Broadridge FXL

Performance Measurement Benchmarking

Broadridge®

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Summary

Broadridge FXL conducted a series of benchmarking tests at Intel's* UK-based FasterLAB in order to validate FXL's cash management processing capacity and identify peak performance metrics.

The scope of performance tests included the initial interface transaction request receipt through to the update of multiple client cash management blotters. Test simulations were run on a single set of hardware and identified a peak performance of 3,900 transactions per second over duration of 30 minutes.

Minimal processor utilization was observed across all computers during testing, which is a significant and positive indication for overall system scalability.

These extraordinary performance benchmark results confirm FXL as the solution of choice for financial service organizations running high-volume, large-scale cash management systems.

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Introduction

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Test Methodology

FXL performance tests spanned the cash management process beginning with the initial interface transaction request receipt through to the update of multiple client cash management blotters. Tests were conducted using the following components:

- A custom-built Cash Flow Feeder (CFF) interface adapter used to write external cash flows to a message queue processed by the FXL Interface Engine;
- FXL Workflow Director Application Servers; one to support interface transactions from the CFF and one to support manual transactions;
- Database to maintain external cash flows, account cash balances and the FXL Schema;
- Five client machines, each running three cash management blotters showing an increasing level of detail across accounts.

These components were distributed across a single set of hardware comprised of eight computers, as detailed below:

Computer 1:	FXL Application Server for processing interfaced cash flows and the Cash Flow Feeder
Computer 2:	FXL Application Server for processing manual requests and FXL Publication Services Note: Cash Management Publication is separated from other types of publications for performance reasons
Computer 3:	Database Server
Computers 4 – 8:	FXL Client Application

FXL built the external CFF specifically for these benchmark tests. The CFF was designed to add a configurable volume of cash flows for a configurable duration to the MSMQ message queue for processing by the FXL Interface Engine.

FXL processed the cash flows received, wrote data to the database and published processed information in real-time to a set of five client machines.

Tests measured ongoing processor utilization and utilization spikes across the hardware, and monitored message queue lag, defined as the build-up of messages in a queue awaiting processing or publication.

Following testing, data written to the database was compared against and reconciled with blotter data, and each of the three blotters on the five client computers were compared against each other to ensure consistent processing and publication.

Performance Tests

FXL conducted five performance tests, each with an increasing transaction load per second. For all tests, the set of processed transactions had the following structure and characteristics:

- Two-thirds of the total transactions simulated were new transactions and one-third were status updates.
- Transactions were booked against two hundred accounts split between two entities. Half of the transactions processed were attributed to 10 highly active accounts, while the other half was distributed across the remaining 190 accounts.
- Transactions were booked in 20 different currencies; 90% of the transactions were distributed evenly across EUR, GBP, JPY and USD, while the remaining 10% were distributed evenly across an additional 17 currencies.
- Transactions processed spanned a 90 day time frame, with 30% of transactions settling today, 30% settling tomorrow, 30% settling spot and the remaining 10% settling over the coming 90 days.
- Transactions were evenly distributed across 4 types of cash flows: client payment, settlement, foreign exchange and corporate action.
- Transactions were evenly distributed across 3 types of transactions: trade, transfer and settlement.

During each of the five tests, the FXL Publication Engine's configurable publication rate was set to publish data every 2 seconds. Between iterations, the test environment was fully reset to its initial configuration.

	Cash flows per second	Number of test iterations	Duration of test	Total cash flows processed
400 TPS Test	400	3	15 minutes	360,000
800 TPS Test	800	5	30 minutes	1,440,000
1500 TPS Test	1500	1	45 minutes	4,050,000
2000 TPS Test	2000	1	30 minutes	3,600,000
4000 TPS Test	4000	1	30 minutes	7,200,000

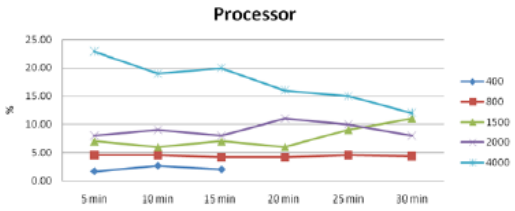
Test Results

FXL performance tests measured ongoing processor utilization and utilization spikes across all hardware and monitored message queue lag, which is defined as the build-up of messages in a queue awaiting processing or publication.

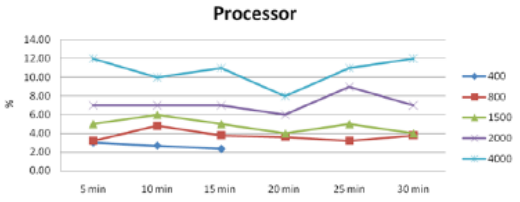
Processor Utilization

Across all tests the FXL application servers and database experienced minimal processor utilization. As transaction throughput was increased, processor utilization showed a corresponding increase in the machines hosting the FXL Application Servers and the Database Server. Processor utilization was highest on the Database Server machine, particularly during the 4,000 TPS Test. This highlights the need for a large database server with sufficient spindles to handle the high volume of I/O operations. Processor utilization on all client machines was negligible regardless of transaction throughput.

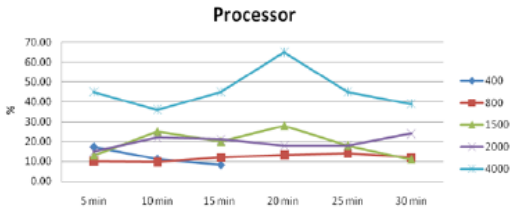
Computer 1: FXL Application Server to process interfaced cash flows and cash flow feeder.



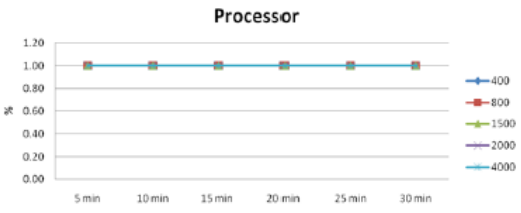
Computer 2: FXL Application Server to process manual requests and FXL Publication Services.



Computer 3: Database Server



Computer 4-8: FXL Client Application Servers

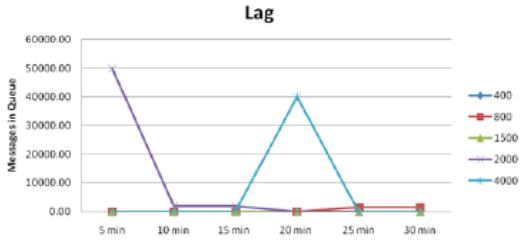


Publication Lag

Publication lag is defined as the build-up of messages in the message queue awaiting processing or publication. FXL tests monitored three different queues: a queue in each of the two FXL Application Services receiving and processing cash flows, and a queue in the FXL Publication Engine (on Computer 2) for publishing to the clients. Several periods of lag of up to 10 seconds were experienced in the 2,000 TPS Test and 4,000 TPS Test during increased processor utilization on the Database Server. As database server processor utilization dropped, the system was able to quickly catch up and was completely reconciled at the end of the test.

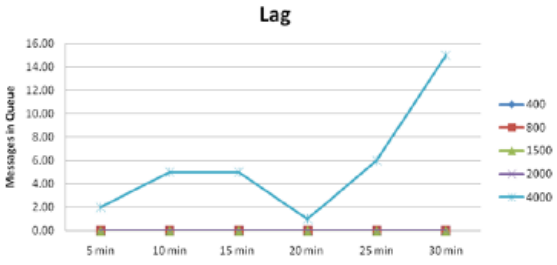
Computer 1: FXL Application Server to process interfaced cash flows and Cash Flow Feeder

The figure below represents lag experienced behind the external interface, which occurs during times of increased processor utilization on the Database Server (Computer 3).



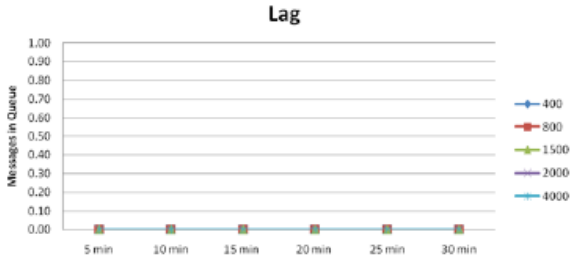
Computer 2: FXL Application Server to process manual requests and FXL Publication Services

The figure below represents lag experienced behind Computer 1 as transactions are pushed to the Publication Engine. Note: The 15 messages in the queue seen at 30 minutes for Test 5 (4,000 TPS) are an anomaly and represent 3/800th of the data processed in 1 second.



Computers 4-8: FXL Client Application

The figure below represents lag experienced behind the FXL Publication Engine (Computer 2) as it published transaction data to each of the five clients.



Data Reconciliation

Following the completion of each test, resulting database records were compared against and reconciled with data published to the client blotters, and data in each of the three blotters on all five client computers was compared against each other to ensure consistent processing and publication. In all cases, data reconciled successfully 100%.

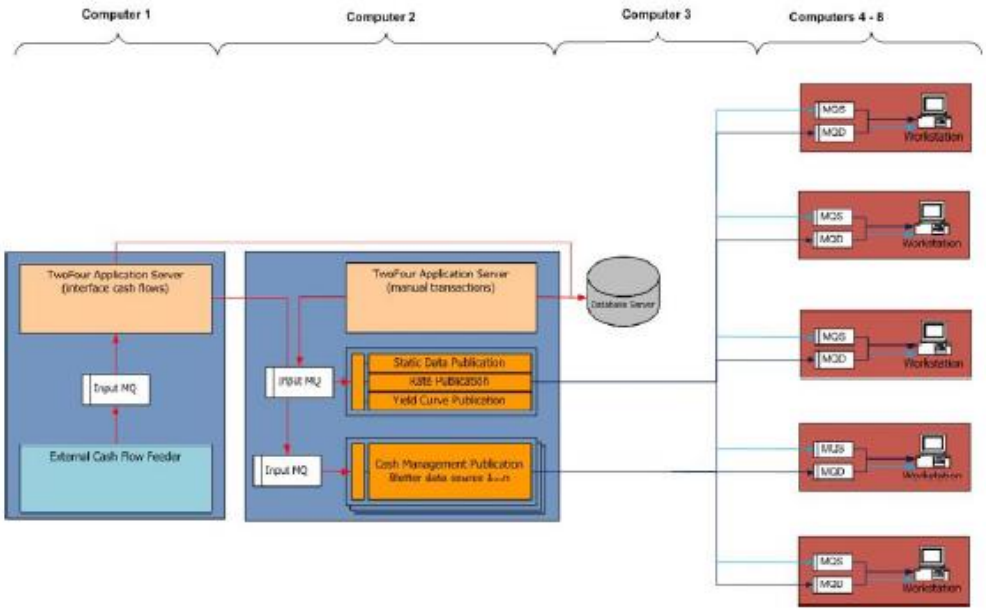
Test Environment

FXL performance tests were conducted on a single set of hardware in order to measure base peak performance capability. As described in the Test Methodology section above, eight computers formed the test environment:

Computer 1:	FXL Application Server for processing interfaced cash flows and the Cash Flow Feeder
Computer 2:	FXL Application Server for processing manual requests and FXL Publication Services Note: Cash Management Publication is separated from other types of publications for performance reasons
Computer 3:	Database Server
Computers 4 – 8:	FXL Client Application

Data Flow

Cash flow requests and processed data moved through the system, beginning with the initial interface transaction request receipt on the two FXL Application Servers (Computers 1 and 2) through to the update of multiple client cash management blotters on the Client Applications (Computers 4 – 8). The diagram below describes the actual flow of data between the software and hardware components during performance tests.



FXL Performance Measurement Benchmarking

The eight computers used during FXL performance tests were configured with the following specifications:

Hardware Specifications

Computer 1: FXL Application Server to process interfaced cash flows and Cash Flow Feeder	Computer 2: FXL Application Server to process manual requests and FXL Publication Services
- Intel® Xeon® processor 3.16GHz (quad core) - 1333MHz front side bus - 16GB FBDIMM memory - 70GB local storage	- Intel® Xeon® processor 3.16GHz (quad core) - 1333MHz front side bus - 16GB FBDIMM memory - 70GB local storage
Computer 3: Database server	**Computers 4 – 8: FXL Client Application**
- Intel® Xeon® processor - 1066MHz front side bus - 4GB FBDIMM memory - 12 enterprise-class Serial Attached SCSI (SAS) HDDs 7.2K rpm 750GB	- Intel® Xeon® processor 3.16GHz (quad core) - 1333MHz front side bus - 16GB FBDIMM memory - 70GB local storage

Software Specifications

Computer 1: FXL Application Server to process interfaced cash flows and Cash Flow Feeder	Computer 2: FXL Application Server to process manual requests and FXL Publication Services
- Intel® Xeon® processor 3.16GHz (quad core) - 1333MHz front side bus - 16GB FBDIMM memory - 70GB local storage	- Intel® Xeon® processor 3.16GHz (quad core) - 1333MHz front side bus - 16GB FBDIMM memory - 70GB local storage
Computer 3: Database server	**Computers 4 – 8: FXL Client Application**
- Intel® Xeon® processor - 1066MHz front side bus - 4GB FBDIMM memory - 12 enterprise-class Serial Attached SCSI (SAS) HDDs 7.2K rpm 750GB	- Intel® Xeon® processor 3.16GHz (quad core) - 1333MHz front side bus - 16GB FBDIMM memory - 70GB local storage

Conclusions

FXL achieved significant transaction processing throughput during benchmark tests on a single set of hardware at Intel's FasterLAB UK-based facilities. With a peak performance capability of 3,900 transactions per second maintained for a duration of 30 minutes, FXL has proven its strength as the solution of choice for financial service organizations running high-volume, large-scale cash management systems.

Tests showed minimal processor utilization across all computers, including client machines, the one component not easily scalable. This has positive implications for total system scalability and FXL will continue to partner with Intel to capture scalability metrics in the coming months.

These tests highlight the importance of a large database service with sufficient spindles to handle the high volume of I/O operations. During the 2,000 TPS Test and 4,000 TPS Test, brief periods of lag occurred of up to 10 seconds during increased processor utilization on the Database Server, but the system quickly caught up as database server processor utilization dropped and was completely reconciled at the end of the test. This lag may be alleviated by using 64 bit SQL Server and/or more disk spindles.

These performance benchmark results emphasize FXL's ability to consistently deliver real-time, high performance processing and to support financial services organizations with global, high-volume operations.

FXL Performance Measurement Benchmarking

About FXL

FXL is an integrated, n-tier client-server application based on Window's .NET* framework. As the only new market entrant in more than 10 years, FXL truly addresses today's market needs using the latest, state-of-the-art technology. FXL is designed from the ground up to address the key challenges faced by financial services organizations today.

- Global 24/7 trading and operations
- Front-to-back Straight through Processing (STP)
- Unattended End-of-Day processing
- Flexible and Configurable Information Views
- Cross-product processing
- High-volume transaction support
- Real-time distribution of information
- State-of-the-art .NET* technology
- Multi-organization and multi-entity (MEMO) support
- Workflow-based processing
- Integrated automated testing to improve software quality
- Internationalization

Key Features

Introducing a new processing platform into an organization's existing – and typically complex – technical infrastructure is difficult. Many of the issues that technologists face when selecting a new system have to do with ensuring a smooth transition, minimising operational inefficiencies and providing tangible benefits for the business. FXL addresses these issues by providing:

- Seamless integration with existing systems: FXL integrates smoothly with a diverse set of corporate support systems, regardless of technology, data type and format, or communication requirements. The Interface Engine is the gateway for all incoming and outgoing data, linking FXL with internal and external systems. The Interface Engine ensures data integrity and consistency, and supports high traffic volumes.
- Built-in support for global operations: FXL is designed to facilitate operations for a global organization. This is a central feature of the system, and has specifically determined the way data is organized, distributed, accessed and updated. Company structures are defined using a flexible 4-tier hierarchical model, data security is managed at an organizational level, and multi-user mechanisms ensure information integrity.
- Cross-product processing support: FXL is a multi-asset class transaction processing system. Traders can view consolidated positions information across all financial products, improving productivity and enabling them to make better decisions faster. FXL's core data model uses one set of tables to consistently support all product types. Additional products can be added to the system with minimal effort and without compromising FXL's ability to view consolidated positions information, process settlements and confirmations, and manage accounting across all asset classes.
- Customizable and extensible development environment: The FXL Development Kit enables organizations using FXL to create components in-house to modify, replace or extend application functionality.
- High availability for business continuity: FXL is designed to provide a highly available environment. It supports a number of server configurations that automatically and transparently provide business continuity to users. Because FXL is built using industry standard technology, it is also compatible with a number of 'off-the-shelf' business continuity tools, including application server clustering and hot-backups of the database to an offsite location. Redundant Workflow Director application servers can also be configured to run against backup databases.

"We believe that the role of the technology infrastructure in achieving optimum application performance is now critical. The lab gives companies the ability to test the many and varied components that make up the infrastructure in order to ascertain which areas will give the best ROI in terms of operational improvement. Speed, cost reduction, management of risk and operational compliance with new regulations are key objectives for financial services technology. Technology choice is now complex and we recognize the huge leap of faith many financial institutions take when they develop new infrastructures and that's exactly the reason why we set up this lab to support the financial services community – bringing an enabling service to both buyer and seller. The Lab is equipped with the layered software, networking and measurement tool and the very latest processor technology - such as the new Intel® Xeon® processor 7400 series and engineering releases of Intel's next generation microarchitecture (codenamed "Nehalem"). Supported by Intel® Xeon® processor 7400 series, testing can take place on typical high end production machines – using proprietary or where available de facto standard based routines. In using the lab FXL can also take advantage of Intel's Financial Services Partner Program which seeks to provide companies with access to the scale of Intel's channels and resources."

- **Nigel Woodward, Global Director, Financial Services for Intel**

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