

# International Securities Exchange scales off the chart

HP ISE White Paper



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# Benchmark result proves ISE's HP platform running OMX CLICK XT can scale up to 1 million quotes per second.

## Executive summary

International Securities Exchange (ISE) is the world's largest equity options exchange. In March 2004, HP and OMX Technology of Sweden performed a benchmark test at the request of ISE to determine the performance parameters of the firm's HP AlphaServer OpenVMS system running OMX Technology's CLICK XT™ trading application. The benchmark, designed by OMX, was conducted at the HP OpenVMS Solution Center in Nashua, New Hampshire, and used essentially the same application code that is used in daily production at ISE.

When the results of the benchmark began to come in, there was a long moment of stunned silence in the benchmark center; the ISE system configuration was able to scale to 1 million quotes *per second*. The benchmark results had important implications for ISE in terms of its ability to handle the steadily increasing volume levels in options trading transactions that have marked ISE's phenomenal success in the finance industry. The benchmark also revealed clear benefits that ISE gains from the HP and OMX system, including

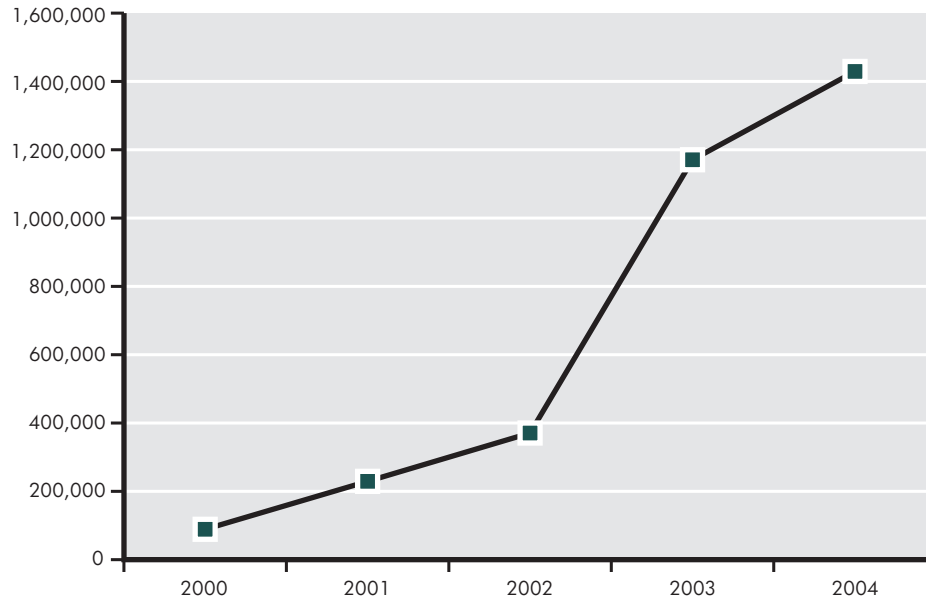
- Increased performance
- Decreased cost of ownership
- Competitive advantage
- Future growth capacity
- Demonstrated disaster recovery ability
- Support from powerful partnerships

Since its inception in 2000, ISE has relied on HP and OMX Technology as trusted partners and advisors. ISE leverages HP expertise to collaborate on new technology roadmaps and ensure that the exchange implements mature high-value technologies. The benchmark has helped ISE understand its current position and how to build its position for the future. The firm continues to rely on HP to help it build an environment that can easily handle change so ISE can maintain its leadership position in the marketplace.

## New business model spurs evolution in the options industry

### Introduction

In May 2000, the International Securities Exchange took one of the biggest risks in the world of finance—trading options electronically instead of from a trading room floor. Thus, with one bold stroke, ISE redefined the U.S. options industry. The firm introduced electronic trading, competition, and lower fees, as well as efficient, equitable pricing to enable instantaneous executions in tight, liquid markets. Today ISE has emerged as one of the industry's biggest success stories, becoming—in less than three years—the largest equity options exchange in the world.



Founded on the principle that technology fosters and infuses new efficiencies and operational innovations into securities trading, ISE has experienced phenomenal growth since its 2000 launch. Trading volume has risen steadily; in October 2004, average daily volume (ADV) in equity options was 1,622,945 contracts, up 37.58 percent from the previous year. For the same month, ISE set a new record for customer volume in its own listings with 26.8 million contracts—surpassing its previous record of 25.2 million, set the previous January. And ISE was the lead market in October 2004 for options on 27 of the 30 stocks in the Dow Jones Industrial Average—which represented 87 percent of the index's total weighting. For the third time that year, ISE traded more options contracts than any other exchange, distinguishing itself as the largest U.S. options exchange based on both equity and index options trading volume during any single month.

While ISE visionaries took a risk with their business model, they took none with their technology architecture. The core of the exchange is powered by HP AlphaServer systems running the HP OpenVMS operating system in

multisite clusters for disaster tolerance. The application that runs on ISE's central trading system is CLICK XT from OMX, which incorporates HP Reliable Transaction Router (RTR) software for transaction and data availability. With the business dependent on the performance of this infrastructure, rigorous capacity planning is a constant. After all, the firm was experiencing a 70 to 100 percent increase in transaction throughput each year, and ISE needed to ensure that its system could continue to scale to accommodate these significant volume levels. So the exchange decided to perform a benchmark test to determine the scalability of its HP platform and the OMX trading software running on it.

Such benchmarks provide valuable knowledge on how to size various customer-specific installations—in this case, whether ISE would be able to scale with demand for the foreseeable future to accommodate its capacity-planning challenge. As it turned out, the results exceeded all expectations.

“I can’t emphasize enough how the scalability of our technology infrastructure, specifically the HP solution with the OMX software platform, has clearly put us in a position to compete.”  
—Larry Campbell, Chief Technology Officer, ISE

### Benchmark background

Companies such as HP and OMX are regularly challenged by customers and prospects to deliver systems capable of handling ever-increasing performance demands on exchanges. As a result, HP performs benchmark activities daily. Because ISE was experiencing nearly 100 percent growth, it made sound business sense from a capacity-planning perspective to determine the scalability of its system.

For high-end options trading systems, a number of issues can pose performance challenges, including

- Inbound flow of prices of underlying instruments
- Inbound flow of prices on competing exchanges
- Inbound order flow from customers
- Inbound quote flow from market makers
- Outbound price information dissemination to member firms
- Outbound flow of prices to competing exchanges
- Deal capture, all deals need to be stored in a database
- Outbound flow of data to a clearinghouse
- Outbound flow of data to Central Securities Depository
- Market surveillance interfaces (both real-time and batch-oriented “data mining”)
- Network supervision

All of these issues typically affect performance at a significantly higher level than most commercial IT systems. However, one issue stands out: the inbound quote flow—in particular when there are competitive market maker firms using quote machines (an application used by a market maker to keep quotes in the market for a large number [e.g., 10,000] of tradable objects).

The traditional method for capacity planning and system sizing is to extrapolate the known values on current systems to what newer, faster, and/or bigger systems should be able to achieve. Such extrapolations run the risk of missing unforeseen bottlenecks where performance is limited at a level that is difficult to exceed. Accordingly, the goals for this benchmark were set at an extremely high level to establish how the overall system architecture would be able to scale. The idea was that, having established the performance capacity from a very large system, one could interpolate a reasonable system configuration for any point in time over the next several years by scaling down from the proven high-level result.

The benchmark took place in March 2004 at the HP OpenVMS Solutions Center in New Hampshire—a dedicated lab that offers a secure application-testing environment. The lab provides access to hardware, software, and engineering resources so clients can stage their applications under controlled conditions. Computer lab equipment is configured to meet clients’ requirements and can be placed on one of four physical networks.

The hardware configuration for the benchmark was the largest in the history of the OpenVMS lab:

- 26 AlphaServer systems/partitions
  - 82 total AlphaServer CPUs in the test setup
  - DS10s, DS15s, DS20s, ES45s, ES47s (4), GS1280 (8), (16), (32) CPUs
- 37 PCs
- 100 network connections
- 74 SAN connections
- 4,000 feet of Cat 5E cable
- 3,500 feet of 2 GB fiber cable
- Running OpenVMS V7.3-2

*Note: A 32-processor GS1280 contained eight hard partitions. A 16-processor GS1280 contained three partitions.*

This benchmark used essentially the same application code that's used in daily production at ISE.

A team of solution architects from HP technology partner Agilysys assisted the HP, OMX, and ISE teams in the system, network, storage, and software setup for the benchmark tests. Using engineers from Agilysys allowed HP engineers to focus on delivering the computer resources needed to complete the task.

## Benchmark results

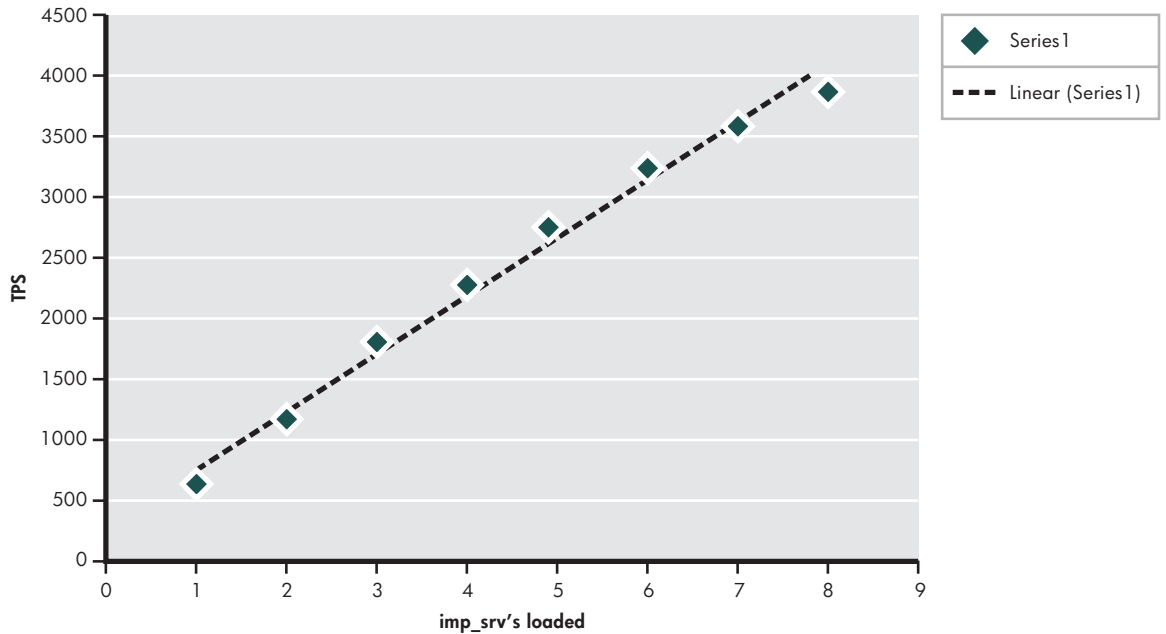
The goal of benchmarking the HP and OMX system was to obtain a tactical, as well as strategic, perspective on the exchange infrastructure. The benchmark was not conducted on existing ISE equipment; rather, it was performed using the new AlphaServer GS1280 servers and software available at that time to determine performance parameters. The test was successful in that it identified potential issues to be addressed—both now and in the future—and revealed clear benefits that ISE gains from the system, including

### Increased performance

The benchmark test on the HP OpenVMS and AlphaServer platform running the OMX CLICK XT trading application established results that exceeded every expectation—as well as an important business metric for the financial services industry—by scaling to more than 1 million quotes *per second*. This can be contrasted with the industry-standard TPC-C benchmark for transaction-oriented applications, which at this time had recently reached the 1 million transactions *per minute* level.

## ISE's solution scaled linearly to 8 CPUs on a single node

*Scalability on an SMP node: This test showed the aggregate number of quotes per second as 1 to 8 matching processes on the 8-way SMP node. The result is virtually linear scalability; the slight decrease at the high end can be explained by uneven load from the load generators used.*



There is, however, a significant difference between the TPC-C application and CLICK XT. TPC-C is an established but “artificial” transaction-oriented application designed to set a standard for transaction and database systems. CLICK XT, on the other hand, is a functional application designed to solve real-world business problems and can handle the obscurities of real-world trading. It’s used in production at about two dozen exchanges and marketplaces around the world. Thus, this ISE customer benchmark is more relevant to many securities trading applications than the more widely quoted TPC-C benchmark.

The test showed that RTR and imp\_srv<sup>1</sup> process (ISE marketplace server) scale linearly to at least eight CPUs on a single SMP node. The RTR ACP<sup>2</sup> process was using 97 percent CPU at this load level, so it’s unlikely that the scaling would continue linearly—which demonstrates a potential to drastically reduce the number of nodes and,

hence, operational costs. These impressive results prompted a test on a 16-way SMP as well, which showed excellent linear scalability up to 10-server process on the 16-way SMP node.

A separate set of tests was conducted with 1 to 10 4-way SMP nodes and showed that 10 nodes delivered 10 times the performance of one node—proving that the scalability holds with 10 4-way SMP nodes and that there is no identified bottleneck against expanding the system even further with more nodes to accommodate ISE’s growth.

“One of the strongest benefits of the OpenVMS platform is its reliability,” emphasized Larry Campbell, Chief Technology Officer, ISE. “We need to keep our customers happy. The OpenVMS solution is proven, and it has significant years of architecture experience behind it. We’re able to compete from a performance capacity standpoint because of the solid nature of this architecture.”

<sup>1</sup> imp\_srv is the server process that receives orders and quotes, stores them in an “order book,” and performs matching operations if possible.

<sup>2</sup> RTR ACP is the RTR process that runs on every node in an RTR network and routes/dispatches work to the appropriate client/server process. It is a single-threaded process, thus it will eventually become the bottleneck in a large SMP configuration.

“It really boils down to market availability and response time/throughput,” added Olle Haraldsson, head of capacity planning and OpenVMS services, ISE. “That’s really what being an exchange is all about. And the HP OpenVMS system and underlying AlphaServer systems are giving us the sub-second response time we need.”

In summary, the scalability results demonstrated by the benchmark were positive beyond anyone’s imagination, proving that the system can scale to 1 million quotes per second and that the system would not hit a bottleneck if ISE’s transactions continue to increase at the present rate. ISE learned that it doesn’t need to extrapolate growth from what it has already experienced; it can interpolate from a known system demonstrated by the benchmark—an enormous advantage in terms of capacity planning.

#### **Decreased cost of ownership**

Based on wisdom derived from years of using the system, a 4-way SMP node might be cost-efficient, although at present ISE’s 2-way node can scale to meet demand. But the benchmark proved that ISE can shift to a 10-way node as demand increases—which, while more expensive in terms of hardware, would lead to savings in operational costs; fewer large servers equate to a smaller footprint, saving valuable real estate, and using less power than more servers with less capacity. This strategy would also result in lower total cost of ownership.

Based on this information, and the flexibility of the modular CLICK XT application, ISE would have the option of deciding whether it made more sense from a cost perspective to run, say, ten 2-way CPUs as opposed to two 10-way CPUs; the management costs of upgrading the systems on two larger CPUs might be less. Additionally, maintenance costs for a smaller number of high-capacity servers are lower than for more, smaller servers.

“In working with HP,” noted Campbell, “we count on their expertise to help us make the right technology decisions to ensure that we’re implementing mature technologies that have high value.”

#### **Competitive advantage**

By introducing electronic options trading, ISE gained a substantial “first-to-market” competitive advantage that—due to its phenomenal success and growth—the company still enjoys today. But the astronomical scalability demonstrated in the benchmark of the HP and OMX system established that the company is well positioned to maintain this advantage as transactions grow.

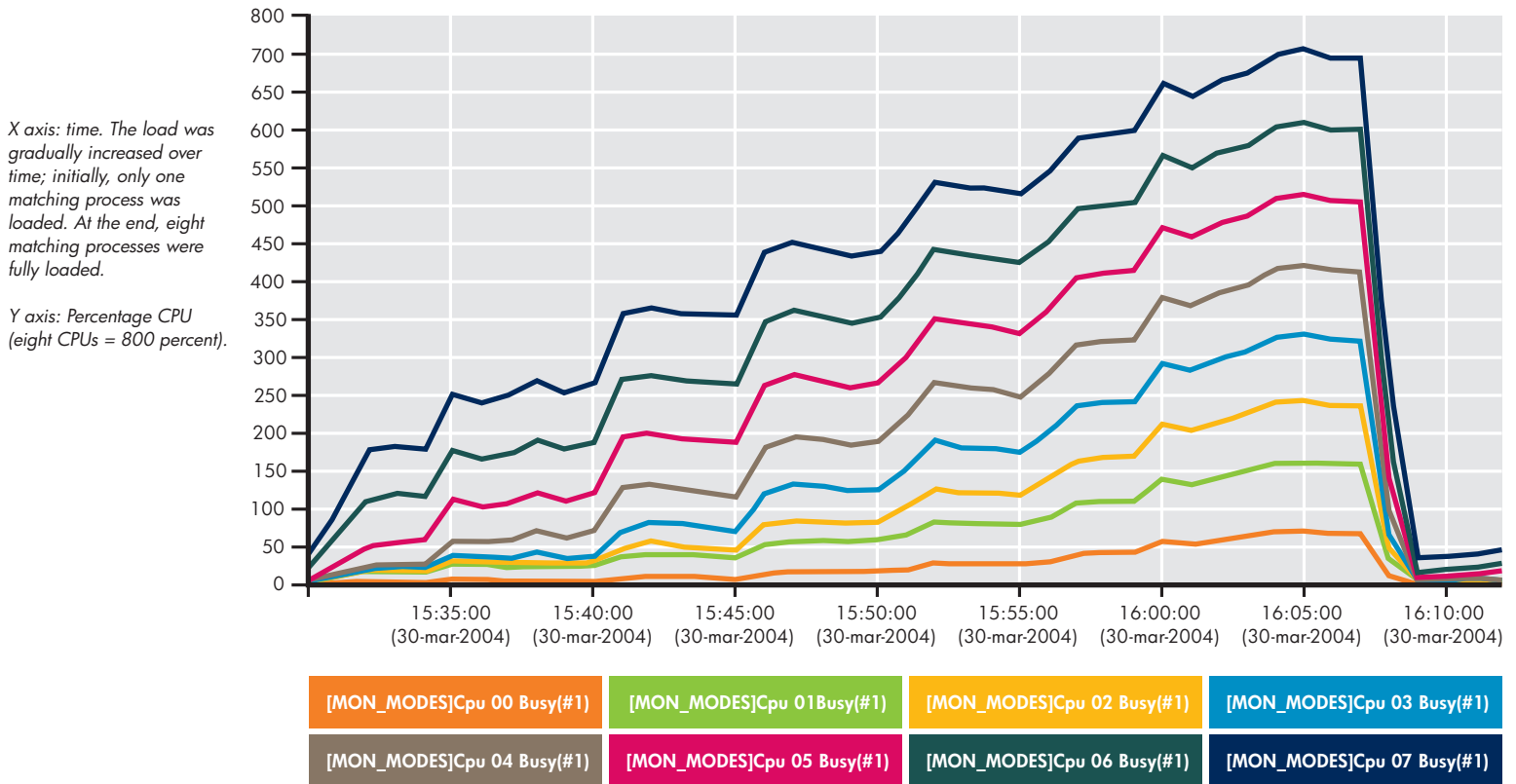
“I can’t emphasize enough how the scalability of our technology infrastructure, specifically the HP solution with the OMX software platform, has clearly put us in a position to compete,” stressed Campbell. “Considering our growing capacity demands, we’re extremely pleased to be in this position today, and—most importantly—we can go further with this technology implementation.”

It’s important to note that ISE has never been burdened with a heterogeneous legacy system and the host of integration and operational efficiency issues that come with such a system. This has allowed the company to stay ahead of the technology curve, building an architecture characterized by business agility and supported by technology roadmaps. In this sense, ISE has leveraged its partnership with HP and OMX to build a system that is based on mature technology and incorporates the factors for agility so it can implement changes quickly and easily—in far less time than many competitive companies without these advantages.

#### **Future growth capacity**

ISE’s growth curve to date is breathtaking, and a key question going into this benchmark was whether the firm’s technology platform can sustain such vigorous growth as ISE continues to lead the options industry.

“ISE is experiencing performance demands from two sources,” pointed out Wayne Arden, senior vice president of sales, Americas, OMX, “The growth of ISE’s business is astounding, rising from a 0 percent market share to a leading position in a little over four years. Second, the industry overall has grown, and options trading volumes continue to rise.”



There are now six options exchanges in the U.S., a fact that translates to an overall increase in market data and puts additional demands on trading systems and the dissemination of market data. It should be noted that part of the industry's growth can be attributed to ISE's participation in it and the company's influence on making trading more cost competitive.

Based on the benchmark results, ISE learned that it does in fact have significant "headroom" for growth; the system's scalability, as demonstrated by a 280 percent increase in quote capacity, proved that the technology can handle escalating volumes smoothly and without fear of encountering a bottleneck. Again, business and technology agility are keys to ongoing success as ISE continues to rapidly implement changes, staying ahead of the technology curve and continuing to work with HP on technology roadmaps.

In numerical high-performance computing, the goal is to load CPUs to 100 percent; however, in a transactional scenario, it is a success to achieve 700 percent of 800 percent loading, considering that there are I/O and network latency issues involved. The overall CPU utilization in the benchmark test was excellent, as shown in this chart of stacked CPU usage per processor, reaching 700 percent out of 800 percent available CPU resources and exceeding expectations.

According to Håkan Winbom, product director, hardware and software infrastructure, OMX Technology, "HP deserves credit for the recent enhancement to OpenVMS SMP scalability; we have observed this both in this benchmark and in actual production work. This means that, simply by upgrading the OS, customers are getting greater productivity from their existing SMP systems."

“We continue to develop on HP OpenVMS and RTR because they meet the existing and projected demands of our customers,” Arden noted. “From a performance perspective they have done very well and we can continue to invest and meet the needs of our customers for the foreseeable future.”

“We looked to this test to position us for the future,” added Campbell, “and it has positioned us well. We understand now what our position is and how to build on it.”

#### **Demonstrated disaster recovery ability**

Disaster recovery was a concern at ISE going into the benchmark. ISE’s current architecture imposed limits on the distance that was possible between ISE’s two sites. It’s important to note that a strict requirement for ISE’s OMX trading application is that transactions be processed at both sites in the same order. Further, the state of the market as reflected by the messages processed needs to be identical on both machines so that, should the secondary site ever need to take over, it can present a true image of the market. With this in mind, changes to the HP RTR component in the OMX trading application were proposed in mid-2003.

The HP Reliable Transaction Router is fault-tolerant transactional messaging middleware designed to implement large, distributed applications using client/server technology. The ISE installation marketplace server processes operate in a disaster-tolerant fashion, using RTR-shadowed partitions—typically, with four such partitions deployed per system. As a result of a joint HP and OMX workshop, changes were made to RTR that both improved performance and enabled greater distance between sites.

The benchmark tests showed that the application can scale up to 1 million quotes per second at virtually no impact to the inter-site latency—the amount of time it takes for a packet of data to get from one designated point to another—for a distance of up to 800 kilometers (roughly 500 miles). This means that ISE can move its secondary site substantially farther away without appreciable loss of performance—an enormous benefit from a disaster-recovery perspective and a business imperative in today’s world.

New test tools used for the first time in the benchmark allowed HP and OMX to test various distances that showed the resulting latency impacts; the companies were able to see the impacts and understand how the overall system performance was affected. As it turned out, performance impacts due to increasing amounts of latency were far less than what initial calculations led the testers to expect.

“The results were a lot better than expected,” observed Winbom. “The benchmark verified that we can scale orders of magnitude beyond the range of OpenVMS clustering. We anticipated beforehand that the changes in RTR and CLICK XT would allow the system to be more tolerant of inter-site traffic delay. The results were even better and showed that the new RTR ‘strict order shadow mode’ allows site separations much larger than most other technologies used—exceeding even what OpenVMS clustering allows.”

“In working with HP we count on their expertise to help us make the right technology decisions, to ensure that we’re implementing mature technologies that have high value.”  
—Larry Campbell, Chief Technology Officer, ISE

**Powerful partnership capitalizes on strengths**

An important goal as ISE moves forward is to contain its administrative resources and achieve maximum efficiency in the way it administers its technology. This benchmark demonstrated to the firm the value of its working relationship with HP—which made a significant investment in people, time, and equipment in the interest of making the proposed benchmark a reality. The total effort involved nearly 200 staff days, of which ISE contributed only 10 percent. This enabled ISE to achieve its goal of capacity planning without making a big investment in resources.

According to Campbell, “HP was extraordinarily accommodating. Its resources were readily available to us, and if this weren’t the case, I don’t know if we could have achieved the results we did.”

Both before and during the three-week benchmark period, ISE relied on HP as a trusted partner to collaborate on new technology roadmaps, leveraging HP’s expertise to help the exchange make the right technology decisions and ensure that it implements mature, high-value technologies. The relationship leverages the strengths of each party; by relying on HP’s expertise in information technology and its applications in the finance industry, ISE can focus on the

business of building and running the finance world’s leading options exchange. The firm continues to rely on HP to help it build an IT environment that can easily handle change so ISE can maintain its leadership position in the industry.

**HP OpenVMS**

HP OpenVMS is an operating system designed to handle enormous amounts of information so companies can offer their customers more value by reducing costs, better utilizing assets, and increasing operational efficiency.

**A rock-solid, highly available and secure backbone for top-priority operations**

HP OpenVMS helps companies achieve manageable, sensible growth by supporting initiatives to create an adaptive infrastructure and technologies for multiple operating environments. And it enables them to maintain reasonable returns on IT investments by allowing them to layer and dovetail multiple hardware platforms, integrate mixed architectures, and include scattered assets into one coherent enterprise. OpenVMS features high-availability, scalability, security, industry-leading cluster technology, and enhanced flexibility for large-scale SMP systems.

#### **Extreme performance for business continuity**

HP OpenVMS is designed to perform under the most extreme conditions, delivering transaction support, bulletproof reliability, and security—anytime, anywhere. Because IT availability equals business continuity, OpenVMS delivers system-wide availability of data and applications with access from anywhere across the enterprise. No other clustering technology can support as many nodes or span as much distance with an active cluster.

#### **Room to grow: OpenVMS can expand and extend**

HP OpenVMS is scalable in two dimensions: It scales “out” to accommodate additional processing and storage in a clustered environment without interruptions to the rest of the cluster. It also scales “up” with the addition of larger processing capacity. High-end, symmetric multiprocessing systems can be quickly integrated into an OpenVMS cluster to meet sudden increases in demand.

#### **Leading the way in worldwide exchange automation**

OpenVMS systems are used extensively in large banks and securities exchanges worldwide. In fact, with OpenVMS, NonStop, and other operating systems combined, HP platforms run nearly 90 percent of the world’s derivatives exchanges. OpenVMS systems are also running in the vast majority of lotteries worldwide for good reason: When a big jackpot attracts long lines of customers on the last day of ticket sales, the lottery system must be available to process the extreme volume of business.

#### **Technology that grows with your needs**

OpenVMS has been ported to the cost-effective, industry-standard HP Integrity server family, based on the Intel® Itanium® 2 architecture. This means companies are assured that HP maintains its commitment to continuously improve and evolve OpenVMS. HP is working closely with industry-leading software vendors such as Oracle®, BEA, BMC Software, and Computer Associates—to name just a few—to fully port OpenVMS environments and application portfolios to Itanium-based enterprise systems. The vast majority of HP OpenVMS ISV partners have already committed to port their applications to OpenVMS on the HP Integrity server platform.

#### **HP’s market presence places it among the industry leaders**

HP has a rich heritage in the FSI that goes back more than three decades and is reflected in a significant presence in all of the top 200 banks, 50 brokerages, 25 insurance carriers and major stock and commodity exchanges. HP powers 130-plus exchanges, supporting 95 percent of the world’s exchange transactions. The company is a leader in handling credit card transactions and electronic funds transfers, offering deep industry domain knowledge in each industry segment.

HP is a technology solutions provider to consumers, businesses, and institutions globally. The company’s offerings span IT infrastructure, personal computing and access devices, global services, and imaging and printing.

For more information go to [www.hp.com/go/FSI](http://www.hp.com/go/FSI)

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