their platforms. Thorough software testing is fundamental in identifying problems that can affect system integrity. Software testing encompasses Functional Testing which ensures that the system works according to specifications and satisfies the compliance requirements, and Non-functional Testing spanning the assessment of performance, latency, capacity, reliability and operability. Test automation decreases time to market and boosts verification coverage.

A popular verification approach used across the industry – not without some merit – is a parallel run comparing the current production system and a new release, this is also known as ‘production data replay’. However, overreliance on this method puts firms at a disadvantage when delivering significant changes into live service.

Let’s say that the two versions of the system under test are two different images. Every output data element is a pixel in the picture. Using replay and parallel runs is similar to pixel-by-pixel comparison. At times, it works well: the pixels remain where they are and few discrepancies are detected. But what if, instead of changing, the picture has slightly shifted? Despite the absence of significant changes, we will detect major discrepancies between the two pictures.

In software testing based on data replay, a small change in the data format can cause breaks across the perimeter. The team will have to spend time on the manual introduction of adjustments and reviewing all false positives, while overlooking the actual problems. In our Trading Day Logs Replay Limitations and Test Tools Applicability research (accessible via the QR code on this page), we demonstrate that a non-deterministic outcome can occur even without differences in the input data, due to the distributed nature of the systems used in trading and clearing.

Y
The Deliberate Practice of Software Testing based on modelling the system allows the creation of test libraries that serve as an executable specification for complex platforms. Instead of relying on a fixed data subset, we are constantly trying to widen the testing scope. Instead of confining the test scope to requirements, we have learned to see the system as a whole that evolves and changes over time, and not a static sum of its parts.

Software testing is relentless learning. Model-based testing relies on the understanding that the best software testing instrument is the human brain. We need to create a mental model of the system – the theory of everything – implement it in code – Build Software to Test Software – and use it to produce relevant test scenarios and their expected outcomes. With the deliberate testing approach, we can go through any possible data permutations.

In contrast, data replay relies solely on the existing data recordings. It is limited by the selected time window, and some rare events might not be included into the test run, since they do not necessarily occur every day.

When a system undergoes a large-scale technology transformation, there are usually many changes in the input and output formats, the way the system processes the data, as well as the structure of the operational processes.

Going back to the pixel analogy, we can say that data replay relates to model-based testing in the same way as bitmap graphics does to vector graphics. The latter can be easily manipulated: objects can be enlarged or made smaller without losing quality. It's impossible to do the same with pixel images and stay happy with the result.

While there are many benefits of using deliberately generated synthetic data, there is always a probability that the model will not take into account some aspect of the system or a business flow present in production. To ensure proper test coverage, we use a set of techniques involving process mining. We take a detailed look at these in one of our WFE publications and on our YouTube channel (directly accessible via the QR codes on this page).

Exactpro focuses on software testing for exchanges, CCPs and financial technology vendors. We serve our clients in twenty countries on six continents. Please contact us to learn more about how to overcome the limitations of operational day replay and release more reliable software into production faster.

Production replay alone is inefficient in supporting large-scale transformational projects. Without comprehensive models and deliberate test automation scenarios, most replays lead to garbage in, garbage out.
TOWARD REDUCING THE OPERATIONAL RISK OF EMERGING TECHNOLOGIES ADOPTION IN CENTRAL COUNTERPARTIES THROUGH END-TO-END TESTING

Elena Treshcheva, Researcher, Exactpro
Rostislav Yavorsky, Head of Research, Exactpro
Iosif Itkin, co-CEO and co-founder, Exactpro

The research paper was accepted as part of the programme at IOMA: WFE’S 37TH CLEARING & DERIVATIVES CONFERENCE 2020 and published in the conference proceedings via the Journal of Financial Market Infrastructures.

This schema of a generalised architecture of a post-trade platform within a CCP enhanced with emerging technologies illustrates the participant structure complexity. A company may be represented by various entities, and these entities may trade in different markets and in different asset classes. Moreover, their margining can be carried out in a consolidated way or in segregated currencies. The links between non-clearing members and clearing members, their changing roles in different markets, the array of accounts – all of this adds challenges to the software testing process.

Key Takeaways

- Emerging technologies that are widely adopted by financial institutions promise functional efficiency and cost reduction, but also pose a number of risks. Extreme complexity and non-deterministic nature of the existing technology platforms are commonly underestimated and need to be addressed, as they will be imminently inherited by the platforms built with the new technologies.

- Potential risks associated with traditional technology platforms in the financial services industry stem from the challenges posed by their multicomponent structure, large number of endpoints and system interdependencies, participant structure complexity, multitude of asset classes and associated life cycle events and their system schedules, variety of protocols and APIs, complex calculations, and distributed multithreaded architecture.

- The risks induced by the existing complexity of FMIs are amplified by some of the characteristics of the emerging technologies. Infusing traditional CCP technology stack with DLT leads to significant platform transformations and associated interoperability issues at the confluence of traditional technology components and those built with DLT. In its turn, AI transformation, in addition to obvious technical challenges of data collection and preprocessing as well as building a trustworthy model, requires additional attention to avoid biases and ensure regulatory compliance.

- To address these challenges, a robust software testing approach is needed. Stochastic processes related to multi-threaded distributed processing across multiple nodes and uncertainties related to machine-learning models require sophisticated testing methods to ensure resilience and trustworthiness of mission-critical software platforms.

- The proposed approach suggests incorporating both active and passive testing techniques reinforced with the statistical analysis of test execution data. High-volume automated testing of distributed clearing systems helps to expand the test coverage and create production-like conditions.

- Test automation framework described in the paper emulates the nodes in CCP infrastructures, generates API calls, and triggers transaction flows. The verification process of bi-directional message flows suggests that the framework stores all the messages sent or received to/from the non-blockchain parts of the hybrid system alongside the data extracted from the ledger to enable passive testing and property-testing over many random cases. The framework provides a platform for building an extensive regression testing library covering functional and non-functional aspects of clearing platforms of any complexity in order to reduce operation risk involved in their implementation and ongoing exploitation in the live service.

Please proceed to reading the full version of the research paper at risk.net.
LEDGEREDGE SELECTS EXACTPRO TO DELIVER RESILIENCE FOR ITS DISTRIBUTED LEDGER ENABLED CORPORATE BOND TRADING ECOSYSTEM

Exactpro, a leading software testing provider for mission-critical financial market infrastructures, today announces it has been chosen by LedgerEdge, the next-generation ecosystem for corporate bond trading, to deliver functional testing and ensure the resilience of LedgerEdge’s global corporate bond trading platform powered by distributed ledger technology.

LedgerEdge aims to revolutionise the $41 trillion corporate bond market by devising a new trading ecosystem, harnessing R3’s Corda system for distributed computing, that improves liquidity and provides greater transparency.

To assess and maintain the quality of LedgerEdge’s platform, Exactpro is developing a test library using the model-based capabilities of th2, Exactpro’s next-generation toolkit for automating functional and non-functional testing of distributed transaction processing systems.

As the project continues its pilot-phase in anticipation of the expected release during the second half of 2021, Exactpro has completed a functional requirements review at this early stage of the project and carried out functional touch testing of the components and applications delivered so far.

We are delighted to partner with LedgerEdge on such an ambitious and innovative project. The past year has highlighted the importance of operational resiliency and Exactpro continues to develop and deliver effective testing solutions in order to meet this growing demand.

Alyona Bulda, Head of the Global Exchanges Division at Exactpro

We are passionate about delivering the future of corporate bond trading. As we get closer to launch, it’s necessary to have a trusted partner to help us test our operational resilience and ensure we can meet the demands of the market. Exactpro’s bespoke tools and methods will enable us to achieve this, and we are excited to see the results of our collaboration.

Robert Bose, Chief Technology Officer at LedgerEdge

About LedgerEdge

LedgerEdge was founded in 2020 by an expert team of financial market and technology professionals to solve the fundamental challenges of discovering liquidity and executing trades without harmful data leakage in the corporate bond market. With the foundation of a distributed technology architecture, it will deliver a fundamentally better ecosystem and experience for finding data, sharing data, and executing trades. For more information, please visit our website, LinkedIn or Medium pages.
Exactpro, a leading software testing provider for financial market infrastructures, is pleased to announce the receipt of QA Financial’s “Automation Technology Project of the Year: Exactpro and R3” award, in recognition of its work with R3’s Corda Enterprise Distributed Ledger Technology (‘DLT’).

Exactpro delivers testing services underpinned by tools and proven methodologies as a result of a significant R&D investment. The project saw the extension of comprehensive functional and non-functional capabilities to meet the new and exacting testing requirements of the latest Corda Enterprise DLT release, itself forming the basis of a few significant new FMI-driven platforms.

Matthew Crabbe, CEO of QA Financial, says: “QA Financial’s annual awards recognise innovation and achievement in software quality assurance in financial services. Exactpro’s work with R3’s distributed ledger platform is a great example of how important software testing is to the development of new financial technologies, and how automated testing technologies in particular are critical to the functioning of complex markets.”

Commenting on the award, Iosif Itkin, co-CEO of Exactpro, says: “We are delighted to be recognised for our progress with testing in the DLT space in conjunction with R3, to help them deliver a cutting-edge, robust, and performant enterprise-grade platform for use by their growing number of production clients. Our achievements ensure that future DLT projects match or surpass the level of reliability of their legacy counterparts and bolster our status as a market leader in software testing for systemically important infrastructure service providers in the future.”

"There are many challenges in testing distributed ledger platforms, including the interoperability of nodes in the network and the near infinite permutations of connections between them. It’s a challenge that expands into hundreds of millions of tests, and automation is the only viable solution," added James Carlyle, CIO, Head of Production, R3.

Exactpro continues to innovate in new technologies such as artificial intelligence and blockchain, bringing state-of-the-art testing methods to FMIs implementing next generation projects.

Risk.net is the world’s leading source of in-depth news and analysis on risk management, derivatives and regulation. The annual Risk Technology Awards nominations are granted after a thorough review by a panel of judges consisting of industry experts and Risk.net editorial staff. A total of 142 entries in 23 categories were recognised this year.

Firms entered the awards and were judged primarily on their achievements in the pre-coronavirus age’, as the announcement states. How they leveraged their tools and adapted approaches is key. 'Rather than trying to predict future circumstances, we should stress technology platforms to their limits, with rigorous checking for monitoring and alerting mechanisms, and system failover capabilities," says Iosif Itkin, co-CEO and co-founder of Exactpro. "Instead of waiting for a catastrophe to happen, we emulate it during our tests, thus providing stakeholders with the information on the real state of the platform and its readiness for the unexpected."

"Ensuring the highest quality and reliability of our clients’ technology platforms has always been Exactpro’s priority," adds Iosif. "It’s an honour to have our approaches recognised at such a high level."

In this Risk.net interview, Alexey Zverev, Exactpro co-CEO and co-founder, talks about mitigating risks while driving innovation in the time of high volatility and explains what made Exactpro stand out among the contestants.
SKYTRA SELECTS EXACTPRO TO TEST ITS NEW DERIVATIVES TRADING SOFTWARE

Skytra is a recently established Airbus company. Its goal is to provide an innovative solution for the air travel industry to hedge and manage its revenue volatility risks caused by short-term revenue visibility and support long-term financial planning for airline operators. Market participants will soon be able to trade cash-settled futures and options contracts based on Skytra Price Indices developed in collaboration with the air travel industry.

As announced earlier, Skytra is applying for the Financial Conduct Authority (FCA) authorisation to act as a Benchmark Administrator and to operate a Multilateral Trading Facility (MTF). Skytra is a recently established Airbus company. Its goal is to provide an innovative solution for the air travel industry to hedge and manage its revenue volatility risks caused by short-term revenue visibility and support long-term financial planning for airline operators. Market participants will soon be able to trade cash-settled futures and options contracts based on Skytra Price Indices developed in collaboration with the air travel industry.

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Nasdaq, the architect and provider of the world’s most widely adopted financial market infrastructure technology, will provide, host and manage the core technology for Skytra’s derivatives trading venue.

Skytra and Exactpro have announced that based on the results of a successful RFQ process, a Master Services Agreement between the two firms has been signed whereby Exactpro will provide various IT consultancy and software testing services to Skytra. The initial engagement will include Exactpro supporting functional testing of Skytra’s derivatives trading platform powered by Nasdaq.

Our timescales for launch are challenging, and we needed an experienced IT partner who could help us ensure that the delivered software works as per our business, operational and regulatory requirements. Exactpro will conduct a number of independent, unbiased functional and regression test cycles as part of our overall delivery programme. I am confident that Exactpro, with its proven track record of successful delivery of quality assurance projects for the financial services industry, will provide exceptional service for Skytra.

Jeremy Norwood, CIO of Skytra

We are honoured to have been selected by Skytra to work on this ambitious undertaking in collaboration with our Skytra and Nasdaq colleagues. On our end, we have allocated an experienced agile project team equipped with our tools built for automated testing of our clients’ software.

Alexey Zverev, co-CEO and co-founder of Exactpro

Skytra, the new Airbus’ venture for airline risk management, and Exactpro Systems, a specialist independent software quality assurance firm, sign a Master Services Agreement.

The software testing collaboration between Skytra and Exactpro will provide the stakeholders with additional confidence in the quality of Skytra’s derivatives trading platform prior to go-live in a transparent, regulated and secure environment.

We are honoured to have been selected by Skytra to work on this ambitious undertaking in collaboration with our Skytra and Nasdaq colleagues. On our end, we have allocated an experienced agile project team equipped with our tools built for automated testing of our clients’ software.

Alexey Zverev, co-CEO and co-founder of Exactpro
OUR COVID-19 RESPONSE

To ensure the continuity of operations for all our clients, and keeping in mind the worldwide effort to slow down the spread of COVID-19 and its newly emerging variants, most of the Exactpro teams worked from their homes using secure VPNs from 17 March 2020 till the implementation of the safe office reopening program across all locations. We have now set up a work routine, flexible to our staff’s needs in this new context.

PROTECTING OUR PEOPLE

By switching to remote work when needed, we manage to maintain safe and orderly operations and a full workload across all Exactpro business lines. With Exactpro being headquartered in the UK and running software testing and development operations in Georgia, Sri Lanka, Russia, Lithuania and having an administrative office in the US, we are attuned to multiple local regulations and government recommendations, including encouraging our staff to vaccinate, wear masks and take other precautionary measures set forward by the NHS, CDC, and globally – by the World Health Organisation.

ASSISTING CLIENTS

Most of our clients are regulated market infrastructures, which makes our long-term goal locked in on ensuring operational resiliency. Our clients’ systems have shown strong performance throughout the unprecedented volatility of the pandemic. Despite the disruption, Exactpro is over 700 staff strong and continues expanding the worldwide network of its software testing and development centers. Our team looks forward to continuing the delivery of Exactpro services to clients out of both the existing and new locations.

FOCUSING ON SUSTAINABILITY

2020-2021 has been the time of reassessing our values and redefining what truly matters. With the pandemic in the foreground, we have looked into ways to encourage our distributed team to successfully adjust to a new work culture, socialise, exchange experience and get inspired by other team members, continue taking good care of themselves by participating in sports challenges and wellbeing sessions, and acquire the tools necessary for feeling at one with each other while staying apart.

We realise that the post-pandemic office environment will not be the same, therefore, we are in the process of transforming it into a welcoming communal space accounting for the need to enjoy each other’s company, support one’s physical and mental health, and find a safe place for children’s short-term leisure, among other more traditional office-related activities. We have also accelerated our sustainability work and prioritised our plan of aligning our strategy with the UN’s Sustainable Development Goals.

We encourage everyone to follow up on your vaccination plan and stick to your local health department guidelines.

#ExactproPeople Employee Appreciation Program

Socialisation Activities

Wellbeing & Mental Health Seminars

Adapted Internal and External Workflows for the New Business Routines

Encouraging Vaccinations, Providing Free PCR tests for Safe Outdoors Team Building Activities

Transforming Staff’s Home Workstations

Sports Challenges

Transforming the Office Space into a Safe Environment Fit for the New Business Routines
EXTENT is an annual forum for sharing innovative trading and post-trade technology ideas and expertise among specialists working in the global financial markets industry. Next year, EXTENT will celebrate its 10th anniversary. We look forward to regaining the ability to host physical EXTENT events and have the ambition to expand the forum’s reach to the key financial centres all around the world.

The EXTENT agenda features, but is not limited to, the following sections:

- Post Trade and Distributed Ledger Technology
- Non-functional Testing in the Cloud
- Regulatory Impact on Software Testing
- Resilience of Financial Market Infrastructures
- Agile Software Testing and DevOps
- Artificial Intelligence and Software Testing

The EXTENT series events highlight the latest trends in developing programme and hardware platforms used at exchanges, brokerages, investment banks and other trading participants, focusing on quality assurance and efficiency of such platforms.
Would you like to provide your feedback on our work?

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