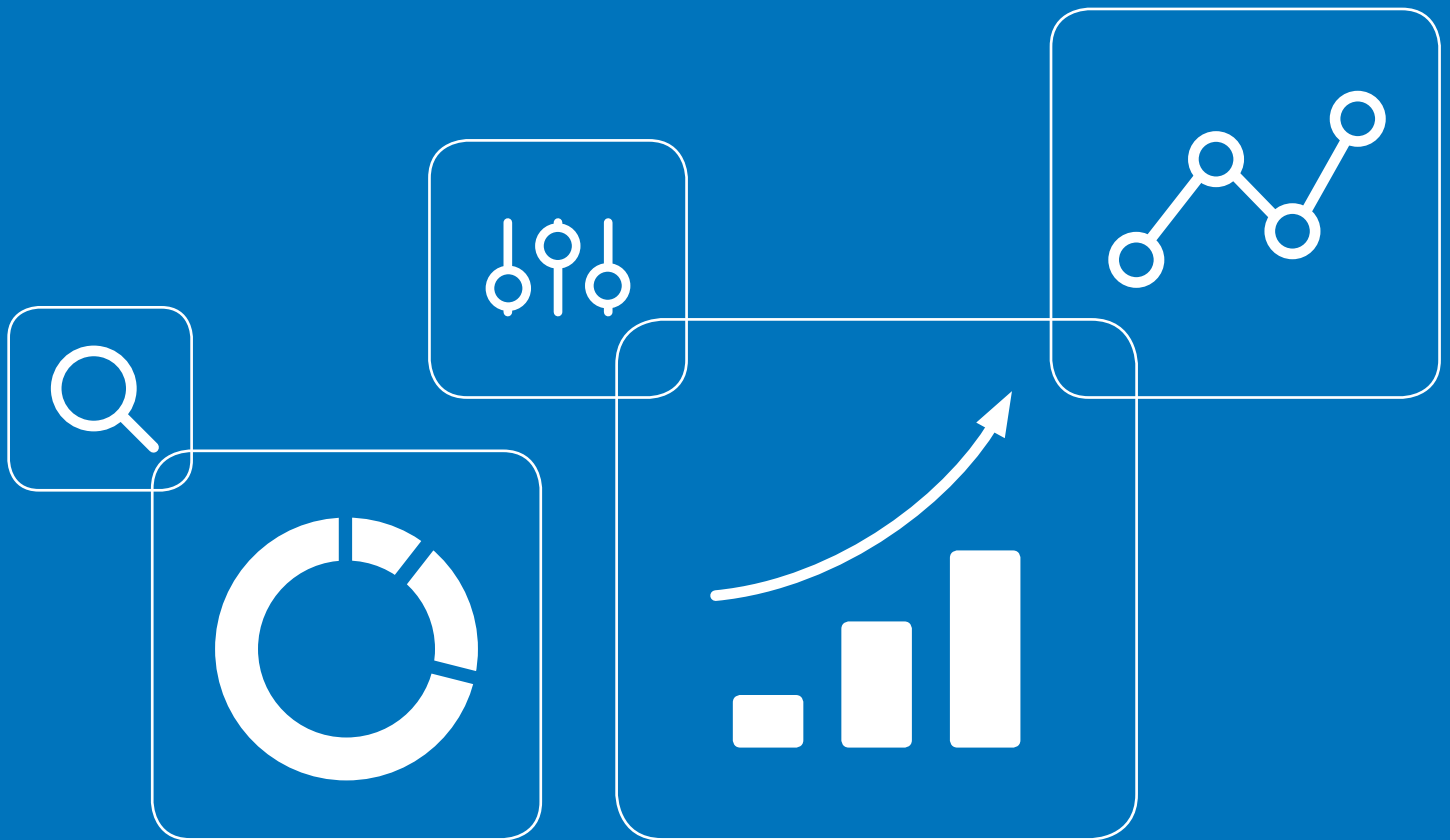


BEST PRACTICES FOR TRADE INFRASTRUCTURE AND EXECUTION ANALYTICS

PeerPaper Report



BASED ON REAL USER REVIEWS OF CORVIL

ABSTRACT

Financial services firms that engage in trading are reliant on highly complex IT infrastructures to make money. In today's trading environment, order execution is critical to success. Microseconds count as trades move from system to system—and in and out of trading venues and stock exchanges. The people responsible for building and supporting trading infrastructure have arrived at a number of best practices for trade infrastructure and execution analytics. These range from measuring performance at a granular level and monitoring latency at each stage of transaction execution to analyzing venue performance. Insights are based on the experiences of IT Central Station members who work with the Corvil monitoring and analytics solution set.

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INTRODUCTION

Securities trading firms rely on complex algorithms and IT infrastructures to earn strong returns. Timely order execution is critical to success, with even delays as short as a microsecond or less potentially affecting trading outcomes. Connections and interactions between systems in the transaction flow can affect the performance of the overall order lifecycle.

For the trading technology and operations teams that are responsible for building and supporting trading infrastructure, best practices help keep the firms on track for success. Performance monitoring and analysis of order execution form many of these practices, which include measuring performance at a granular level, monitoring latency at each stage of the order lifecycle

and correlating order outcomes with technology performance. Analyzing trading venues, such as stock exchanges, for their performance or conditional outcomes at a given time is also essential. These insights, and others contained in this paper, are based on the experiences of IT Central Station members who work with the Corvil monitoring and analytics solution.

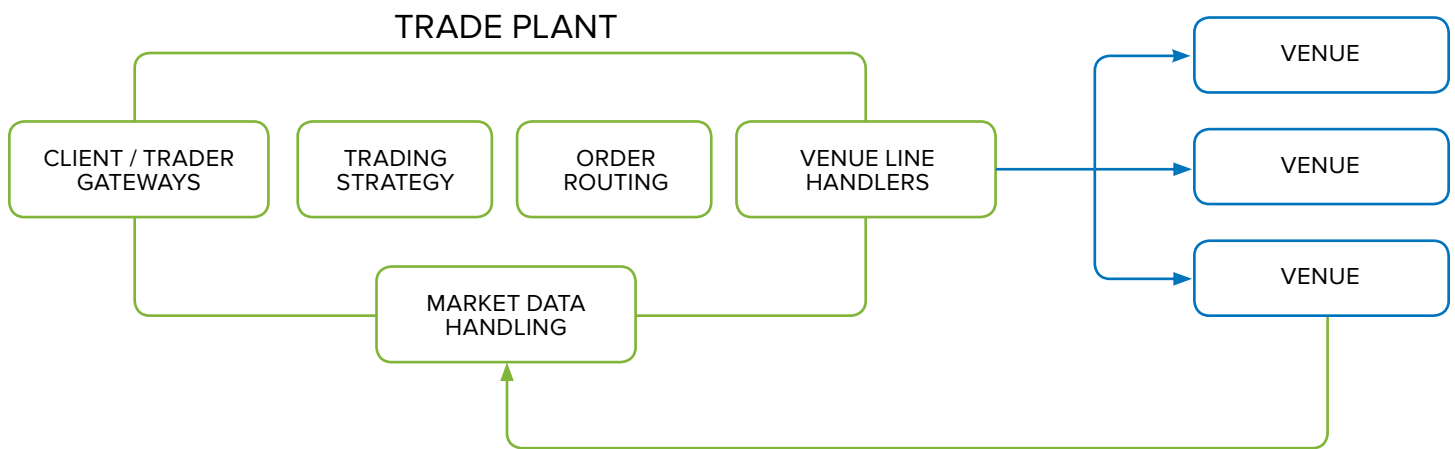


Figure 1 – High-level architecture of an electronic trading plant.

Time and Performance Pressures in Electronic Trading

Trading businesses seem to walk a series of tightropes. In simple terms, there are the basic buy/sell/hold decisions (i.e., what to buy or sell and when) that guide the overall process. It's a very competitive business, one where the wisdom of one's decision-making may be presented for all to see, in brutally quantitative terms, at the end of every day. These pressures keep plenty of trading professionals up at night.

Then, there's the actual execution of those trading decisions. With many fragmented options for liquidity, deciding **where/with whom** to execute an order is as important as what to order. An order typically triggers a sequence of transactions that occur across a variety of systems. Figure 1 shows a high-level diagram of trade plant infrastructure.

Trading works on short time scales. The prices of a security may continually change and in small fractions of a second. The speed of executing a trade can thus have an effect on the financial success of the trade. Slow transaction execution can negatively affect performance, profit and/or customer experience. In this way, electronic trading system performance and financial trading performance are deeply linked.

The Role of Performance Monitoring and Analytics for Trading Systems and Infrastructure

Trading represents a true entanglement of business and technology. Execution/ecommerce teams are responsible for delivering a competitive level of execution outcome and transparency to clients and traders. Quants and trading application teams depend on technology to automate the institution's trading and execution strategies. Trading technology teams are tasked with providing the infrastructure, connectivity and systems to allow all of this to function. They must deliver optimal performance of those, relying on a network of connected systems and venues.

As a result, trading infrastructure/operations teams are responsible for keeping systems up and orders executing regardless of market volatility. After all, disruptions in service or degradation of trading system performance come at a high cost. Additionally, trade support teams are tasked with examining the execution success of specific orders and responding to client/trader and venue inquiries. For example, trade support needs to understand if a customer's order was successfully filled or canceled and why or why not. This often entails examining not just the performance of one or more orders, but correlating it with the underlying

technology behaviors at a given time.

Performance monitoring and analytics therefore form an important part of running an electronic trading business. The work in keeping trading systems running as they're intended is only one use of the information gleaned by a performance monitoring and analytics solution. Context around client or trader activity and performance of venues and counterparties can be derived from real-time transaction data to create a fuller picture of trading business performance.

Given the complexities and interdependencies of the various connected systems that support trading, it's critical for each team to understand the impact of performance issues on their respective areas of responsibility as soon as they arise – be they technology related or business/execution-related. To make this happen, financial firms deploy specialized software that monitors and analyzes trading performance and order execution at a granular level.

While the sophistication of performance monitoring and analytics solutions can vary widely, the best practices outlined in this paper suggest that the ideal solution should deliver insight into infrastructure and application performance, examine all orders and transactions, provide precision time-sequencing, detect short time-scale conditions and correlate transaction and technology performance. The benefits of deploying such a performance monitoring and analytics solution include:

- Full transparency into execution outcomes
- Accurate visibility into order execution lifecycles
- Real-time awareness of latency for every hop in the trade plant
- Improved response time for order and execution enquiries
- Reduced mean-time to repair (MTTR) trading infrastructure problems
- Service-provider accountability for Service Level Agreements (SLAs)
- Reduced operational risk due to technology failure
- Insight to know where to optimize for better outcomes

Best Practices for Trade Infrastructure and Execution Analytics

Trading firms have developed best practices for performance monitoring and execution analytics. These include measuring trading performance with granularity, tracking the full transaction lifecycle, measuring latency at each transaction stage and so forth. Members of IT Central Station who specialize in this kind of work have shared their best practices recommendations. The following offers highlights of their recommendations based on their experiences with the Corvil solution.

MEASURE TRADING PERFORMANCE WITH TIME PRECISION, ACCURACY AND GRANULARITY

Industry professionals who support trading operations understand that the speed, volume and automation of modern electronic trading operations create unique monitoring requirements around the precision and accuracy of time measurement and latency calculations. To this point, a [Senior Network Engineer](#) at a financial services firm with over 500 employees described his process of selecting a solution for performance monitoring and analytics.

He said, “None of these tools - they were mostly scripts that people wrote - could work at that nanosecond precision that Corvil gives us. Market data has moved on and the trading has moved on where that kind of granularity matters. Whereas before we could probably get away with it - the millisecond range was okay for us - now, we need to know things like spending this amount on a Solarflare card adds 50 microseconds. We need to be able to measure that 50 microseconds, which was something we couldn't do before.”

Clock synchronization integrity is foundational given the speed of electronic markets and pressures from regulators. Accurate time dictates the sequence of activities and causality, i.e., if event B happens after event A, then event B could not possibly have caused event A. If the clocks measuring the times that A and B happen are out of synch, the sequencing of events, and the related performance calculations, become distorted and in worse-case scenarios, leave firms at

risk with regulators.

Speaking to this issue, the financial [Senior Network Engineer](#) noted, “We’ve just started doing the UTC clock sync, where you can use the Corvil to analyze your time signals and generate a report.”

A cursory view of transaction data or technology performance is not enough to know where to invest to optimize returns versus guessing with high opportunity cost and low impact. This issue was on the mind of an [EMEA Head of Electronic Trading App Management](#) at a financial services firm with over 10,000 employees. He praised his platform in this context, saying, “It also allows us to see at a very granular level the amount of time taken through each of our components, both internally and externally. Therefore, we can use this solution to establish whether or not we have any suboptimal applications, network configurations, switches, or client providers.”

The financial [Senior Network Engineer](#) offered further perspective, saying, “The ability to dig into the messages is definitely a valuable feature. We don’t have any other tool like that, at least in the network space where I work. It is very useful to be able to get such granular information.”

He then added, “As network engineers, when we deal with packets, we can dig down into the TCP level and that’s about it. We can’t actually decipher the actual messages. For latency analysis, sometimes you’re dealing with Exchange-driven time stamps and you actually do need to dig down to that level of detail. That’s been the most valuable feature for us.”

Visibility at microsecond (or less) timeframes also provides insight into network congestion issues such as microbursts that are invisible to monitoring solutions reporting network throughput averaged over longer periods of time. As a [Network Operations staffer](#) at a financial services firm with more than 1,000 employees put it, “Most of the tools that we have don’t have any visibility into microbursts. Corvil can provide that visibility into microsecond timestamping.”

The benefits of granularity include better productivity and faster problem resolution. The financial services company’s [Senior Network Engineer](#) observed that

“Corvil has definitely helped reduce incident diagnosis time. Just the fact that it’s so easy to pull out captures or the actual messages, whereas before that was probably the thing that would take us the longest, just getting the data.” He continued, commenting, “Before you can start looking at the data you actually have to get the data. Now, it’s easy. We just say to the user, ‘Tell us the time XYZ happened.’ We can find it, we can zoom in on it, we can extract the messages.”

For this IT Central Station member, granularity and precision help with understanding the impact of trading venue activities. For example, he said, “It’s very easy to see that when a particular venue is sending multiple quotes together, queueing up one behind the other, rather than as they are generated.” Being able to see a pattern like this quickly leads to faster resolution of any trade timing that might arise as a result of it.

“ Without Corvil, it would take 20 to 30 minutes, and with Corvil, it takes a minute.”

For the [Network Operations staffer](#), his performance monitoring and analytics solution reduces incident diagnosis time. He explained, “[A] market data feed going down triggers a traffic detection gap, which will send an alert to our SNMP destination. Without Corvil, it would take 20 to 30 minutes, and with Corvil, it takes a minute. We have incidents pretty often, so this solution is saving us about two hours a week.”

INSTRUMENT THE FULL ORDER LIFECYCLE AND MEASURE LATENCY AT EACH STAGE OF TRANSACTION EXECUTION

Best practices suggest that it’s wise to look at the integrity of the full transaction lifecycle rather than that of a single layer like the network or the server. For the [EMEA Head of Electronic Trading App Management](#), the value was that his solution “provides us with a holistic overview of the client order flow through client connectivity to our internal components and risk checks in an exchange.” As he put it, “This is not something that we can easily provide ourselves.”

Working from the idea that one can't manage or improve what can't be measured, the financial [Senior Network Engineer](#) said, "It [Corvil's dashboard] shows the latency from the exchange to us. Then it shows the latency from us into what we [his firm] call our MDS system, and from there into our calc servers, which actually do the grunt work of generating the prices, and from there into our price distribution system. At each point, we have a nice, stacked view that shows the latency of each component."

He continued, saying, "What we've done a lot of work on is tick flow. We generate prices on various instruments, for example, DAX Futures. We need to understand, internally, how long does it take for the DAX Future tick to leave the exchange and to exit our pricing infrastructure, which generates the prices and feeds them into the apps that the clients use. We need to know at every step what that latency is."

With this approach, he can know where to invest to optimize. He observed, "We can look at this and say, 'Oh, actually it's our calc servers that are causing the most latency.' A good example is that recently our platform guys did some analysis on the kind of improvement we could expect if we put Solarflare network cards in our servers."

“We can cut the data different ways to look at it, either from an individual client perspective, trading across multiple venues, or we can target the analysis on a specific venue.”

He fleshed out this case with details, adding, "The analysis showed we could get a 50 microsecond improvement. By using our Corvil data, we could say that, while Solarflare would give us 50 microseconds of improvement, our calc servers alone are generating something like 20 to 30 milliseconds of latency on a bad day. So in the grand scheme of things, spending all this extra money to save 50 microseconds isn't going to cut it when there is a lot more scope to save latency by just rewriting the code on our calc servers. Corvil allows us to see where our issues are and then we don't waste money on areas that aren't going to give us the biggest gains."

VIEW ORDER/TRANSACTION DETAILS AND HOW THEY RELATE TO INFRASTRUCTURE PERFORMANCE

Trading technology professionals recommend gaining the ability to look inside the order messages to provide correlated analyses along multiple axes of client, commercial/business and tech infrastructure. An [Assistant Vice President of Equities Liquid Markets Technology](#) at a financial services firm with over 10,000 employees spoke to this need, saying, "We are using it

“Corvil allows us to see where our issues are and then we don't waste money on areas that aren't going to give us the biggest gains.”

[Corvil] for tracking the client round trip times, as well as the venue round trip times. The time it takes when the order comes in from the client to the time that it takes when it goes out. Plus, we are tracking the times when an acknowledgement comes back from the exchange. So, these are the type of statistics that we are using at the moment."

The practice of viewing transaction details along the client axis helps the firm know if it is meeting client performance expectations. In this context, the [EMEA Head of Electronic Trading App Management](#) praised his solution's ability to "break down the latency performance at both the venue level and client levels." He added, "We can cut the data different ways to look at it, either from an individual client perspective, trading across multiple venues, or we can target the analysis on a specific venue." Figure 2 shows how performance analysis derives client and execution context.

This IT Central Station member's primary use for the solution is latency monitoring and benchmarking. "We look at the geographical location of our servers and European exchanges," he said. They use the product to measure the time it takes to receive an order from a client, route the client's order to the exchange in the exchange data center and execute on the order book. They also measure the hops all the way back to the client's execution. As he put it, "That latency allows us to establish whether or not there might be any

Analysis at every step delivers full picture of execution performance

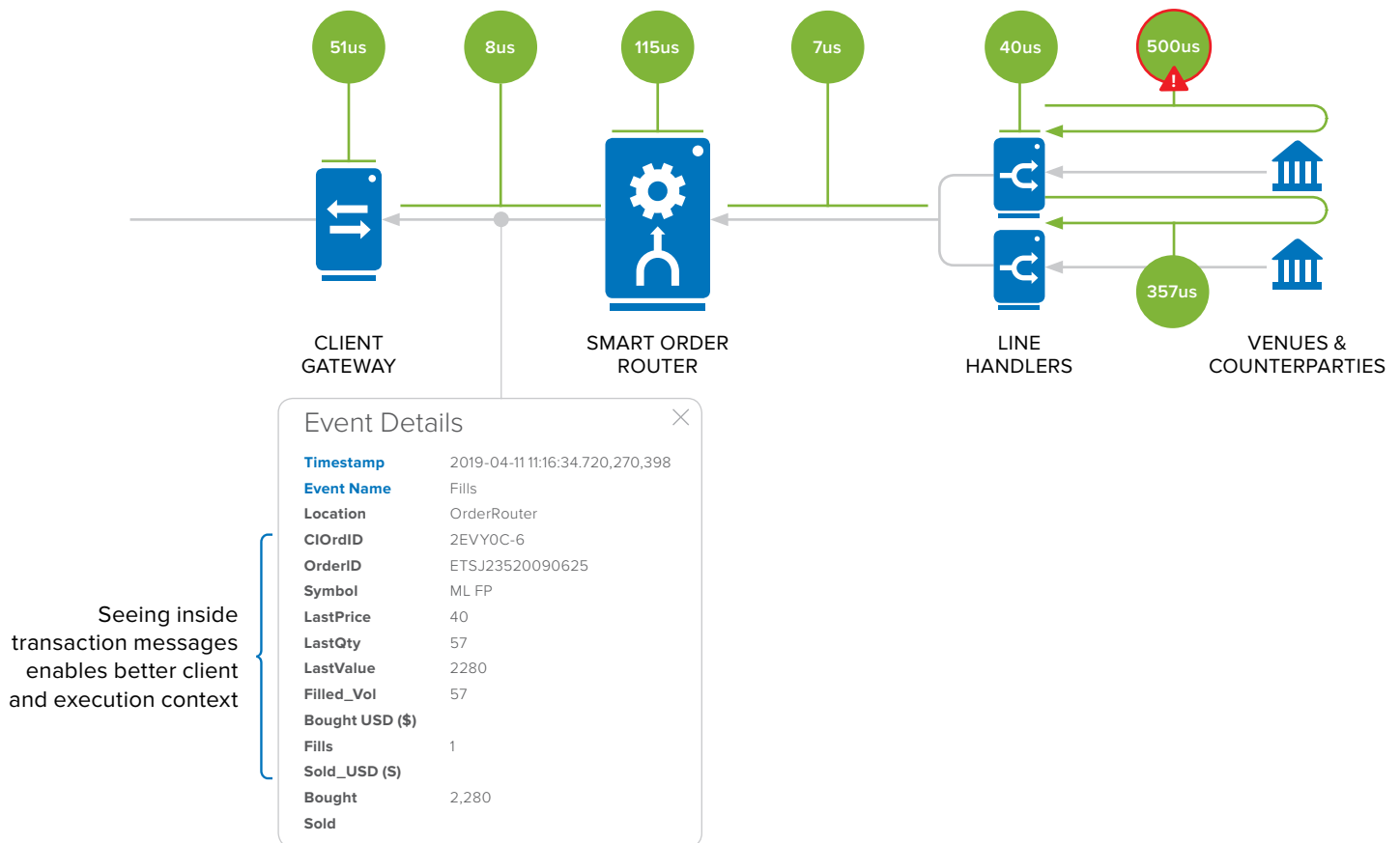


Figure 2 – Seeing inside transaction messages enables better contextual analysis.

problems with the connection, or understand if we're meeting expectations around latency benchmarks from the clients' perspective."

"It has all the decoders, so it's capturing every network packet and it's decoding in real-time and it's giving us latency information in real-time," explained a Corvil [User](#) at a financial services firm with over 10,000 employees. "It is easier to identify the flow and get quotes whenever we want. It's the real-time decoding and getting the latency information statistics that we find the most useful."

Productivity also rises, as the Corvil [User](#) observed. He shared, "We have also seen increased productivity from using this solution. If I had to go figure out the latency and then see where the problem is, I would have to do a lot more analysis from my own logs, but that wouldn't be as reliable. If I'm capturing anything in my process then I'm adding a latency on top of my

processing, as well as disk latency, network latency, etc. Having a source outside of my process telling me how my process is doing is way better than just doing everything from my process."

It's not enough to look at transaction-related messages along one dimension. The best practice is to see inside the message to obtain the data required for analysis along multiple axes. "As long as the client message or the trader message has the relevant information, you decode it and you have that information," explained the Corvil [User](#). He added, "We have statistics based on client. We have statistics based on exchange. With the new introduction of this Intelligence Hub, which we are still reviewing, you can break it down by any number of parameters, like symbol, or site, etc."

He further noted, "It's not latency data but the amount of flow, and the rate at which the flow comes. Corvil is able to capture all of that, the number of orders, the

number of cancel replaces, and the rate such as 100 messages per second or 1000 messages per second. You can see all of these breakdowns in Corvil itself.”

For the financial [Senior Network Engineer](#), the solution enables multi-axis analysis because “you can build your own metrics.” As he put it, “The fact that, as long as you know what the field is in the message, you can build your metrics based on that field and that is very good. It means you can do the analytics that you actually care for. You can customize it in a certain way, which is good.”

Such practices confer the benefit of understanding exactly where a problem is originating. Information on latency allows teams to “establish whether or not there might be any problems with the connection,” as the [EMEA Head of Electronic Trading App Management](#) put it. Or, he added, “Understand if we’re meeting expectations around latency benchmarks from the clients’ perspective.”

The [Assistant Vice President](#) concurred, saying, “If more time is spent on the venue round trip’s time, there is very little control that we have, because there might be an increase in latency at the venue’s site which we don’t have visibility of. Therefore, we can discuss with the exchange or market, why there was an increase in latency at this particular time, and whether there was any particular changes at their site or if something was different.”

This executive shared the value he got from having specific data. He said, “If we have those statistics, then we can go to the market or the client, providing them those statistic and talk about them in more detail. For example, why was there an increase or decrease in any particular latency during a certain day?”

ANALYZE AND COMPARE VENUE PERFORMANCE

Brokers and trading firms do not work alone. They engage with many different trading counterparties and venues which have an impact on the speed and quality of trade execution. For this reason, it is critical for firms to actively monitor and compare how various venues are performing – both from a responsiveness perspective as well as a trade outcome perspective (potentially even looking at this performance by symbol,

order type, etc.). Once armed with this analysis, IT Central Station members indicated several options for improving trading outcomes, from working with venues to understand why issues are occurring, to routing to alternative venues, to optimizing the performance of their smart order routers.

The financial [Senior Network Engineer](#) said, “We do venue performance analysis. A good example is FX [foreign currency exchange] pricing. We take all the OTC pricing from various liquidity providers like the Tier 1 banks. Key metrics for us with FX are things like sending-time latencies. We look at that. We always knew anecdotally that one of our feeds was really poor when it came to latency. But without Corvil, we didn’t have the numbers to prove it.”

The [Network Operations](#) staffer looks for anomalies that might signal a delay in trade execution. He said, “We do measure latency of our market data feeds coming down from the exchanges. If it breaches a threshold, we do contact the venues, then they make necessary corrections. This helps us improve our order routing decisions, because if it is too high of a latency, we just go through another venue.”

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The [Assistant Vice President](#) offered, “If we have the venue round trip time from the time it leaves the application, we can just go back to the exchange, discuss this, and say, ‘Why has it taken so much time?’ Maybe there have been scenarios where the exchange or market comes back saying they did some type of configuration changes at that site during that particular time, and that’s why there was an increase in latency. Or, they needed some type of changes at their site to improve the latency. This helps in our venue performance analysis.”

One benefit of venue analysis is the ability to make better routing decisions. As the financial [Senior Network Engineer](#) commented, “Having latency information helps us improve order routing decisions. A lot of our

trading is automated. It's not that the Corvil tool is used to directly feed the automation [in this particular environment], but it has provided visibility to allow us to support the process."

The [Assistant Vice President](#) went further in describing how his performance analytics solution enables better routing analysis. He said, "For certain applications, we target the time that it takes for the acknowledgement to come back, or for the request to go to the exchange. It should be seamless. So, we use different statistics for different markets. Based on that, we can work with different markets or exchanges to match the timings. Or, we use a different routing logic within our application to be able to process the order at the same time. Based on this analysis and the statistics that we have, we can use it to match or change the routing logic that we have."

Similarly, the [Network Operations staffer](#) noted, "We can ensure the round trip time: From the time we push out an order to the time that we receive an ACK back. Before we started using this tool, we didn't have any visibility into this scope of information. Now that we do, we can tweak our performance on the smart order routing (SOR) engines."

PROACTIVELY GATHER CLIENT INTELLIGENCE FROM TRADE PLANT OPERATIONS

Executing orders on behalf of clients is an increasingly competitive field. Managing client relationships depends on identifying changes in client order flow, trading patterns and execution metrics. Such metrics can be strong indicators of how the client is experiencing the trade plant's execution services. To understand where things stand in this department, the best practice is to be proactive in gathering intelligence about client activity, experience and outcomes and how trading system performance is affecting those outcomes.

For the [Network Operations staffer](#), this means breaking down the latency of each client. Their performance monitoring and analytics solution [Corvil] "provides the accurate timestamping on most of the sessions that we use for ordering, showing us the time that we send out an order to the time we get our execution report back." As he noted, "We can monitor that latency very closely."

A Corvil [User](#) at a financial services firm added further context, describing, "We get multiple clients sending into the same process and we can see, by visualization, that there's one client who seems to have better performance, another client who seems to have a little degraded performance. Why is that the case?"

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Answering his own question, he said, "All of these patterns of trading from different clients on different markets can be drilled down into. In this scenario, it helped us to look at the protocol implementation of our process and see if we could make improvements to our protocol....When you break it down by client or by market you can see which client is performing better, which market is doing better. Then you can drill down into that and see the trading pattern of that client: Why he is doing well, why the other guy seems a little off."

The [Assistant Vice President](#) revealed, "In the cases where we go live with any new client, or if we go live with any new exchange flow, then it helps to know the latency on day one. Then, we can produce the latency comparing it to any other flow or with any other statistics."

"It's easier for us to demonstrate the performance benefits of our applications, because our clients recognize Corvil as an industry-standard product and trust in it."

He was pleased with the analytics features of his solution, saying, "Sometimes, we are using the data search functionality for analyzing certain data over a day or so to find out if we are seeing some increased latency over a certain period of time. We are using the 'Inspect Data' analysis or Data Search [functions in Corvil] to find outliers for anything specific, trying to identify whether for an order canceled or an order that has been replaced where we are seeing an increase in

latency?” For instance, he used his solution to probe the time of day when there might be an increase or decrease in latency or how much latency there was at a particular time.

Stronger, more enduring client relationships can flow

from the ability to show consistent performance. As the [EMEA Head of Electronic Trading App Management](#) put it, “It’s easier for us to demonstrate the performance benefits of our applications, because our clients recognize Corvil as an industry-standard product and trust in it.” Trust invariably leads to more business.

CONCLUSION

It takes sustained diligence in performance monitoring and analysis to facilitate effective securities trading. The complexity and interdependencies in the underlying trading infrastructure make anything less than a serious effort worthless. As IT Central Station members shared, a collection of best practices helps guide teams in effectively optimizing trading system performance and achieving optimal trading outcomes. The speed and volume of trading creates unique precision and accuracy requirements for performance monitoring.

Performance details are required at each stage of the transaction to determine where to invest for the biggest performance boost. Seeing inside transaction messages is necessary to glean additional client, venue and execution context. Understanding venue performance supports order routing optimization for optimal execution. Trading that meets the needs of traders and their clients is one benefit of adopting these practices. Further benefits include more productivity in the IT department as well as faster time to resolve performance problems. Trading is endlessly competitive and the pressure to perform better never lets up. With the right tools, however, Trading Technology teams can take the lead in enabling a trading performance advantage.

ABOUT IT CENTRAL STATION

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The Internet has completely changed the way we make buying decisions. We now use ratings and review sites to see what other real users think before we buy electronics, book a hotel, visit a doctor or choose a restaurant. But in the world of enterprise technology, most of the information online and in your inbox comes from vendors but what you really want is objective information from other users. IT Central Station provides technology professionals with a community platform to share information about enterprise solutions.

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Corvil is the leader in performance monitoring and analytics for electronic financial markets. The world's financial markets companies turn to Corvil analytics for the unique visibility and intelligence we provide to assure the speed, transparency, and compliance of their businesses globally. Corvil watches over and assures the outcome of electronic transactions with a value in excess of \$1 trillion, every day.