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.
- 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.
- Headquartered in the UK, Exactpro has operations in the US and Eastern Europe.
- We maintain orderly operations and a full workload across all Exactpro business lines.
- In September 2018, Exactpro opened a new R&D center in Tbilisi, Georgia.
- We encourage everyone to #StayHome #StaySafe and take all the necessary precautions.
- Incorporated in 2009 with 10 people, the company has experienced significant growth as satisfied clients require more services; now employing 630 specialists.
- Since Exactpro’s foundation, the company’s client network has expanded to over 20 countries around the world.
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The Exactpro client network

- We encourage everyone to #StayHome #StaySafe and take all the necessary precautions.

Orderly Operations

exactpro.com
This year has not been the easiest. And yet, 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 have officially launched th2 and released it as open source software. We are prepared to roll th2 out across all our projects in 2021. 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.

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 recent market volatility has taken a toll on global clearing systems, with clearinghouses seeing historic moves in transaction volumes and sporadic shifts in intraday margin requirements; markets have also experienced abnormal price fluctuations. While our clients’ systems have proven resilient, it’s too early to rest on our laurels.

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.

I’m excited to be working as a member of our expanding London team, literally next door to some of our major clients and partners, alongside Alexey Zverev, Maxim Rudovsky, our Senior Project Managers Pavel Sigov, Alexey Pereverzev, Maxim Nikiforov, Asya Legotina, and Andrey Zavora, and our Business Development Team – Michael Smith, Lilia Tira and Ian Salmon.

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.

The Exactpro motto is ‘Build Software to Test Software’. With 600+ specialists on board and over eleven years’ experience of running a distributed team, we have excelled at testing and deliberately breaking our clients’ systems to ensure the most resilient performance and prevent production incidents from turning into disasters.

In the first quarter of this year, most of our teams switched to remote work, and we are proud to be able to continue providing the expected quality of software testing services without disruption. I think our industry and the whole world are successfully learning to work in the new normal and still get the job done.
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.

- Delivers end-to-end automated functional and non-functional testing of complex financial systems
- Enables intelligent interaction with many widely adopted network protocols as well as API, UI, DLT and cloud endpoints
- Executes sophisticated test algorithms
- Collects and processes distributed test data (for machine learning and other purposes)
- Performs model-based testing and analyses the behaviour of systems under test
- Integrates with a variety of widely adopted test tools and frameworks via its open interface
- Is an open-source solution; th2 source code is available on GitHub

exactpro.com
th2 is a multi-component microservices framework managed via Kubernetes, where every component is a Docker container. The microservices interact via two interfaces – gRPC and MQ – for best performance.

Containers can be created in multiple programming languages. The variety of programming languages supported by th2 makes the solution platform-agnostic and easily integratable into virtually any infrastructure.

Machine Learning (ML) and data science have long transformed traditional software testing and development approaches. An ML-driven data lake is the main ML-component of the th2 platform. It stores the output from thousands of test nodes. Collecting the output includes collecting raw and test data, including the positive and negative outcomes, and, thus, bug reports that are instrumental in fixing defects. As a result, the data lake produces a test execution report and provides an intuitive dashboard for in-depth results analysis. The stored data can be easily exported for further processing.

How the Data Lake works

After connecting to the system and receiving the raw and the test data, th2 parses it and collects it in a single data lake for storage and easy extraction. It not only normalises the incoming data, but also allows for various intuitive visualisations of the end-to-end testing results based on the relevant parameters. On top of that, keeping the data for processing in the data lake allows us to apply more sophisticated software testing methods driven by AI and data mining techniques. This approach lets the Exactpro QA Engineers detect hidden trends, improve the testing strategy and quality, maximise test coverage, and create and maintain powerful test libraries with a lot of analytical effort being put into the process.

Benefits of th2

The data-driven approach leveraged by the Exactpro solutions ecosystem helps to continuously enhance software development and testing efficiency and ensure that our clients get the best technology that data science has to offer.
KUBERNETES: THE TIME, THE HURDLES AND THE INVESTMENT – IS IT ALL WORTH IT?

Over the last several years, Kubernetes has become a buzzword in the tech circles, both due to its presumed advantages and the controversy surrounding its implementation. With its automation and vast deployment orchestration capabilities sounding promising, the open-source platform is worshipped by its adopters – represented in fintech by HSBC, Starling, Monzo, Google, BlackRock, RedHat, Capital One, ING and many other incumbents and startups – but dispraised by others.

For large-scale distributed systems, Kubernetes offers prospects of resource optimisation via its capacity to balance the load and quickly scale up (at peak times) and back down (at idle times). Blue-green deployments make for fast releases set up on a rolling basis. The iterative deployment adds reliability, boosts efficiency and lowers the overhead. The benefits in terms of test automation flexibility when using Kubernetes seem to be almost infinite. So, what’s the catch?

In the fourth edition of its State of Container and Kubernetes Security Report released this fall, StackRox cites “a staggering 90% of survey respondents” that “have experienced a security incident in their Kubernetes and container environments during the last 12 months.” Human error is named the primary reason for the hacks and data breaches. It is justified by the fact that “containers and Kubernetes have a lot of knobs and dials, increasing the chances of human error”. Needless to say, the complexity of potential architecture issues grows exponentially with multi-cloud adoptions.

One must admit that container clustering and deployment automation are hard problems to solve, especially at scale. Implementing Kubernetes is essentially about learning a whole new technology stack. There is no ‘big button’ that will make it work, there is just painstaking labour of customising every little detail. On the bright side, there is no need to discard everything you have built before and start from scratch. Kubernetes integrates into the existing traditional infrastructure, the ultimate payoff of its implementation being getting a system that is perfectly aligned to your needs. This is complemented by professionalised workflows, improved stability and quality across the SDLC, as well as switching from a heavyweight monolithic architecture to a suite of discreet easily manageable components that don’t affect the operability of the overall service, when deployed.
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 am happy to have come on board a year ago to help Exactpro expand 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 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.”

Thomas Toller
Managing Director of Exactpro Systems LLC, USA

RELYING ON THE CONTEXT – SCIENCE, TECHNOLOGY, SUSTAINABILITY

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 year, 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.

“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.”

Elena Treshcheva
Researcher, Exactpro Systems LLC, USA

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.”

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.”
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.
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.

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 three case studies discuss the testing of a collateral and liquidity management system for a leading global rates and multi-asset clearinghouse and a multi-national central counterparty.

DLT
This 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.

Market Surveillance
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.
THE EXACTPRO SOLUTIONS ECO SYSTEM: THE INTELLIGENT WAY TO TEST

th2 has evolved out of the Exactpro test tool suite that—over the past 11 years—has established itself as a go-to toolkit across half of the top 20 global systemically important financial market infrastructures. Each of the test tools has its unique focus.

FUNCTIONAL TESTING

Active Real-time Testing
Sailfish is an active real-time keyword-driven test tool delivering fully autonomous scheduled test execution that does not require ongoing monitoring. Sailfish can also be used as an exchange simulator for testing post-trade systems.

Passive Testing, Monitoring, Onboarding
Shsha is a post-transactional passive testing tool that tests the back-end of trading platforms, market data, post-trade and market surveillance systems without interacting with them. Shsha can be used for testing against audit and regulatory requirements as well as for client onboarding certification tests.

NON-FUNCTIONAL TESTING

Stress, Load, Performance and Failover Testing
Load Injector is a powerful load generator built to stress-test scalable high-load trading infrastructures. It is an open-cycle load generator capable of supporting both model and measurement approaches of performance testing.

A COMBINATION OF FUNCTIONAL AND NON-FUNCTIONAL TESTING

Realistic Simulation of Market Agents for Testing Purposes
Minirobots is an active multi-participant testing tool which simulates the behaviour of real traders, having complete autonomy in making routine decisions under specific market conditions. Depending on the testing needs, the robots can act independently or in groups. Experience has shown that the best software testing results are achieved at the confluence of functional and non-functional testing.

Post-trade Systems Testing
ClearTH is a web-based application for testing post-trade systems. The tool simultaneously executes multiple end-to-end test scenarios in batches. This allows us to raise the level of test automation. ClearTH detects abnormal behaviour of the system under test and effectively predicts potential issues. It offers many built-in actions to cover the majority of activities in post-trade systems.

THE DELIBERATE PRACTICE OF SOFTWARE TESTING

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 test libraries and tools we have developed over the years apply to various business contexts, from regulated markets to MTFs, from dark pools to clearinghouses and brokerage systems. They have been successfully implemented in a wide range of technical and middleware infrastructures.
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 DL T 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 FMs implementing next generation projects.

Exactpro is named Managed Support Services Provider of the Year by Risk.net. 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 received 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 in what came next, though, is no less, if not more, important. However, in software testing for complex distributed systems, such as banking and capital markets systems, outages and abnormal peaks in transaction load, numbers of connections or asset prices are something one should prepare for head-on as part of business-as-usual activities.

"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. You can proceed to watching the interview with Risk.net via the QR code on this page."
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.

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.
EXACTPRO - JSE COLLABORATION TO TEST THE MILLENNIUM EXCHANGE™ PLATFORM

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.

“...and dedication to our clients.

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.

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.

Hendrik Kotze, Chief Information Officer, JSE

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

Exactpro successfully automated and tested the following functionalities of the trading system:

- Equity and Derivative Order/Quote Management
- Order Matching and Price Monitoring
- Order Book Reconstruction and Trade Publication
- Request for Quotes (RFQ) Management
- Trade Reporting
- Daily Life Cycle
- Client Connectivity and Authentication
- Reference Data Management

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:
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.

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.

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.
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 it 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 Krishna Tharnoju, Consultant at Pictet Asset Management, 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
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).

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
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.
MANAGING RISKS AROUND MACHINE LEARNING’S TOP USE CASE

Large financial market infrastructures tend to incorporate artificial intelligence (AI)-based software components to their existing multi-component platforms, as opposed to using standalone AI solutions. For instance, a substantial and complex clearing system may have multiple components in addition to the clearing engine — a platform that incorporates reference data, risk management, collateral management, payment systems, and other functions, often totalling dozens of different components.

Some of these functions can be replaced with AI-based applications, and as the BoE and FCA found, usually AI/ML is deployed for risk calculators, market surveillance, and fraud detection systems. When a traditional infrastructure is infused with AI components like this, the hybrid nature of the resulting software systems creates challenges around ensuring smooth integration and assurance of the resulting system’s quality. As the methods for market abuse continue to evolve at the same pace as the sophistication of market surveillance systems deployed to fight fraud, firms should rethink how they approach validating and verifying these AI-based applications.

Complexity

When merging traditional technology with AI, the biggest mistake is underestimation of the original technology.

The technology underpinning capital markets is notoriously complex and prone to non-deterministic behaviour.

When AI/ML are integrated into these existing systems, their complexity and non-determinism in system behaviour are magnified as these characteristics are inherited by systems enhanced with AI. The key to mitigating this challenge is testing the market surveillance system with an equally powerful AI application.

Specifically, the approach should account for a set of market surveillance subsystems:

- A gateway subsystem that obtains data from different data sources
- A data enrichment subsystem
- Real-time and offline alert engines to detect abusive market behaviour
- A data repository to store structured and unstructured data
- A GUI module that provides drill-down capabilities to investigate the detected alerts

Data

Market surveillance systems are built on data analytics and pattern recognition, typically interconnected with numerous trading platforms, market data feeds and news feeds. The introduction or upgrade of any of those systems can severely impact the effectiveness of the monitoring platform, and so testing requires a comprehensive understanding of the surveillance monitoring function.

The best approach is end-to-end testing for the whole message flow. This starts with injecting data in the upstream system via the trading interface (e.g. FIX Gateway), receiving messages via the market surveillance stream gateway, and then comparing the received messages with the expected ones. If a response is not available from the market surveillance system in real-time via a channel, testing by comparison is used. This type of test comprises comparing the contents of output data from the system against the actual results.

The data consistency verification test is performed after each operational cycle of the system and compares messages from different end points of the market surveillance system under test and the external (integrated) systems. Data from the downstream gateways of the exchange system and the trade reporting system, data from the input gateway of the market surveillance system and data from the market surveillance system’s data warehouse are the end points tested to verify data consistency.

The Oracle problem

Another challenge commonly associated with AI systems is known as the Oracle problem, when there are no predefined rules on which input-output combinations are right and which are wrong. Though in most cases the decision as to whether the test passed or failed is not made by humans, human intervention is useful when the test’s outcome is not strictly defined. When the Oracle problem comes into play, testing should be significantly enhanced by automation, and, more importantly, equipped for collection and storage of test execution data. This enables the results to be analysed first by scripts and algorithms and then – evaluated and verified by humans.

In addition to verifying the popularity of ML and AI applications for market surveillance, the BoE/FCA survey found that of the respondents currently using ML, more than half indicated their applications are governed through their existing model risk management framework or enterprise risk function. Given that the large number of connections and components contributes to the probabilistic nature of the behaviour of an ML-empowered surveillance mechanism, an AI-based system is unlikely to be successfully validated through traditional testing. An equality-sophisticated approach to testing not only ensures the success of a market surveillance system, but optimises the system to increase efficiency, mitigate costs, ensure regulatory compliance and better prepare a firm to mitigate the ongoing evolution of financial fraud.
Welcome to Test World
A world of Adventure
A world of Danger
A world of Fantasy
Go-Live without Consequences
Retrospectives without Judgements
Testing without Limits

Follow the dawn of machine learning and the evolution of test automation technology in this dark odyssey that begins in a world of Agile.

In Test World: Reboot, we guide you through the story behind Test World, the fanfiction art we created based on HBO's critically acclaimed sci-fi TV series entitled Westworld.

The plot of Westworld is complex; it features exceptional narrative, non-linear storytelling, dynamic point-of-view changes and striking metaphors. What seems evident at first may turn out to have a deeper sense to it.

The video clips that we created are also filled with more meaning than might initially appear, and that's what we will try to explain. In this show, we saw a great opportunity to illustrate a lot of the typical situations that we - as software testers - face in our day-to-day work. We will talk about purely technological as well as cultural, communication and many other issues with the help of our main characters.
ARE COMPANIES RIGHT TO OUTSOURCE SOFTWARE TESTING?

By Iosif Itkin, co-CEO and co-founder, Exactpro, and Daria Degtyarenko, Researcher, Exactpro.

With regulatory requirements and business pressures putting an ever-tightening squeeze on financial services, firms tend to look for the most efficient ways of ensuring the quality and stability of their platforms, with some turning to quality assurance outsourcing. However, outsourcing might not always be the best plan, for four key reasons: responsibility, capability, agility and quality.

Responsibility

In its SYSC 8.1 General outsourcing requirements, the Financial Conduct Authority (FCA) states that a regulated entity must not ‘delegate responsibility’ while outsourcing ‘critical or important operational functions or any relevant services and activities’. The quality of software systems and platforms underpinning the financial market infrastructure’s (FMI’s) operations and services is certainly important and, arguably, critical. Therefore, it is a regulatory directive that quality assurance must not be delegated.

Capability

To stay competitive, any company must be technology-focused. No company would want its core competency to be building low-quality products, so quality assurance is not a peripheral function. Software testing cannot be viewed as an ancillary activity for a capable, competitive firm.

Agility

Relying on external vendors could hinder the flow of information necessary for companies focused on reducing time-to-market and undergoing agile transformations. Flexible software development and acceptance-testing methods require synchronisation among all team members, which can become difficult when outsourcing, because the teams are divided by firewalls, time zones, distances, and cultures.

Quality

‘Quality cannot be tested into a product’ — so goes the aphorism, meaning that product quality is not solely determined via testing. Firms focused on quality work on holistic approaches to software development, continuously analyse testing outcomes, measure attributes related to product quality and invest in improving risk management tools with the aim to prevent rather than cure. ‘Quality is everyone’s responsibility’, as another old saying goes. Why would anyone want to rip out an integral piece of the intertwined quality puzzle by outsourcing software testing? Exemplary organisations take their regulatory responsibilities and technology capabilities very seriously. They relentlessly strive to achieve quality and agility in their delivery. So surely the case for DIY software testing is watertight. However, true software testing is not there to confirm perfection. Software testing exists to uncover something that somebody doesn’t want to exist. It is about providing objective information about the system under test in a form beneficial for the stakeholders. To paraphrase James Madison, one of the founding fathers of the US, if companies were angels, independent software testing would be unnecessary. If angels were to develop software, neither external nor internal controls would be necessary. Software testing, if independent, does not set managers free from responsibility. Rather, it pressures them toward higher levels of regulatory compliance.

When Tolstoy wrote in ‘Anna Karenina’: ‘Happy families are all alike; every unhappy family is unhappy in its own way,’ he meant that in order for a family to be happy, it must succeed with respect to a specific range of criteria, and failure on any single count leads to unhappiness. Similarly, to be successful, all production systems must work well within a narrow range of criteria that assures their users’ and stakeholders’ satisfaction. In order to consistently reach that benchmark, it is of paramount importance for a technology firm to have a strong in-house capability to build, check and monitor systems to ensure that the family stays happy.

Software testing is focused on exploring the darker side of systems. Research confirms that developers are less likely to deploy advanced software testing techniques, such as passive testing, in part due to the congruence bias, i.e. overreliance on proving a specific hypothesis that directly results in neglect of indirect testing. Thus, leaving software testing to developers or cross-functional teams could mean prioritising the component level and ‘happy path’ checking over proper risk assessment of an interconnected system as a whole.

Fundamentally, biases are not the enemy, because they exist for a reason: to increase efficiency. Superiority requires focus, and a good strategy always requires making a choice. In this particular case, it is whether to prioritise improving the core product versus building a sophisticated test harness. The creation of test harnesses is the core capability of an independent software testing business, so it doesn’t make sense to hire smart testers and then tell them what to do.

By the same token, outsourcing does not guarantee software testers’ unbiased independence. Many articles have been written about cross-functional, self-organising teams and confusing software testing to sprints. Genuine agility is antifragile. Iterative processes considerably benefit from prompt independent feedback. In implementations that are agile in name only, there will always be a way to blame inefficiency on faulty communication. Reliable systems are not built on trust. Rather, they are built on the absence of trust. That is why independent software testing is fundamental to well-functioning financial firms, similarly to the importance of a free press to a well-functioning democratic system.

Independent testing alone is not enough to achieve quality, especially when introduced at a late stage of software delivery. The best way to limit the total cost of the project is to incorporate independent testers into self-organising teams as observers and contributors, so they can detect problems as soon as possible. Whether the issue is a software defect or a process deficiency, it is never too early to embrace reality and deal with it.

If outsourcing software testing is a necessary evil, the shame of delegation reflects a gap between the status quo and the ideal world. Relying on outsourcing is not perfect. However, if applied properly, outsourced testing can at least create awareness that a gap exists and, possibly, can help to narrow it.

Why should ideal companies not use software testing outsourcing?

In this video, Iosif Itkin reviews the controversy around financial market infrastructures outsourcing their software testing processes, touching upon regulatory, financial and organisational issues behind outsourcing, and explains why fintech firms still turn to outsourcing on a regular basis.
For digital exchanges, the outage question is not a question of ‘if’ but ‘when’. But as Exactpro founder Iosif Ikin notes, there’s a lot to be said for expecting the worst and planning accordingly.

A Coinbase outage barely makes news these days, they’re happening so often, nor does a Binance outage or one from BitMex or Kraken. Barely a week goes by without a major digital exchange outage somewhere. So what can 10 years of testing regulated trading platforms teach digital exchanges about building in resilience?

For a start, these aren’t ‘black swan’ events. Statistician Nassim Taleb, who popularised the black swan concept around the impact of improbable, outlier events, pointed out in March that Coronavirus (Covid-19) does not fit the definition. The pandemic, Taleb told Bloomberg, is a white swan: the virus threat was predicted back in his 2007 book. Covid-19 has rocked markets, but firms that prepared by not only planning for the worst and act accordingly. It is not enough to minimise the impact is to relentlessly speculate for the worst and act accordingly. It is not enough to test a technology system to validate what works within the predefined SLAs or KPIs. Systems must be pushed beyond capacity to evaluate what the actual meltdown looks like and how the system reacts when – not if – the major disruptions happen. Too often, we are asked to avoid ‘unrealistic’ scenarios when performing tests. For example, just several months ago we were required to limit a load test to double the maximum previously observed in production – an approach proven insufficient by the recent spike in trading volumes caused by pandemic-related market volatility. This lesson is, apparently, the one to be learnt by the digital exchanges, as some of them experienced failures as well.

1. Exchange outages are inevitable

To build resilient platforms, one needs to work in assumption that things will go very wrong, a perspective that enables introduction of additional protection layers into automation technology. Like the white swan of Covid-19, the best way to minimise the impact is to relentlessly speculate for the worst and act accordingly. It is not enough to test a technology system to validate what works within the predefined SLAs or KPIs. Systems must be pushed beyond capacity to evaluate what the actual meltdown looks like and how the system reacts when – not if – the major disruptions happen. Too often, we are asked to avoid ‘unrealistic’ scenarios when performing tests. For example, just several months ago we were required to limit a load test to double the maximum previously observed in production – an approach proven insufficient by the recent spike in trading volumes caused by pandemic-related market volatility. This lesson is, apparently, the one to be learnt by the digital exchanges, as some of them experienced failures as well.

2. Design for observability

Although there are usually several contributing factors to any major outage, there is one element present most of the time: absent, inadequate, or faulty monitoring. When conditions head downhill and there is little time to understand what is happening, it is easy to respond with reckless steps, only to aggravate the problem. When it comes to boosting the resilience of automation technology, information about the systems themselves is vital. Chaos monkey testing within distributed systems enables the exploration of how various disruptions are reflected in the technology’s monitoring systems, and whether that data is transparent enough to determine an appropriate response.

3. Honesty and fidelity matter

Software testing provides vital information about the quality of the platform, and it must be truthful; because without access to objective data, we cannot learn from failures. Covering up the truth amplifies the negative impact of problems and human errors. Though it may be tempting to comfort stakeholders by re-classifying defect statistics to paint a brighter picture of a system’s readiness for launch, this approach rarely results in resilient platforms. Even rejected defects are useful, because they provide substantial immunity to real threats to the system under response.

4. Look for substantiality

To build resilient software, it is important to value essence over form, thinking more about assuring the system’s quality rather than about how it will look on paper. However, quite frequently, people tend to “improve” reports to make things look less scary. For instance, in agile transformations, some organisations interpret agility as co-location rather than collaboration, or in compliance testing, box-checking around a small set of requirements instead of extensive system exploration with the focus on what needs to be improved to assure the resilience and high availability of the platform.

5. Plan to be Agile

Firms understand that they benefit when able to rapidly adapt to change, especially during a crisis. Research proves that faster feedback loops contribute to better software. While in some industries it is possible to harvest information complexity of test harnesses for financial platforms rivals the platforms themselves, which means both the platform and test tools need to be developed simultaneously. Early testing ensures the relevant information is available when needed. Rather than obtaining information during a crisis, it is better to perform deep exploration of system functions during calm periods, and then apply those insights during volatile times.

While the exchange and clearing platforms tested by Exactpro were prepared with correctly functioning circuit breakers and the ability to sustain prolonged load ahead of the emergency of Covid-19, many systems don’t have the benefit of independent testing to ensure resilience levels that can handle the next crisis. With more digital trading firms entering the global capital market, it is particularly important to use takeaways obtained from the experience with traditional regulated exchanges: both successes and mistakes are valuable lessons to be learned by their digital counterparts. It is not enough to merely plan for disruptions – those plans and the technology that underpins them must also be tested to ensure resilient, continued operations during unexpected events.
EXACTPRO AND QUOD FINANCIAL UTILIZE A DATA-DRIVEN APPROACH TO SOFTWARE TESTING

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.

Mickael Rouillere, Chief Data Science Officer, Quod Financial

Thursday, 24 September 2020, London - Exactpro, a leading software testing provider for financial market infrastructures, and Quod Financial, an innovator in multi-asset trading and automation, announce the next phase of their collaboration by implementing machine learning driven QA testing to Quod Financial’s technology, reducing the overall complexity attached with modern testing systems.

The proof of concept (PoC) was successfully completed over the summer, where Exactpro deployed th2 – a new open source microservices-based test automation platform – and, in collaboration with Quod Financial, adapted it for their test environment. Exactpro and Quod have created a set of automated test scenario templates aimed at testing business workflows in algo trading and smart order routing, while performing log analysis. This success represents the next step in Exactpro and Quod’s journey in implementing the next generation of multi-layer automated testing for clients.

Through their ongoing collaboration, Exactpro will provide the Quod community with the th2 open platform, along with a resource pool to support future testing. This will offer Quod’s clients an automated and integrated testing environment where real scenarios can be used for Quod trading, including algorithmic trading, market making, and smart order routing.

th2 is the next generation of an open source toolkit for ‘Software Development Engineers in Test’ professionals who can work equally and effectively as programmers, testers and data analysts. The toolkit allows developing efficient machine-driven end-to-end libraries for testing complex distributed transaction processing systems, such as securities trading systems and exchanges, banking, brokerage, post-trade (e.g. clearing, settlement, custody), payments, etc.

th2 is a Kubernetes-driven microservices solution. It enables intelligent interaction with many network protocols, API, UI, DLT or cloud end points and provides the ability to execute sophisticated test algorithms, collect and process distributed test data (e.g. for Machine Learning), perform model-based testing and analyze the behavior of systems under test.

th2 has an open interface allowing integration with a variety of widely adopted test tools and frameworks.

Alexey Zverev, co-CEO and co-founder of Exactpro, said: “We are delighted to confirm this next phase of our collaboration with Quod Financial. The POC demonstrated the outstanding capabilities of th2, successfully testing Quod’s adaptive trading technology, and we are excited to see how it can be developed further. We look forward to continuing to work with the team from Quod.”

Deploy faster, upgrade more frequently, innovate with trading.

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.
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.

NO/NO – INSIGNIFICANT DATA FORMAT AND FUNCTIONALITY CHANGES

In test automation based on replay, the same set of input data – that can be taken from production or saved for testing purposes – is replayed against the existing and the next versions of the system. Reportedly, the method allows one to identify and analyse the discrepancies between versions. The output data gets compared at the end of such a run.

The data is expected to either have no discrepancies or have so few that a QA analyst will be able to analyse them and determine whether these are expected or regression bugs.

This approach refers to a certain ‘old’ version of the system as the only test oracle. Thus, if the system had previously contained outstanding issues, there will be no way to reveal them and expect a different (better) outcome from the comparison. In fact, the correct functioning of the system may be perceived as a bug.

This way, defects can persist in the system for years and not be detected. We can admit, however, that data replay can work well with very limited functional and data format changes.

YES/NO – SIGNIFICANT DATA FORMAT CHANGES AND MINOR FUNCTIONALITY UPDATES

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.

NO/YES – EXTENSIVE FUNCTIONALITY CHANGES AND MINOR DATA FORMAT UPDATES

When the system’s business-as-usual behaviour serves as the only test oracle, it is impossible to apply test automation to new functionality. Since data replay only allows us to check the existing functionality, verification for the new functionality is mostly manual and the testing scope is very limited.

The data replay approach also fails when the new functionality is outside the testing scope. There is no way to detect it or test it.
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.

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.

**THE DELIBERATE PRACTICE OF SOFTWARE TESTING**

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.

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.
Would you like to provide your feedback on our work?

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