



Ingenious Award Program Submission

TMX Group – Quantum XA Equity Trading System

June 2014



Project

TMX Quantum™ XA Equity Trading System

Project Category

New Generation of ultra-low latency Equity Trading system

Category

Large Private Organization

Nominated Company

TMX Group Ltd.

TMX Group is the center of Canadian capital market operates cash and derivative markets for multiple asset classes including equities, fixed income and energy. TMX provides clearing facilities, data products and other services to Canadian and international financial community.

Business Objective

Build an ultra-low latency equity trading system that puts TMX as a leader in front pack of Stock Exchanges internationally in terms of performance and latency. The roundtrip orders processing latency of below 100 μ sec (microsecond) was desired. In addition, create a Canadian Technology leadership position among other major stock exchanges in the world that is innovative.

Business Circumstances and Achievement

TMX Group is the operator of Canada's major equity markets, providing domestic and international investors with access to the Canadian marketplace. TMX Group owns and operates four equity trading markets: TSX Toronto Stock Exchange, TSXV Venture Stock Exchange, TMX Select and TMX Alpha.

TMX technologies team first built the Quantum Equities Trading platform back in 2007. Quantum trading technology was deployed on all TMX equity markets. The Quantum trading engine had an acceptable latency when it was originally developed more than 6 years ago. Today, despite the Quantum trading technology's robust stability and good track record, it is lacking the level of latency that is expected from a world-leading exchange. The TMX technology team set a goal for latency improvement that would leapfrog our competitors, while



preserving the full TMX market functionality and world-leading high-availability, thus starting a research and development initiative to achieve this major challenge. After two years of intense work and creative research, the *TMX Quantum XA* architecture was created.

TMX Quantum XA is the new generation of the TMX Quantum equity trading system that provides ultra-low latency order processing that is, to our knowledge, the fastest in the world. The median roundtrip latency achieved across the full trading day, including all order functions, is 26 microseconds, measured at the TMX network edge in the production environment. Furthermore, the latency variability (or ‘jitter’) as measured by the 99th percentile is just 38 microseconds. This unique, innovative proprietary technology was fully developed in-house by the TMX technology team over the past 24 months and launched into production for the TMX Select Market in July 2013. The same technology has been launched on TMX main equity markets on June 2nd, 2014. Our leading exchange competitors in the U.S., who are considered among the fastest stock exchanges in the world, have nearly twice the latency achieved by *TMX Quantum XA*, and multiple times the ‘jitter’.

Due to innovative approaches to architecture, development, integration and the combination of various cutting edge technologies that no other major exchanges in the world have implemented in the past, *TMX Quantum XA* technology is the top candidate for “Ingenious Award”. *TMX Quantum XA* trading platform is the fastest in the world.

Highlights of *TMX Quantum XA* system achievements and innovation:

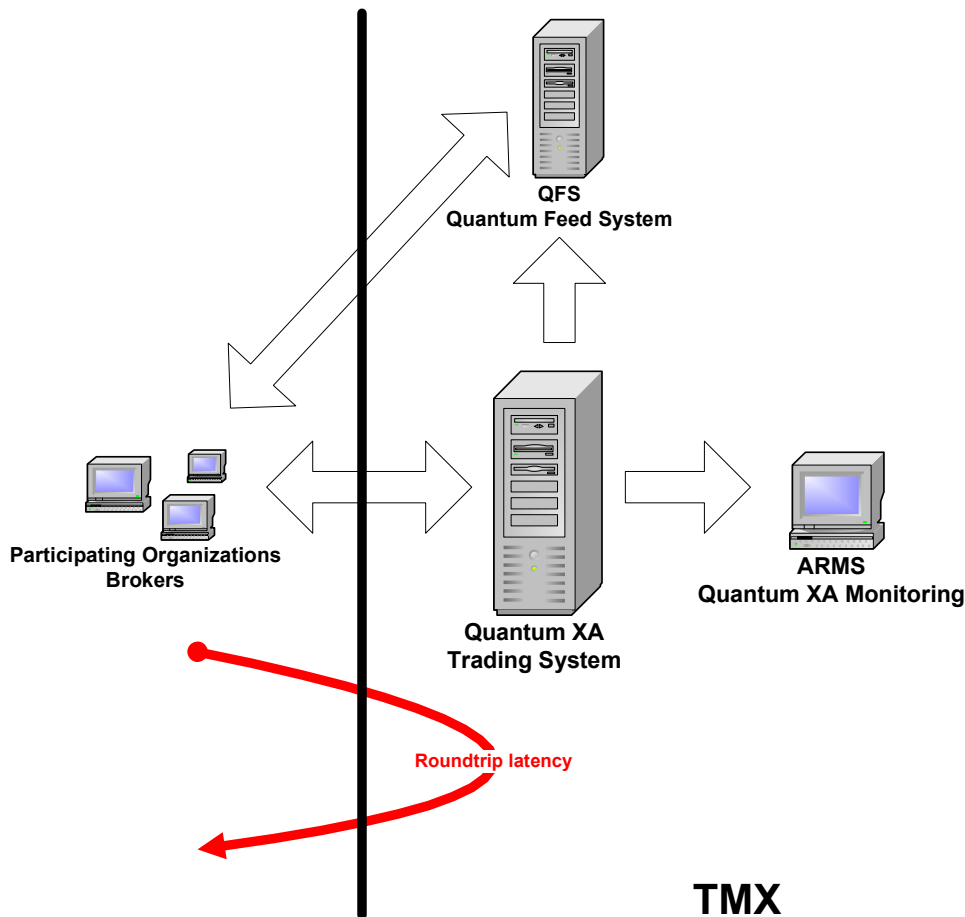
- Ultra-low latency and ‘jitter’
- Creative, cutting edge technology
- Significantly lower cost and smaller footprint
- Industry-leading high-availability
- Short time to market

TMX is in the process of patenting aspects of the technology that was created in *TMX Quantum XA* architecture and design. There are currently five patent applications being reviewed and submitted.



Technical description of the application and challenges

TMX Quantum XA is a high performance trading platform that has been developed to provide ultra-low latency and jitter, high throughput, and at the same time, high availability. *TMX* trading clients, participating organizations, brokers and trading access vendors are connected to *TMX Quantum XA* trading system via FIX4.3 or STAMP protocols. Both protocols require user authentication which is handled by the *TMX Quantum XA* application. *TMX Quantum XA* publishes market data to *TMX* feed distribution system called QFS (Quantum Feed System). *TMX Quantum XA* provides high-speed real-time monitoring and reporting capability via ARMS (Application Reporting and Monitoring System).





Quantum XA Network:

An ultra-low latency network was designed and implemented, comprising 40 Gb/sec backbones and 10 Gb/sec server and user interfaces. The network design incorporates fast cut-through network switches and the reduction of network hops to minimize the network traversal time. At the same time, some of the network security functionality that was traditionally satisfied by a firewall appliance was redesigned and implemented inside the *Quantum XA* application. The *Quantum XA* Network is a lightweight and dedicated fast network.

Quantum XA Servers, NIC cards and Direct Servers Communication:

A combination of hardware acceleration technologies, high performance servers utilizing high speed CPUs, fast memory/cache technologies, exclusive BIOS settings and programmable/customizable network cards have been integrated and tuned through extensive detailed technical analysis, and many iterations of experimentation..

Quantum XA Trading Application:

The *Quantum XA* application has been designed with ultra-low latency as the chief objective. Several application architectural approaches were innovated that have not, to our knowledge, been used before.

Design and Development consist of:

- Financial protocol (FIX) translation optimization using assembler instructions.
- Various code optimizations of heaviest-used code paths.
- Bypassing OS and Kernel operations/functions in favor of direct network layer operations.
- Proprietary fast replication technology between primary and standby servers utilizing special hardware and advanced application design and integration mechanism.
- Trading Cluster Manager Function to achieve robust high availability without impacting performance.
- Application flow control mechanism for shaping inbound micro-bursting traffic.
- Proprietary real-time monitoring system for high traffic trading utilizing a fast memory-based stats engine design and distinctive way of indexing and searching large volumes of real-time trading data.

* Please note due to confidentiality of the technology, the content of this document does not contain detail design information.



Role of IT

The concept of this innovation was initiated by TMX IT team. From proof of concept to delivery to production environment, TMX IT teams played the main role in this project. With IT team's innovation in designing ultra-low latency trading system combined with past delivery and build capabilities of trading systems, TMX IT team has performed an instrumental position to success of this project. This project puts TMX in front pack of exchanges in term of technology in Canada and internationally. TMX IT has performed sophisticated technical, design, architecture, build, deploy and operational activities along with advanced project management practices to successfully deliver this project. IT innovation by using creative way of technology integration techniques between Network, Hardware Acceleration and specialized Software resulted in over achievement of the goals for equity trading engine with ultra-low latency of below 100 microseconds. There are currently patents under registration by TMX for technological advancement that is made by TMX Quantum XA system.

Advantages, Innovations, Benefits and Measurable Result

TMX Quantum XA Main Product Features and Benefits:

- *TMX Quantum XA Select* - phenomenally reduced the order entry response latency measured at TMX trading server edge by approximately 100 times from the previous generation of trading engine (Quantum). (Quantum: 2000 μ sec range ► Quantum XA: 20 μ sec range)
- *TMX Quantum XA Select* - Median roundtrip order response latency measured at the TMX network edge is 26 μ sec.
- Improved burst management and traffic flow control.
- High speed dedicated trading network.
- *TMX Quantum XA* infrastructure has reduced the TMX trading footprint significantly. Total Cost of Ownership of the trading engine and gateway servers of the trading enterprise is reduced by approximately 50%.
- Increased throughput capability: *TMX Quantum XA* is being designed to be capable of 200,000 messages per second, per dual-processor server and can be scaled horizontally across multiple such servers.
- Provide state-of-the-art cluster manager for robust high availability.
- Real-time monitoring application with capability of viewing message latency at nanosecond granularity at each processing step.
- *TMX Quantum XA* architecture and design is planned to be expanded to other matching/trading platforms such as derivatives, options, commodities, etc. and not limited to equity trading.
- *TMX Quantum XA* provides the best of the trading latency in its class and at the same time allows flexibility, ease of maintenance and instant change and deployment

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capabilities, thus making it by far a superior technology platform compared to FPGAs (field-programmable gate array) technology that is used by some of our competitors in their trading platform.



Other supportive Information

- Additional technical or project information can be presented upon request. TMX IT team is available for meetings or conference calls to discuss further technical evidence that might be required for supporting this submission.
- *TMX Quantum XA* client references can be provided to prove the fast latency that is claimed in TMX production environment by this submission.
- *TMX Quantum XA* internal latency reports captured from network appliances in production environment can be provided as supportive latency measurement evidence.
- *TMX Quantum XA* technical team is available for interviews and providing further information.
- TMX IT management is available for detail presentation about TMX Quantum XA platform.

Link to *TMX Quantum XA* web site and public notices:

<http://www.tmx.com/en/trading/tsxquantum/index.html>

http://www.tmx.com/en/news_events/news/news_releases/2014/02-20-2014_TMXGroup-TMXQuantumXA.html

Other Awards short listed, nominated or won

1. TMX Quantum XA Equity Trading System was short listed as finalist and rated second from the top for 2013 American Financial Technology Awards in the category of Most Cutting-Edge IT Initiative:

<http://www.waterstechnology.com/waters/news/2306360/american-financial-technology-awards-2013-all-the-finalists>

2. TMX Quantum XA Equity Trading System was short listed and won CATAAlliance Innovation and Leadership Awards in the category of Sprott School of Business at Carleton University Outstanding Product Innovation Achievement Award:

http://www.cata.ca/Media_and_Events/Press_Releases/cata_pr05221402.htm



http://www.tmx.com/en/news_events/news/news_releases/2014/05-22-2014_TMXGroup-QuantumXA-Award.html