



A Low-Latency Solution for High-Frequency Trading from IBM and Solarflare

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Executive Overview

In the world of High-Frequency Trading (HFT), opportunities exist only fleetingly and therefore trading solutions delivering the lowest latency need to be competitive. Low-latency 10 Gigabit Ethernet has become the interconnect of choice for High-Frequency Trading solutions. IBM® and Solarflare® have demonstrated an ultralow-latency reliable messaging solution that performs at high throughput rates to facilitate High-Frequency Trading solutions.

This solution uses the IBM®-BNT® 8264 10Gb switch, coupled with IBM's WebSphere® MQ Low Latency Messaging (WMQLLM) software using the Solarflare SFN5122F 10 Gigabit Ethernet adapter with OpenOnload® drivers. This solution delivers a powerful combination of networking hardware and messaging software that meets the latency and throughput requirements of high-frequency trading environments.

This has been demonstrated through independently audited benchmarks published using the STAC-M2 Benchmark™ test. In addition to the STAC-M2 Benchmark test, further testing was performed by IBM to explore the latency performance that this solution delivers. The results show that the average latency of this solution remains in the extremely low range of 6 – 11 µsec, with standard deviation remaining less than 2 µsec even as message sizes grow large and message rates reach 1 million messages / second.

High-Frequency Trading

HFT has gained a strong foothold in financial markets, driven by several factors, including advances in information technology that have been conducive to its growth. Unlike traditional traders who hold their positions long term, high-frequency traders hold their positions for shorter durations, which can be as little as a few seconds. They typically end their day with few to no positions carried over to the next business day.

HFT uses strategies such as statistical arbitrage and liquidity detection. Statistical arbitrage relies on the principle that stocks in a pair or pool of correlated stocks that diverge from their statistically expected behavior will converge and profit is achieved by taking positions based on this expectation. Liquidity detection is the strategy by which small trades are sent out to detect large orders that are not visible and then taking positions based on the expectation that the large orders will move the market. These strategies require programs to analyze massive amounts of market data using complex algorithms to exploit opportunities that exist for a few seconds or even less than a second. The execution of these strategies requires information technology that can compute complex algorithms, and exchange messages at extremely low latencies—even at very high rates—to handle volume spikes without impacting system performance.

Therefore IT organizations in the financial services industry face tremendous pressures to optimize the transaction lifecycle. There is a critical need for the underlying messaging infrastructures to deliver extremely low latency and very high message throughputs.

Solution

IT organizations are expected to deliver solutions offering low latency with high throughput without using of specialized technology, to avoid high cost in terms of capital and skills. The trend has been to favor solutions that use commodity hardware and software components. Low-latency 10 Gigabit Ethernet has become the interconnect of choice. What follows are benchmark results that demonstrate a messaging solution stack that delivers on the technology requirements of high-frequency trading systems.

IBM and Solarflare have demonstrated an ultralow-latency messaging solution that performs at high throughput rates with reliability. This solution stack, shown in *Figure 1*, addresses the

requirements of the financial industry and delivers the solution using commodity hardware and software components.

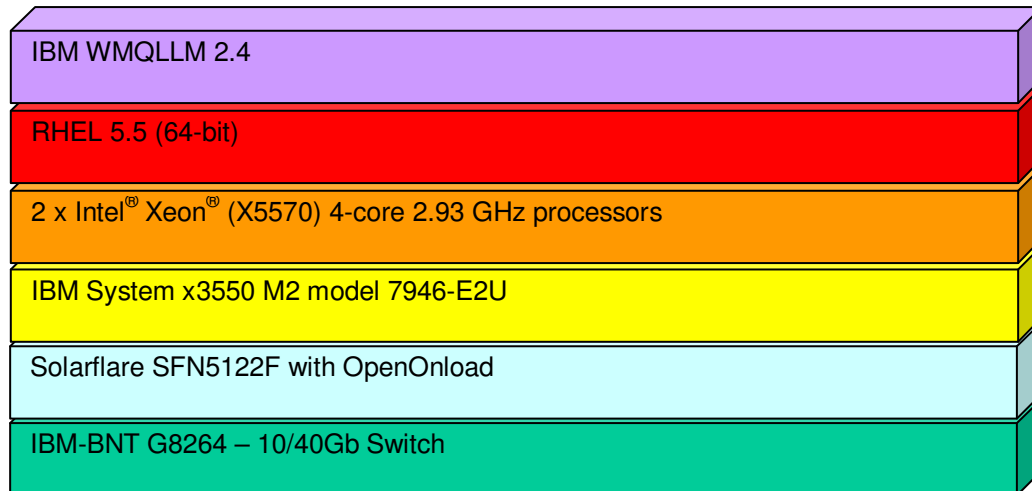


Figure 1. Solution Stack Components

This solution uses the IBM-BNT 8264 10 Gigabit switch, coupled with IBM's WMQLLM software using the Solarflare SFN5122F 10 Gigabit Ethernet adapter with OpenOnload drivers. This solution delivers a powerful combination of networking hardware and messaging software that meets the latency and throughput requirements of high-frequency trading environments. This has been demonstrated through independently audited benchmarks published using the STAC-M2 Benchmark test. In this paper we present additional test results demonstrating the latency characteristics of this solution.

IBM-BNT Rackswitch G8264 10/40 GbE Switch

The IBM-BNT RackSwitch™ G8264 is high-performance switch designed to meet the demanding requirements of high-frequency trading systems. It provides line-rate, high-bandwidth switching, filtering, and traffic forwarding, without delaying data. This switch offers up to 64 10GbE ports and up to 4 40GbE ports, 1.2 Terabits per second non-blocking bidirectional throughput in a 1U footprint. In addition to a rich set of layer-2 and layer-3 connectivity, the G8264 supports the newest protocols, including Data Center Bridging / Converged Enhanced Ethernet (DCB/CEE) for support of Fibre Channel over Ethernet (FCoE). Redundant power and fans, along with numerous high-availability features, enable the RackSwitch G8264 to always be available for business-critical traffic.

The single-chip design and the default cut-through mode are key to ensuring extremely low deterministic latency and jitter. Large data-center-grade buffers enable congestion free operation. Furthermore, the G8264 delivers best-of-breed performance and function, including Layer-3 with a standard 40GbE interconnect into the core, rather than taking the approach of a proprietary core interconnection, as chosen by some Ethernet vendors.

IBM Websphere MQ Low Latency Messaging

WebSphere MQ Low Latency Messaging is a transport fabric product engineered for the rigorous latency and throughput requirements typical of today's financial trading environments. The product is daemonless and provides peer-to-peer transport for one-to-one, one-to-many and many-to-many data exchange. It also exploits the IP multicast infrastructure to ensure scalable resource conservation and timely information distribution.

Designed to dramatically improve throughput and reduce latency while maximizing system reliability, WMQLLM can help high-frequency trading organizations enhance the responsiveness of their existing trade infrastructure while developing new solutions for emerging business

opportunities. Several factors contribute to the high performance enabled by WMQLLM. For example, a unique method of message packetization enables delay-free, high-speed data delivery. Proprietary batching technology dynamically optimizes packetization for reliable delivery and lowest latency, based on throughput, message sizes, receiver, and system feedback. In addition, very compact packet headers leave more network bandwidth for application data.

WMQLLM supports high performance interconnects, such as 10 Gigabit Ethernet and InfiniBand® to enable higher throughput with lower latency, reduced latency variability, and low central processing unit (CPU) consumption.

Solarflare SFN5122F 10GbE Server Adapter with OpenOnload

The Solarflare SFN5122F is a low-latency, low-power 10GbE server adapter. Solarflare server adapters are designed to provide high performance in the most demanding application environments. Solarflare's OpenOnload application acceleration middleware was used in combination with the SFN5122F to enable full operating system bypass, which dramatically reduces host processing overhead and enables high transaction rates while substantially reducing application latency with very low jitter. OpenOnload performs network processing at the user-level and is binary-compatible with existing applications that use TCP/UDP with BSD sockets.

For this solution test, the Solarflare OpenOnload library was configured to enable the application threads to run without contention with each other, and without requiring any interrupt processing or other interaction with the kernel active on the dedicated core. These techniques implemented in Solarflare's OpenOnload enabled the system to be entirely vertically separated on CPU cores, thus avoiding any application-level crosstalk. As a result, extremely low jitter was observed in the results. The very low latency of the Solarflare SFN5112F server adapter, when used in combination with OpenOnload, results in a low degree of buffering in the adapter and protocol stack, which also makes a significant net reduction in overall application-level latency.

Performance Testing

The STAC-M2 Benchmark specifications test the ability of a solution to handle real-time market data in a variety of configurations. The specifications reflect the input of seven leading trading firms and six vendors of high-performance messaging and provide key performance metrics. Independently audited STAC-M2 Benchmark results have been published using the solution described in this paper. Details can be found at <http://www.stacresearch.com>.

In addition to the STAC-M2 Benchmark test, further testing was performed by IBM to explore the performance such a solution can deliver in terms of latency.

Single-Hop Latency Test

As shown in *Figure 2*, the test is a reflector test and the setup consists of two machines, A and B, connected through an IBM-BNT G8264 RackSwitch. On System A, the "sender" sends packets at the rate being tested to the "reflector" on System B. The "reflector" receives every packet, and only forwards to the "receiver" on System A those packets that have a time stamp for latency measurement. The "receiver" on System A extracts the time stamps from the reflected packet and uses it to measure round trip time. The single-hop latency is calculated as half of the round trip time. The standard deviation is calculated using the round trip time.

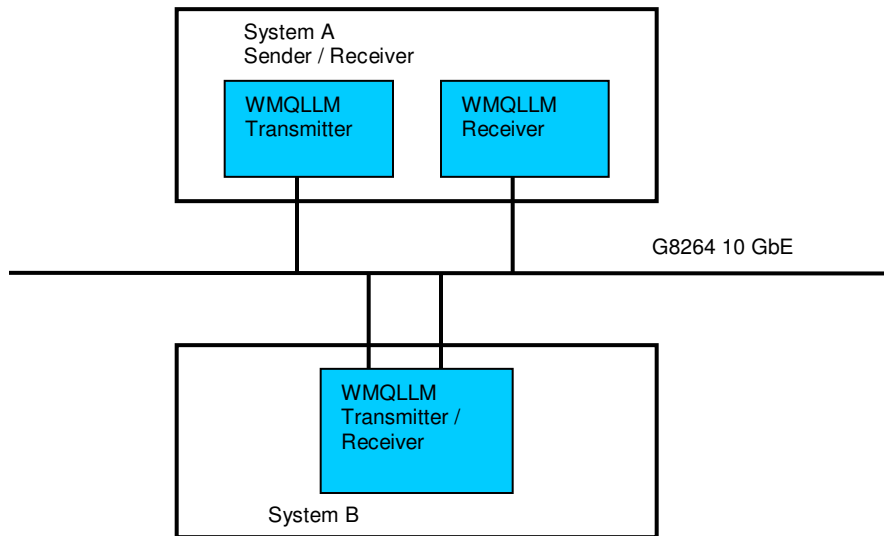


Figure 2: Reflector Test Layout

All latency tests ran for 5 minutes. Approximately 300,000 latency samples were recorded for each 5-minute test. From these 300,000 samples latency statistics were calculated. Two test parameters were used to vary the workload for this testing: message size and message rate. *Table 1* shows the results for each message rate and size test combination.

LLM Latency using IBM-BNT G8264 10/40 GbE and Solarflare SFN5122F OpenOnLoad					
Msg Rate [msgs/sec]	Msg Size [bytes]	Single Hop			RTT
		Average [µsec]	Median [µsec]	99P [µsec]	Std Dev [µsec]
10,000	128	5.95	6.0	6.5	0.80
100,000		6.24	6.0	6.5	0.83
1,000,000		8.72	8.0	10.5	1.43
10,000	512	7.29	7.5	7.5	0.47
100,000		7.52	7.5	8.5	0.51
1,000,000		11.68	11.5	14.5	1.77

Table 1: Single-hop latency

Key Takeaway

The average latency of this solution remains in the extremely low range of 5.95 –11.68 µsec with standard deviation remaining less than 2 µsec even as message sizes grow large and at very high rates.

Conclusions

These results clearly show that a messaging solution stack created using IBM's WMQ Low Latency Messaging, G8264 10/40 GbE switch and Solarflare SNF5122F adapters with OpenOnload delivers the solution that high-frequency trading applications need.

This solution stack delivers an ultra-low latency solution that scales to very high message rates with very little jitter in latency. That, combined with its ability to deliver low latency even as message sizes increase, makes this combination an ideal technology solution to meet the demanding requirements of high-frequency trading applications today and in the future.

References

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Develop high-volume, low-latency finance solutions with IBM WebSphere MQ Low Latency Messaging, Financial industry solutions White paper, IBM, October 2009)

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