



Enhance Service Delivery and Accelerate Financial Applications with Consolidated Market Data

What You Will Learn

Financial market technology is advancing at a rapid pace. The integration of infrastructure from best-in-class vendors is required to ensure performance. This white paper details the advantage of developing and optimizing lowest latency market data solutions, integrating the following:

- Cisco Nexus 3548 full-featured lowest latency switch
- AdvancedIO V5031 FPGA network card with Cisco UCS C240 M3 server
- MayStreet Bellport market data software

The white paper covers in detail the advantage of developing and optimizing low latency solutions that span the network, server and applications. It demonstrates a viable solution for managing several major market data feeds in a single network card, a key requirement of many trading applications.

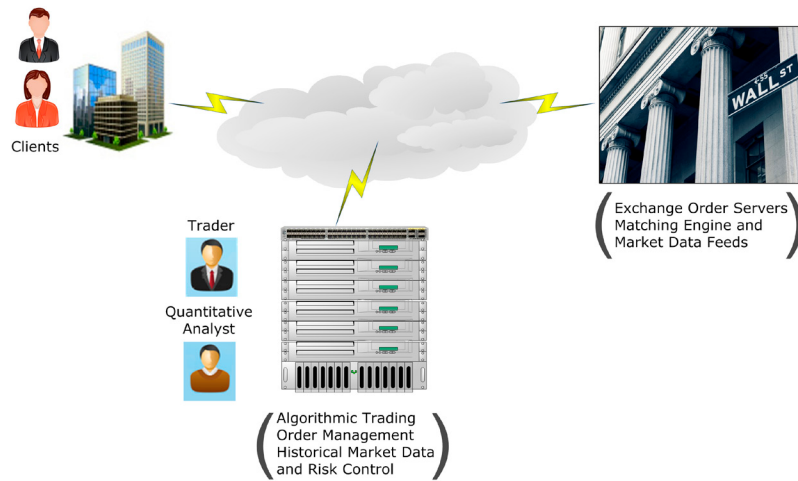
Introduction

The financial infrastructure of the capital markets is highly distributed and complex. This is especially true in the United States, with eight equity exchanges, nine equity option exchanges, three futures exchanges and almost forty alternative trading venues. The large volume of data coming from all the various sources puts significant strain on traditional trading systems, which need to ingest and filter the desired information while operating at wire speed and processing complex trading strategies. Trading companies are constantly looking for strategic technologies and partners to give them a competitive edge.

In today's world, a slow response time to a trading event can have a serious effect on a company's ability to compete, and in many cases on the company's survival, with a significant impact on profit and loss. Elegant architectures along with top-quality infrastructure products designed to eliminate communication bottlenecks are required to achieve the necessary high performance and provide risk mitigation. These solutions must take into account the need to accelerate computation intensive algorithms and to provide ultra-fast responses to trading events.

To build the best trading system, organizations must reduce latency, increase service availability, and help ensure interoperability. Investing in a fast, robust, and scalable network infrastructure can give a trading company an edge over the competition ("Figure 1").

Figure 1 — The Financial Trading Network



Choosing the right partners can be the most important decision the solution architect makes. Because of increasing demand and the increasing complexity of today's financial markets, an ecosystem of best-in-class partners, technologies, skills, and support is necessary to deliver a robust trading system and the infrastructure that supports it.

Choosing the right networking and switching infrastructure helps ensure that trading platforms communicate with the trading exchanges in the fastest time possible. High availability and high performance servers that can scale easily to the increasingly demanding requirements of trading strategies are essential to the delivery of a trading system that can both meet current needs and incorporate future technologies. Adoption of field programmable gate array (FPGA) technology in network cards enhances the performance of trading platforms by filtering out undesirable data before it reaches the server. FPGA technology also provides significant acceleration for complex mathematical computations that provides a differentiated competitive edge. In addition, use of dynamic software that brings simplicity to a complex market data problem enables the quick deployment of trading strategies. Only an ecosystem in which the various elements can interoperate and integrate transparently provides the best value for the financial market.

Best-in-Class Ecosystem

Cisco, AdvancedIO Systems, and MayStreet unveil a best-in-class ecosystem of partners to enhance service delivery and accelerate financial applications using FPGA technology in a single cohesive offering.

The Cisco Nexus® 3548 Switch and the AdvancedIO® V5031 10G Ethernet (10GE) FPGA network card together provide an excellent combination of networking and processing capabilities to provide the right deployment flexibility. Although network architectures vary depending on product availability, two scenarios should be considered: centralized market data processing and distributed market data processing.

In a centralized approach, the market data from a stock exchange is passed through a switch to servers running trading applications. In theory, the switch can decode market protocols and filter market data in addition to performing network functions. In reality, there are multiple disadvantages to such an approach. For this approach to be viable, special attention to latencies inherent in the data paths is needed and a standard software mechanism is required for each application thread running on the client server to control the filtering function on the switch. As well, all applications and data must compete for limited processing resources as more market data feeds need to be decoded, limiting capacity and throughput.

A centralized approach introduces complexity and delays inherent in the certification process of market data algorithms with existing switch code. In addition, it makes the introduction of new algorithms problematic as incompatibilities may cause network-wide issues. Moreover, unnecessary operational and management complexities arise between network staff responsible for managing the switch and application developers and increases the risk of downtime associated with updating applications on the switch which means loss of access to all servers connected to the switch.

In a distributed approach, the market data from a stock exchange is passed through the Cisco Nexus 3548 Ethernet Switch to the AdvancedIO V5031 FPGA network card installed in the Cisco application server. The advanced switch is responsible for performing network functions (Network Address Translation (NAT), Switched Port Analyzer (SPAN), etc.). The AdvancedIO V5031 FPGA network card is responsible for decoding exchange protocols and filtering market data before reaching the application thread running on the server.

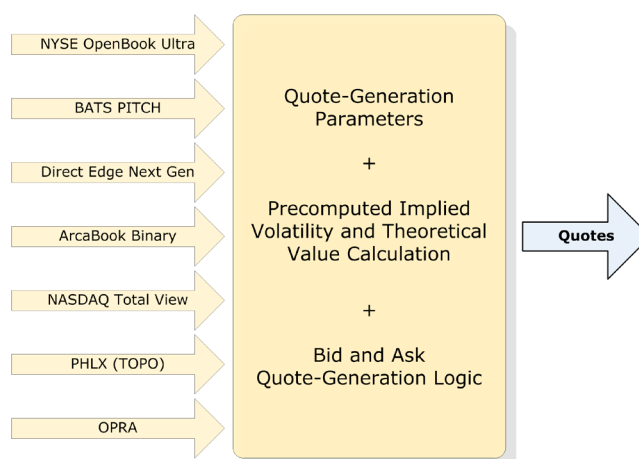
This solution, unlike a centralized approach, allows processing power to be distributed in close proximity to the trader's user space and the performing of real-time updates while maintaining real physical separation of client's proprietary information. This enables the trader to add their own code and intellectual property to implement differentiated applications and services. A distributed approach also provides ample computing resources for analysis, processing, and control of all the client's stock baskets and can scale to implement the entire order flow. It also simplifies the operational and management complexity and reduces the risk of any down time to a single server.

Application Example - Market Data Acceleration

The equity options market is one of the most data-intensive areas of trading. It combines a large data volume with demanding latency requirements incurred by pricing and hedging using the underlying stock markets. A trading system must be able to receive multiple market data feeds from multiple exchanges at 10 Gbps and higher data rates. It must also decode several market protocols and filter the desired symbols before sending them to predefined baskets to be analyzed by the trading strategies.

For example, the market data feeds required for equity market making on the Philadelphia Stock Exchange (NASDAQ PHLX exchange) are shown below in "Figure 2". A trader may be interested in products starting with symbols A, B, or C, but the raw data for all the major stock venues needs to be ingested: the Options Price Reporting Authority (OPRA) feed for National Best Bid Offer (NBBO), and the local Top of PHLX Options (TOPO) feed. This processing puts a significant strain on trading systems and takes resources away from the important task of analyzing the data and making decisions about trades.

Figure 2 — NASDAQ PHLX Equity and Options Market-Making Server



Despite advancements in server technology, filtering the desired symbols in software is latency intensive because it occupies precious processing cycles and takes resources away from the important tasks of making and processing trading decisions. It also introduces significant latency and occupies the system bus with unneeded data. As shown in the case study, FPGA technology on the network interface card can provide the computing power needed for all the filtering and the determinism required by the trader for superior application performance.

A Case Study

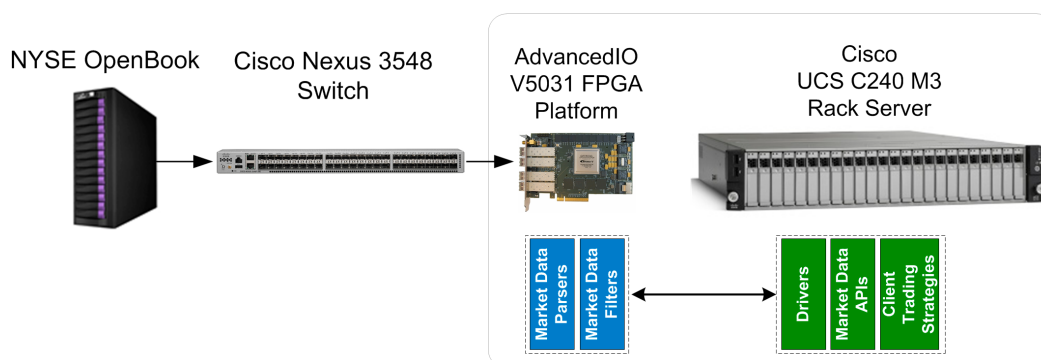
A case study revealed that by fully integrating capabilities from ecosystem partners, a solution can be developed to provide a practical and powerful response to the needs of financial markets. These findings can be used both to help traders understand the performance of their applications and choose their trading infrastructure.

This case study explores a solution for offloading the complex task of processing the various market data feeds from the user's trading application, outsourcing the computation intensive filtering to the network interface card, and passing only the data required by the trading application to the server. For demonstration purposes, the study targeted the NYSE OpenBook Ultra market data, but the techniques and infrastructure used in the demonstration apply to all other market data. The infrastructure used to complete the study, shown in "Figure 3", consisted of the following:

- [The Cisco Nexus 3548 Switch](#) is the communications fabric between the stock exchange and the trading application. The Cisco Nexus 3548 offers this optimization by achieving latencies of less than 250 nanoseconds (ns) for all workloads – Layer 2 and Layer 3, and unicast and multicast — regardless of features enabled. Cisco Algorithm Boost (Algo Boost) silicon technology, a core component of the Cisco Nexus 3548, pairs ultra-low latency with a comprehensive feature set that is essential for running a trading infrastructure, including active buffer monitoring, NAT, SPAN, and robust Layer 3 capabilities. For more information, refer to www.cisco.com/go/nexus3548.

- [The AdvancedIO V5031 Network Card](#) is the FPGA platform responsible for processing market data. The latest AdvancedIO FPGA network card, the V5031 has a powerful and scalable hardware architecture powered by the Stratix® V FPGA by Altera®. By continually applying unique performance improvement techniques for market data processing and the host bus interface, the AdvancedIO V5031 offers the lowest latency platform available in its class. The tight integration with MayStreet's market data library provides a strong value proposition to the financial market. This ensures the trading application has greater control over normalization, eliminating potential errors introduced by third-party normalization schemes. For more information, refer to www.advancedio.com/v5031.
- [The Cisco UCS C240 M3 Rack Server](#) is the financial application server and host for the AdvancedIO V5031 FPGA platform. The enterprise-class server features two Intel E5-2690 2.9 GHz processors and 98 GB of memory running at 1333 MHz. For more information, see www.cisco.com/go/servers.
- [The MayStreet Bellport™ Software](#) is the market data library responsible for presenting a simple, flexible and consistent interface across all markets. The software runs on the UCS C240 server and manages market data subscription on the V5031 FPGA network card. For more information, refer to www.maystreet.com.

Figure 3 — Sample Network Configuration of Ecosystem Financial Infrastructure

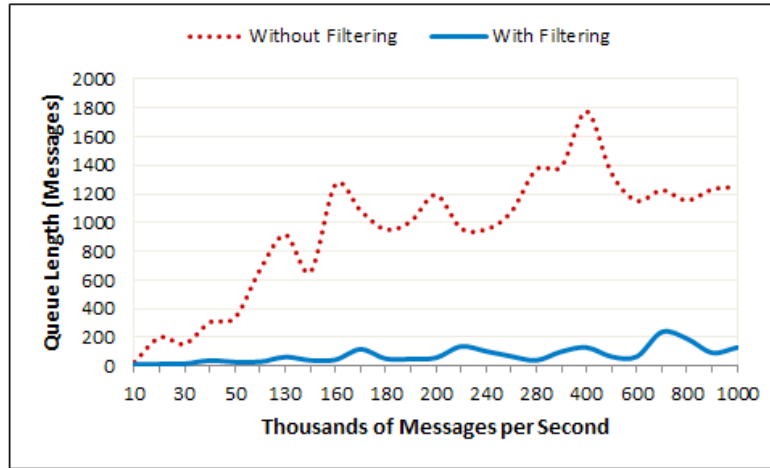


The performance of a trading application depends on data coherency. Filtering and decompression in real-time on the network card, instead of in the user space, provides significant advantages, including an order-of-magnitude less context switching, increased parallelism, and less message loss. As a side benefit, the offline filtering of historical data enables low-latency trading strategy development by providing the capability to experiment with market data.

The case study explored here examines two scenarios for market data processing: one in which all market data processing was performed in software on the server, and one in which filtering was performed on the network card. As shown in “Figure 3”, historical market data were played at various speeds, with an average message size of 107 bytes. The market data was then distributed by the Cisco Nexus 3548 Switch to the AdvancedIO V5031 FPGA network card for processing before it was presented to the MayStreet market data library. The entire data path forms the foundation for building low-latency financial trading applications right out of the box.

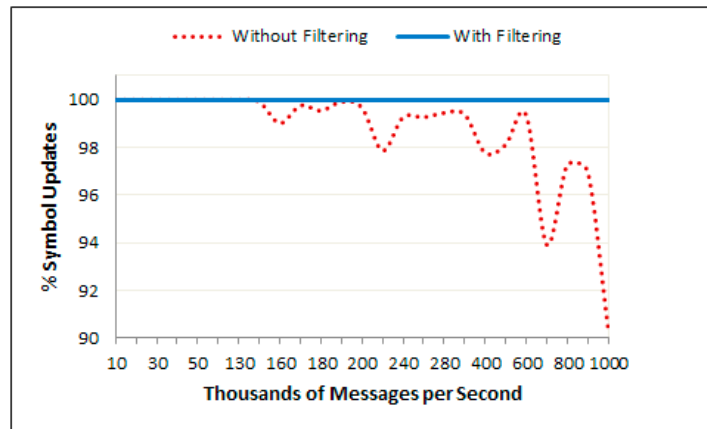
First, the study measured the number of financial transactions that wait for processing by the trading application. As shown in “Figure 4”, the queue length on the server side was substantially longer when no filtering was performed on the network card. A longer queue means that the processor is getting saturated and having difficulty handling the amount of incoming market data resulting in much greater trading latency.

Figure 4 — Effect of Filtering on Processing Queue Length



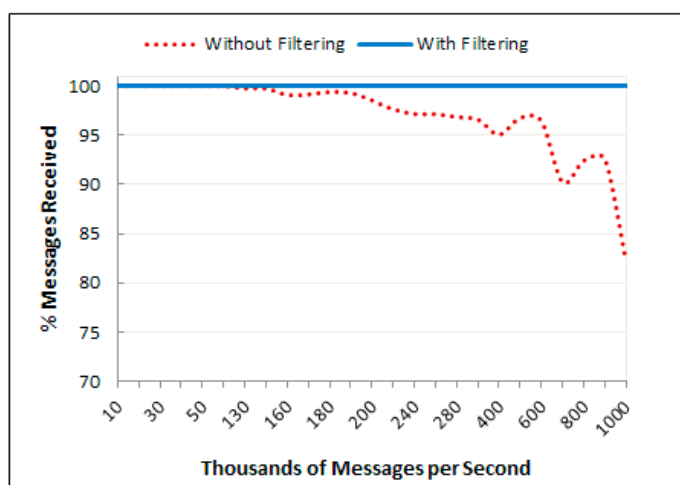
Second, the study measured the percentage of subscribed market data updates that were successfully received and processed by the trading application. As shown in “Figure 5”, filtering on the network card resulted in a 100 percent processing rate. With filtering disabled, message loss began to occur as the market data rate is increased.

Figure 5 — Effect of Filtering on Symbol Processing Coverage (Normalized)



Third, the study measured the number of messages transmitted on the wire and compared this value to the number of messages received by the trading application. As shown in “Figure 6”, all subscribed-to messages were received on the processor with filtering enabled on the network card. However, the processor started dropping messages at higher rates with no filtering on the network card. Overall, the percentage of message loss exceeded 17 percent.

Figure 6 — Effect of Filtering on Message Loss (Normalized)



The results show that by performing filtering on the network card, a significant performance improvement can be achieved. However, NYSE OpenBook Ultra market data demonstrates a lower bound on performance improvements for several reasons. First, it is a medium volume market data feed with a current peak bandwidth of 150 Mbps. By comparison, OPRA market data requires about 1.5 Gbps, or 10 times greater bandwidth. Second, it does not use a compression technique such as FIX Adapted for Streaming (FAST). The binary encoded data makes the interpretation in user space simpler. Many other market data feeds use a string to identify each product requiring less efficient comparison. Third, the study demonstrated performance improvements using a single market data feed, whereas many trading strategies effectively require multiple market data feeds. Additional software threads are required to receive all multicast data streams. The number of threads and the switching between them can cause further resource constraints.

For all practical purposes, more market data processing is needed on the FPGA network card to achieve the levels of performance improvements required by traders.

Conclusion

The world of financial trading is very complex requiring the integration of many products, technologies, and network infrastructure. To facilitate the implementation of such solutions, an ecosystem of companies providing best-in-class solutions and guided by an industry leader such as Cisco is required. The result is better integration, performance advantage, cost reduction, attractive features and significant reduction in the risk associated with integration of solution from disparate vendors.

About AdvancedIO

AdvancedIO Systems, Inc. is a private, profitable, product company with Fortune 100 customers in finance, defense and telecommunication around the globe. We are a premier provider of programmable FPGA network interface solutions built for real-time ultra low latency performance. We offer solutions at the card, system and application levels. With our unique technology and team responsiveness, our customers can quickly introduce advanced solutions providing them with a competitive advantage to stay at the forefront of their market.

About Cisco

Cisco Systems, Inc. designs, manufactures, and sells Internet protocol (IP)-based networking and other products related to the communications and information technology (IT) industry and provide services associated with these products and their use. The Company provides a line of products for transporting data, voice, and video within buildings. Its products are installed at enterprise businesses, public institutions, telecommunications companies, commercial businesses, and personal residences.

About MayStreet

MayStreet LLC designs and develops some of the world's most advanced capital markets technology. Our unique approach of providing complete source code to key libraries allows customers a viable alternative to the build-versus-buy decision while both improving trading performance and reducing costs. Current offerings include ultra low latency market data, order entry, and packet capture based historical analysis.