Solutions for Ultra-low Latency, High-throughput Computing

Specialized computing tasks often demand network and I/O performance beyond those of typical data center applications. Workloads such as high-frequency trading require ultra-low levels of latency and jitter. High-performance computing (HPC) requires high throughput and low latency. Today’s network stacks based on Linux® and Microsoft Windows® are generally not well optimized to meet these requirements. Intel® Ethernet Controllers and network adapters have been well received in the financial services and HPC communities for their exceptional reliability, performance, and I/O virtualization capabilities. This report shows how financial services and HPC customers can benefit from the use of Intel Ethernet controllers and adapters in low-latency and high-performance applications.

Mcorelab has reported latency results using its MCoreRT® parallel processing software platform that are very close to the theoretical minimum latency of the Intel® Ethernet Converged Network Adapter X520. A team at Intel’s Jones Farm Performance Lab undertook testing to verify those claims using the standard methods and processes that Intel uses to quantify the performance of Intel® Ethernet products. MCoreRT incorporates the following optimizations to support ultra-low latency computing on Intel® architecture-based hardware:

- **MCoreRT’s kernel-bypass network stack** allows applications to directly access the network hardware. This capability avoids the overhead of the scheduler and other OS mechanisms, providing for minimum latency and maximum throughput.

- **MCoreRT’s scalable I/O and event-processing system** works to optimize the Intel® platform by scalable utilization of multi-core resources, seamlessly feeding I/O and event streams to the processing cores and providing ultra-fast and scalable event processing and inter-processor communication to applications.

- **Processor quiescence analytics** proactively analyze all available processor cores within the system to help determine which core or cores are experiencing the least noise and interrupts. MCoreRT helps to identify and assign threads to specific processor cores on that basis, minimizing latency and maximizing throughput.

- **Optimized interrupt servicing** manages the order and timing of interrupt handling to reduce the impact of those events on network latency. The resulting predictability and consistency provide better overall support for real-time operations by reducing jitter.

The MCoreRT parallel processing software platform uses these capabilities to provide the ultra-low latency, minimal jitter, and high throughput needed to meet real-time processing demands.

This approach provides excellent performance on both Windows and Linux. Applications can take advantage of the hardware to deliver high throughput using MCoreRT’s advanced parallel I/O and event-processing architecture. Alternatively, applications can use MCoreRT’s kernel-bypass low-latency network stack in transparent mode, which provides unobtrusive latency improvements, requiring no modifications to application software except processor affinity binding.
Testing Environment and Procedure
The Intel LAN Access Division performance team developed its test scenario around the MCoreRT solution and the best-selling Intel Ethernet Converged Network Adapter X520. The methodology specified that Spirent TestCenter* (v3.90) be connected directly to the adapter and server under test. In both Windows and Linux testing, non-required services were disabled; in Linux testing, for example, the User Space interrupt request (IRQ) balancer was disabled to keep IRQs static on the cores. The core affinity was determined by the methodology described below.

The Processor Quiescence Analytic tool measures the IRQ preemption over time to determine the CPU “noise” levels. The team used this tool to determine the most optimal physical core to which it would pin the Mcore stack. This approach was required to avoid disk preemption and reduce maximum latency. Pinning to the least noisy cores would reduce the maximum and average latency results.

The team also made the following configurations and settings on the test platform:
- Disabled Intel SpeedStep® technology
- Disabled C3 and C6 states
- Enabled Intel® Hyper-Threading Technology (this setting should be inconsequential because of pinned cores)
- Disabled Intel® Virtualization Technology
- Disabled Intel® Virtualization Technology for Directed I/O
- Set CPU Power and Performance Policy setting to “Performance”

The team’s goal was to run the tests they believed were most important in ultra-low latency applications to ascertain how well the combination of the Mcore driver and Intel hardware performs and to identify any limitations inherent in this solution.

The system selected was based on the Intel® Server Board S2600GZ, powered by the Intel® Xeon® processor E5-2600 product family. This platform features Intel® Data Direct I/O, which also helps lower latency and improve performance. Further details about the test environment are given in the table below.
Test Results

Figure 1 illustrates a significant latency reduction that scales across the important payload sizes. The performance improvement is an optimal configuration across the cores, profiled and optimized largely by the MCoreRT tools.

![Average Latency Across Important Payload Sizes](image)

**Figure 1.** Latency at various common packet sizes on Windows* and Linux*, comparing Mcore drivers to the standard Linux driver.

To test the scalability of the MCoreRT and Intel architecture solution, performance engineers tested the effect on latency as throughput scaled upward, using both TCP and UDP workloads. The testing confirmed that it is indeed possible to get high throughput on both TCP and UDP without sacrificing latency, as illustrated in Figure 2.

![Multi-Queue Throughput and Average Latency](image)

**Figure 2.** Scalable performance of TCP and UDP.

Conclusion

These test results from the Intel Performance Lab verify that MCoreRT offers a highly optimized solution that delivers excellent latency and throughput results in combination with Intel architecture-based hardware. Customers that require the ultra-low latency capabilities that this solution provides should investigate evaluation options from Mcorelab and perform their own in-house evaluations of this unique product pairing.
To test MCoreRT in your own environment, register for an evaluation at www.mcorelab.com/contact.html