Experts weigh in on technology challenges

Cloud computing on the rise

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Technology teams must be integrated with the business

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Transparency crucial to financial stability
A key lesson drawn from the financial crisis of 2008 is that market transparency is a crucial ingredient to financial stability. Yet, according to European exchange statistics, close to 40% of European stock trading takes place on unregulated OTC (over-the-counter) markets. In the U.S., experts estimate that 25-35% of equities trading takes place on OTC markets.

These statistics highlight the fact that a vast amount of equity trading today occurs without public disclosure about buyers and sellers, liquidity or order size. While it was not the intended consequence of MiFID (Markets in Financial Instruments Directive), I would argue that transparency in the financial markets has diminished since the deregulation of exchanges in Europe started in 2007.

The main goal of MiFID was to increase transparency in stock trading within the European Union. Three markets for stocks were identified: Regulated markets (traditional exchanges), MTFs (alternative markets such as Chi-X), and Systematic Internalizers (SIs), where banks match transactions internally and then publish them externally. The purpose of including the Systematic Internalizers was to increase transparency in OTC trades, transactions between banks and brokers which traditionally lacked transparency, without forcing all transactions onto stock exchanges.

However, as the above statistics show, a considerable amount of stock trading occurs on the unregulated and more opaque OTC markets that reside outside the scope of MiFID. These markets, where banks often handle their own order matching, are in need of increased transparency. The financial crisis showed the merits of more open and public markets.

OTC trading satisfies legitimate demands. To avoid substantial effects in the market, it is sometimes more appropriate for larger orders to take place anonymously outside of an exchange environment. So, I am not arguing that all trading must be done on an exchange. However, when as much as 40% of all European trading occurs outside the directive set forth by the EU, it is time to think about what more can be done to promote transparency.

Paradoxically, while the equities markets are seemingly becoming less open and heading towards a structure that resembles the much criticized OTC markets, intense initiatives are being undertaken in both the European Union and the U.S. to regulate and increase transparency in the OTC markets for credit derivatives. The driving force for these initiatives is, of course, the central role these instruments played in the 2008 financial crisis and the Lehman collapse.

We should not lose sight of the warning signals in the equities markets.

We should not lose sight of the warning signals in the equities markets. Just as a badly maintained road can cause an accident, a flawed or outdated market structure can cause an expensive market breakdown. As an industry, we must remain vigilant and work together to promote transparency and stability in all financial markets.
The Australian Securities Exchange (ASX) and NASDAQ OMX announced a commitment for the delivery of ASX’s next generation trading system – ASX Trade powered by NASDAQ OMX’s Genium INET trading platform. The new system, which is scheduled for rollout Q4 2010, will enable significant latency and transaction capacity advantages.

The Genium INET platform has an average latency of 250 microseconds, and will allow ASX Trade to increase the trading capacity to exceed 5 million trades and 500 million order book changes per day. It will also retain the core functionality of the existing system, including the ability to trade equities and derivatives on one platform.

Dubai Financial Market (DFM) has successfully completed migration to its new trading platform from NASDAQ OMX. The new system is designed to create a more efficient marketplace and trading experience and enables trading of cash equities with potential for derivatives products.

The Financial Information Services Division (FISD) of the Software and Information Industry Association named NASDAQ OMX Outstanding Data Provider of the Year. The award recognizes exchanges or data providers that most closely adhere to the FISD’s best practices in customer service and communications. Tom Davin, Managing Director of FISD said, “The award recognizes the importance that clients and distributors place on clear and timely communications from their information providers.”

Kuwait Stock Exchange (KSE) and NASDAQ OMX signed an agreement in which NASDAQ OMX will provide trading technology and strategic advisory services to the exchange. As part of a joint venture to develop the Kuwait capital market, NASDAQ OMX will deliver technology for trading and surveillance to KSE. The new trading platform will be used for equities, bonds and derivatives.

The Singapore Exchange Limited (SGX) launched a new clearing system, SGXClear, powered by NASDAQ OMX technology. A key benefit of SGXClear is the introduction of an electronic interface that will provide clearing members with connectivity and enable Straight-Through-Processing (STP) and automation of members’ back office operations. The new system also has enhanced capabilities in terms of speed and functionality and increased capacity to support significant growth in the derivatives business.

NASDAQ OMX Commodities and Nord Pool Spot announced the successful launch of n2ex, a new marketplace, powered by NASDAQ OMX technology, for physical U.K. power contracts. The launch included a day-ahead and a prompt market. In 2008, the Futures and Options Association selected a consortium bid from Nord Pool Spot and NASDAQ OMX Commodities to deliver market and clearing services for the U.K. Wholesale Power Market.
The elephant in the room

Market data volumes are on the rise, and exchanges are challenged to minimize latency, reduce the cost of consumption and generate revenue.

HIGH FREQUENCY trading and the proliferation of trading venues in the U.S. and Europe are driving market data volumes ever higher. As volumes increase, firms upgrade their technology so they can handle the flow, which enables them to produce even more data. This scenario has had an impact on market participants’ ability to consume data quickly and on exchanges’ ability to sell market data products. To this end, exchanges are challenged to put in place an infrastructure that can keep up with rising data volumes and a market data strategy that ensures a revenue stream.

Many new venues use market data as a loss leader while they build market share. So, if exchanges are going to charge for market data, they need to maintain a high quality offering.

For starters, exchanges need to recognize that their customers must cope with data from many venues. An exchange’s technology investment will be multiplied several times over for their downstream users. Exchanges need to understand how their customers access data and need to work closely with the customers to ensure they can meet their needs.

Randall Hopkins, Senior Vice President of Global Data Products at NASDAQ OMX, explains that customers pay a direct cost for market data. Moreover, they need to procure bandwidth to bring the data in house as well as acquire computer systems, feed handlers and databases to process the data.

“The all-in cost varies depending on the product set the customer chooses and the technology configuration,” he says. “But the market data itself typically represents 25-33% of the total cost.”

IT IS IMPORTANT for exchanges to develop strategies and implement technologies to minimize latency for data consumers and to decrease the total cost of data consumption. Not everyone requires the lowest latency data. Some market participants do not mind data being a millisecond or two slower, but they want to pay less for it. “Everybody talks about latency, but volume is the elephant in the room,” says Stewart Orrell, Senior Manager in Financial Services at Equinix, a provider of global data center services.

Obtaining data feeds over a cross connect in a data center is typically more cost effective than running a line to another location. Further, not all data sources are in the same place, and connectivity requirements vary between customers. Ultimately, the breadth and depth of connectivity choices will determine the way firms procure bandwidth.

Some vendors want to distribute market data over the Internet or into clouds. They will want to be close to the access points for the different distribution mechanisms, such as an Internet-peering platform or a cloud distribution node.

“In each of the regions several market data hubs will develop similar to the Internet model where customers have access to diverse networks and various sources of data,” says Orrell. “They also will have space to grow their processing plants for the market data in a cost-effective way.”

MEANWHILE, THE INDUSTRY will continue to develop ways to compress and conflate data so it can be distributed through different mediums. FAST and ZLIB are two compression technologies already in use. But exchanges still have to offer uncompressed feeds because some business models are predicated on receiving information in uncompressed forms.

Each region has its own unique
set of challenges. Europe is similar to the U.S. in that there is a proliferation of venues, and data volumes are increasing. In the U.S., market centers are located mainly in New York and Chicago, and customers try to locate their servers close to the data sources. But in Europe, market centers and customers are more geographically dispersed in London, Frankfurt, Paris, Amsterdam and Zurich. Network connectivity between the different cities is important.

In Asia, Trading Volume is increasing, but it is not as high as in the U.S. and Europe. Execution venues have not proliferated; markets tend to be closed, and they do not interact together. That dynamic will likely change in the near future as the entry of alternative venues creates more competition. At that point, exchanges will have to determine where to centralize market data processing in a geographic area that is widely dispersed.

Firms use message data from the Financial Information Forum (FIF) for internal capacity planning. According to FIF, the OPRA One Second Peak annual growth rate in 2009 was 38%. The November 2009 OPRA Peak Quote to Trade ratio was 4,421x, down 37% since the November 2008 peak. In the same month, the One Minute Peak Rate on consolidated equity feeds and OPRA was 901,565 messages.

Research from Aite Group shows the primary challenge to market data infrastructure involves the exponential growth in data volumes. Across U.S. market data rates, data volumes nearly doubled on an annual basis over the last two years. Looking at U.S. equities alone, Aite Group expects message volumes to average 1.2 billion messages per day by 2011. Still, just over half of market data professionals interviewed by the research organization believe their current market data infrastructures are good enough for today’s challenges, though all indicated they were slating at least one area of their infrastructure for improvement.

"This situation is going to impact clients more than exchanges, but exchanges will still have to figure out how to get data to their customers in a cost-efficient way," says Orrell. For example, what is the best way to get data from Tokyo for customers with data centers in Singapore?"

Ultimately, technology is the key enabler which will have to be continually improved to keep pace with increasing market data volumes. Customers will look for innovations that will enable them to manage data effectively and derive maximum value. The burden is on exchanges to meet those needs.
The technology function has always focused on delivering robust, reliable and cost efficient solutions. Today, however, technology is also expected to drive growth and revenue. For exchanges, that means having the ability to process large transaction volumes at lightning speed under extreme conditions. Markets must always function smoothly with the ability to monitor and measure liquidity and counterparty risk in real time. Exchanges are also measured by their capacity for innovation and ability to build new products and services. Technology is the key enabler.

To gain insight into how exchanges leverage technology to execute their business strategies, we have formed a panel of experts: Jeff Olsson, Group Executive of Technology, Australian Securities Exchange (ASX); Jitendra Puri, Vice President of Technology, Bolsa de Valores de Colombia (BVC); and Anna Ewing, Executive Vice President and Chief Information Officer, NASDAQ OMX.

SD: Let’s begin by talking about the major technology challenges facing exchanges today.

Olsson: Exchanges are undergoing more challenges than at any time in history. As competition becomes more pervasive, traditional IT departments are challenged to quickly adapt technology to meet specific business needs. Toward that end, technology teams must be integrated with the business. Technologists often become captivated with particular technologies, but today we have to focus on delivering business solutions that may or may not include a technology element. We have to understand business needs and organizational strategy. I no longer view myself as a technology executive but rather as a business executive who understands and can use technology.

Puri: For a small exchange, we have invested significantly in technology, but we now need a critical mass of volume to achieve a positive return. The number of orders per second is increasing, but not all orders are turning into trades. Our derivatives market has not taken off as we had hoped because investors don’t yet understand the value of these products. We are now focused on delivering education programs that will facilitate future market growth.

BVC is involved in a cross-border initiative to integrate the exchanges of Peru, Chile and Colombia into one virtual market. To do so, we must link the exchanges and migrate our brokers to a common screen so they can trade any equity product listed on all three exchanges.

We need cost efficient technology to help us continue along that path.

Ewing: Facing more competition, exchanges are under intense pressure to increase capacity and latency and deliver cost effective technology solutions. We must be able to handle higher volumes at greater speeds and to lower transaction costs. As Jitendra pointed out, the order to trade ratio is much wider nowadays – with hundreds of orders often resulting in only one trade and, thus, reducing efficiency. Technology remains at the heart of any exchange function. We must continue to invest in new technologies, but also to focus on cost efficiency. These factors are putting new demands on IT.

SD: Anna Ewing referred to competition. How will competition affect ASX, and how can technology help you gain an advantage?

Olsson: My view is that consolidation of liquidity is good for markets, but in the near future competition will change the face of business in Australia. Fortunately, we have learned from other jurisdictions’ experiences. Reliability becomes more important in a competitive environment. Outages are a great way of handing liquidity to your competitors. Low latency is an imperative, and as order size diminishes and transactions increase, trading system capacity must keep up.

To meet these challenges, ASX has deployed technology from NASDAQ OMX, which is among the fastest
Glossary of terms

**Cloud computing:** A general term for delivering hosted services over the Internet. Unlike traditional hosting, cloud computing is typically sold on demand; users can adjust how much service they need at any given time, and the service is fully managed by the provider. All that is needed is a personal computer and an internet connection.

**Virtualization:** The creation of a virtual (as opposed to actual) version, typically an operating system, server, storage device or network resources. For example, virtualization can be used to partition a computer’s memory into separate “virtual machines,” to simulate multiple machines within one computer, thus improving scalability and reducing the hardware footprint.

**Service oriented architecture (SOA):** A structure that supports communications between services. An SOA framework, for example, facilitates online shopping, by enabling communications among the various computer programs — catalog, order, shipping, tracking — so one can perform a unit of work on behalf of another.

**Complex event processing (CEP):** The use of technology to predict high-level events likely to result from specific sets of low-level factors. CEP identifies and analyzes cause-and-effect relationships among events in real time, enabling personnel to proactively take actions in response to specific scenarios.

**Open source technology:** Refers to a program in which the source code is available free of charge to the general public for their use as is or in a modified form.

**Co-location:** Providing space for a customer’s telecommunications equipment or servers on the service provider’s premises. This practice is common among high frequency traders and generally results in lower latency.

Source: techtarget.com
available. Our trading system was the first consolidated equities and derivatives platform in the world. We have had 100% up time since we went live in August 2006, which has enabled us to keep ahead of increased capacity demands. At the same time, it has helped us to contain costs. The implementation was risky, but we often have been the global leaders in new exchange technologies. Overall, our customers have been pleased.

Time to market is extremely important, so we have to provide technology solutions faster than ever. We are reliant on third-party vendors, and we have to ensure they deliver high-quality solutions and fast turnaround. In fact, we spend a lot of time fine-tuning our processes, which has resulted in a much higher rate of delivering projects on time and on budget. Integrating technology with the business is embedded in our culture.

SD: We’re hearing buzz around cloud computing. How can this technology be leveraged in an exchange environment?

Ewing: Cloud computing can lower the total cost of ownership and improve efficiency, and NASDAQ OMX has been an early adopter of this technology. We don’t think it’s suitable for use with low latency, high-speed services, but it can be leveraged to provide generic business services, especially in the post-trade arena.

For example, we store market data in an Amazon cloud for our innovative Market Replay service. We also use cloud technology for QFolio, our popular iPhone app for investors. QFolio is interesting because we brought existing services into a fresh distribution channel and delivered our technology to new and existing customers in ways they prefer.

Olsson: Cloud computing has great potential, but I would be concerned about using it for critical applications. The reliability and performance might not be what we have come to expect. For now I plan to use it in some non-critical areas.

Puri: Cloud computing is relevant for companies that have large, dynamic, internal testing and development environments. Most exchanges are unlikely to use public clouds until security concerns are resolved. But private clouds provide an opportunity to reduce costs and make resources available to IT project teams and units as needed. I see tremendous value in that.

BVC has not used private clouds yet, but we have taken advantage of public ones after determining that our risk would be limited. We needed some Linux servers and realized that it would take too long to free up the resources to buy them. Instead, for $20/month, we now access the servers at the click of a button. We are in the middle of a pilot to see what other applications are adaptable to the cloud environment.

SD: Cost reduction is often a reason for taking advantage of newer technologies. What technologies have you adopted that have improved the bottom line?

Puri: Virtualization has had a big effect on cost. Our entire non-production infrastructure is virtualized, allowing us to turn one machine into many machines as well as enabling better resource allocation and the ability to deploy on demand. We have reduced our costs because we buy fewer servers. At the same time, we save space and energy in the data center.

Service Oriented Architecture (SOA) and open source technology are also important. BVC is among the first exchanges in Latin America to adopt SOA. Our internal and external linkages—including connections to the central counterparty clearing operation—are all based on SOA. We now write, develop and test a service only once, then deploy it to as many users as necessary.

Another technology we have embraced is open source, basically because it is a great way to reduce costs. Linux supports our core business applications and SOA infrastructure, and we use MySQL as our internal database. I encourage our IT team to test, try and experiment, and if it works, embrace it.

Olsson: We have found similar benefits at ASX. Virtualization has enabled us to have multiple test and development environments, which has...
significantly reduced the number of physical servers needed, thus reducing our overall costs. We also use SOA extensively. It has improved our legacy business models and is important as we drive to Straight-through-Processing.

We have realized some good operational and financial benefits from open source technology, particularly in systems management. We have been successful using a tool called Nagios. Open VMS has also been critical to ASX’s success. It just sits behind the scene.

Ewing: I would say that virtualization is best-of-breed for any organization with heavy data center usage. It enables us to use computer power more efficiently, compress business applications into a smaller footprint, reduce power usage in the data center, and lower the total cost of ownership.

SOA is practical. It supports a web-based architecture so different applications can share the same data and all systems can be accessed with a single security sign on. It streamlines systems, improves communications and provides a single view of data.

Open source technology is driving down the cost for generic software and is an important component of our technology architecture.

To echo a point Jeff made, the key to realizing the full potential of any technology is to integrate it firmly in a business context. We are constantly reinventing our business, and technology provides both the efficiencies and the tools to reduce costs and drive growth and profitability.

SD: Let’s talk about two other technologies. Complex Event Processing (CEP) enables organizations to analyze data in real time, and co-location lowers latency.

Ewing: We find CEP to be useful for surveillance – reviewing all market data events and finding patterns. Many participants use this technology to work off patterns and build rule models for program trading.

Co-location is critical in attracting low-latency, algorithmic traders. Of all the technologies we’ve discussed, co-location stands out as strategically important from a business point of view. We can develop new offerings for co-location clients, such as additional market data services, and tools for measuring service quality. In the U.S., we are working with the SEC and other exchanges to ensure that co-location is regulated properly and operated fairly.

Olsson: I agree with Anna. Co-location has generated new business for ASX, and through co-location, we have reduced order latency in our trading systems by a factor of 10. I see co-location growing as ASX tries to attract algorithmic traders from overseas. Faster speed will be a source of competitive advantage. The people on our communication team make this possible. They are the unsung heroes.

CEP complements SOA, and is useful for risk management and business process automation.

Puri: At this point, we are still studying how to best implement CEP at BVC, although we see our brokers exploiting that technology.

We also see tremendous potential for co-location, but that is in the future for Colombia. We are standardizing on FIX now, and we will move to co-location as customer need dictates.

SD: One last question: What drawbacks are there to these technologies?

Olsson: We’ve had experience with most, and some have provided real benefits to ASX. However, I’m wary of new technologies that are touted as being a panacea for the industry. My job is to cut through the hype and ensure we understand the benefits and risks.

With any new technology, there are associated costs in training and skills transfer. For example, we are moving toward Linux and the use of open source, but our skill base has not traditionally been in that area.

Puri: I agree with Jeff that rapidly changing technology has an impact on human resources. I’m constantly challenged to keep my team up to speed so that skills are not a limiting factor. Exchanges serving smaller markets are also challenged to maintain the rhythm of capital expense necessary to maintain the most modern infrastructure.

Ewing: I agree that technology advances put more demands on the technical and business skills of the IT staff. But NASDAQ OMX is at its core a technology company. As such, it’s our job to continually innovate which can only be accomplished by understanding the benefits of new technologies and integrating these technologies into our overall business strategy.
In the past, traders evaluated exchanges based on their fill rates and prices. But today most orders are cancelled and only a small percentage are filled. According to Celent, high frequency trading now constitutes about 42% of daily U.S. equities share volume and is expected to exceed 50% by mid-2010. A report by New York-based agency broker Rosenblatt Securities says up to 40% of European equity trading is high frequency. Meanwhile data from UBS shows that Asia lags at about 10%. To these players, time is as important as price. To be efficient, traders have to understand price manipulation, changes and trends quickly.

Before reaching a trading venue, an order may touch several systems, including those at a Direct Market Access broker, service connectivity provider and co-location provider. Exchanges’ customers want to be able to measure latency between their systems and each of these touch-points. The longer it takes to understand a latency bottleneck, the more likely it is that customers will miss opportunities in the market.

Tight integration between execution and investment strategies is critical to delivering risk-adjusted return on investment, or alpha. With explicit transaction costs so low in trading, it is the implicit costs that can destroy the return created in the investment proc-
The faster, the better

High frequency traders require ultra-low latency connections, which enable quicker messaging, quote updates and data feeds. Celent estimates that the total round-trip latency for the high frequency trading process is in the range of 100–200 milliseconds, approximately 400 milliseconds faster than algorithmic trading. Some high frequency trading firms could be even faster. Since 2007, execution times have fallen by 31% amongst small orders (100–499 shares) and 71% amongst the larger orders (500–1999 shares).

Firms must optimize their trading environment to ensure that real return is not lost through market impact and delays. Portfolio managers and traders must be in sync with the urgency of trades and scheduling, select the appropriate algorithms and adjust them as conditions change.

“Latency is of paramount importance to deliver the alpha from statistical arbitrage strategies, for example, where trading profits are available only for microseconds,” says David Easthope, Senior Analyst at Celent. “Thus, the investment strategy and execution strategy are inextricably linked.”

For exchanges, latency is a source of competitive advantage. The same instrument can be traded on several venues, and latency affects market makers’ ability to quote spreads and provide liquidity. Traders send their orders to the venues that offer the best prices and rebate policy, as well as the lowest latency.

THERE ARE SEVERAL approaches to measuring latency. Some firms may simply look at the statistics provided by their brokers. Others may take a careful look at the latency figures of the networks upon which they depend. Savvier firms measure the entire latency cycle, from market data delivery from exchanges or aggregators, to internal application latency, to order book matching latency. What matters most is that an accurate measurement is taken which weighs all relevant factors and that adjustments are made to lower latency and improve execution.

“In the past when you had a latency issue, customers would immediately stop trading with that exchange,” says Shawn Melamed, CEO of Correlix. “That’s bad for exchanges because they’re not getting the liquidity, and it’s bad for traders because their strategy is down. Every minute the strategy is down, they’re losing money.”

The ability to monitor latency helps traders tune their strategy, select the right venues, react to problems quickly and avoid bottlenecks. The more information an exchange can provide its customers, the more likely it is they can create smarter, more sophisticated strategies. That creates stickiness in the relationship.

“By sharing the measurements with our participants, we can understand latency across the full transaction chain,” says Mats Andersson, Chief Technology Officer, Global Software Development at NASDAQ OMX. “They know exactly how long it takes to get from their order management system to the exchange’s matching engine and back – for every business transaction, and also how much latency each component in the chain adds.”

Many market participants are more likely to trust latency measurements from an independent third party. Correlix is one company that provides a solution for measuring the latency from the customer’s order management system to the exchange or third party connectivity providers such as co-location facilities. Then it measures the latency that the exchange trading system adds for handling a transaction and providing a response.

Traders receive the latency data through a user interface and as a raw data stream that goes straight to their black box, just like market data. This allows them to monitor latency changes and tune their strategy accordingly. The solution uses a consistent methodology, so they can more accurately compare the performance of multiple exchanges.

“Large high frequency trading shops have many machines running hundreds of sessions to the same exchange,” says Melamed. “They need the ability to immediately understand which session is faster and identify the fastest route to the market.

Real-time latency monitoring enables exchanges to pinpoint the cause of a problem, down to the specific component, and fix it quickly. Real-time streaming data enables them to make automatic changes in the infrastructure so the system is self-healing.”

NASDAQ OMX to provide independent latency measurement

NASDAQ OMX has selected Correlix Inc. to provide real-time latency insight to allow NASDAQ OMX customers access to independent real-time latency measurement information for intraday and post-day analytics. NASDAQ OMX will initially provide latency measurements for The NASDAQ Stock Market and plans to expand the service to make latency information available for other NASDAQ OMX markets around the world.
In the clouds

Cloud computing can reduce costs and accelerate time to market.

Exchanges have long been able to obtain computer services through application service providers (ASPs). Instead of buying and installing software, they simply execute a computer program over a network. The ASP model is sometimes called Software as a Service (SaaS).

“While many people view cloud computing as the emperor’s new clothes, it is in reality a very flexible extension of the ASP model,” says Carl-Magnus Hallberg, Senior Vice President of Global IT Services Operations, NASDAQ OMX. “Key additions to the concept are on-demand computing with utility payment models as well as Platform as a Service (PaaS), where your own applications are delivered from the provider’s servers, and Infrastructure as a Service (IaaS) which enables exchanges to lease server capacity on a per hour basis from providers such as Amazon, Google or Microsoft.”

THE MANY ADVANTAGES of cloud computing include lower costs, scalability and the elasticity to cope with variations such as trading spikes. Exchanges can scale their server capacity up or down depending on their needs, and they only pay for what they use. They can also speed their time-to-market for new products and services. The concept is particularly compelling for smaller exchanges that cannot afford high-end software or custom outsourcing arrangements.

Any data that is not sensitive can be put in a cloud. For instance, exchanges can run most of their web services there, store non-critical market and reference data, and support purchasing and vendor management.

DAVID LINTHICUM, author of Cloud Computing and SOA Convergence in Your Enterprise, points out that cloud computing works best when the applications and processes are new and independent or loosely coupled. That makes it easier to move certain parts into the cloud and retain others on premises. He also notes that the points of integration should be well defined and exist as an API, and that the IT staff should know how to get information in and out of a system. Moreover, the core internal enterprise architecture should be healthy; otherwise adding clouds could make it too complex.

Despite its advantages, some exchanges are reluctant to adopt cloud computing due to concerns about security, confidentiality, auditability, transparency and latency. Over the long term, according to Carl-Magnus Hallberg, these issues will likely be resolved.