Mainframe Migration: Performance of Enterprise Server™ for Windows®

White Paper
Abstract

This paper is aimed at business professionals (CIO’s and IT managers) who manage mainframe legacy information systems, and who are interested in solving certain Total Cost of Ownership (TCO) issues involved in their systems. This paper will examine the performance aspects of mainframe migration. A knowledge of the value and importance to an organization of an effective IT infrastructure, and the challenges in achieving this goal are assumed; however, in-depth knowledge of specifics is not required, as this paper will introduce each concept as it is encountered.

For decades, countless organizations around the globe have relied on the performance, capacity, reliability and longevity of IBM mainframes to support their businesses, by processing data, printing billing details, running internal reports, calculating insurance premiums or bank balances, driving applications run by the customer call center staff, and more. In the 21st Century, three quarters of the world’s data still resides on the mainframe1, accessed by COBOL systems.

*Lift and Shift* is the term Micro Focus uses to define for the process of migrating COBOL CICS applications from the IBM mainframe environment to a more cost effective platform, while maintaining compatibility to the existing business application interfaces. Migrating mainframe applications and data to a new platform environment has performance implications which this paper addresses. We conclude based on our performance benchmarks that Micro Focus Enterprise Server with MTO operating in a high-end multi-processor Intel and Microsoft environment can attain the equivalent of a 1347 MIPS for typical CICS COBOL DB2 workloads. We go on to compare price and performance between the mainframe and Enterprise Server and discuss the implications on a mainframe migration return on investment (ROI).

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1 Source: Gartner.
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Introduction

The history of the IBM mainframe is a successful one. Despite attempts by other hardware and software manufacturers to erode the install base, many of the world’s major organizations still rely on IBM mainframes to execute the production systems that effectively “run” their business. Not least is the banking and insurance vertical markets, IT services provided by mainframe systems are almost ubiquitous, processing terabytes of data through applications that number many millions of lines of code, servicing a myriad of business activities.

The ability of mainframe business systems to move off the mainframe has been hampered by a number of factors. Technical factors often dominate the discussion when bringing up mainframe migration. Common questions include are the same APIs available; what are the transaction protocol; does the database support the same standards; what of language compatibilities? Various vendors have taken a piecemeal approach to this. Where, for example, ANSI has standardized the SQL language (and IBM mainframe DB2 supports it), the ability to create storage on disk, package statements within the database for fast execution, and other factors have not. Where all transaction managers report that they support “two phase commit” in the manner of IBM CICS, the newer implementations often force additional criteria upon the application program.

Rather than a piecemeal adherence to “more or less” the same standards of the existing enterprise application, is the need to support the mainframe “state of mind.” While evaluating a migration plan the new platform must meet the criteria of the existing glass house. There are the technical matters of compatibility, of course, but there are equally important factors such as:

- Performance
- Scalability
- Reliability
- Availability
- Serviceability
- Security
- Usability

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2 Three-quarters of the world’s data still resides on the mainframe. Source: Gartner.
Addressing all issues will allow for a smooth migration and operation of business applications to a new platform, while utilizing the same processes and procedures that have been in place within an IT organization. Compatibility is key and Micro Focus has established CICS compatibility through many years of providing the Mainframe Express development toolkit. That toolkit allowed mainframe developers to edit, compile and test their mainframe environment on a Microsoft Windows® PC against a simulated CICS and DB2 environment. Once verified functionally, the developer uploads the COBOL source code to the mainframe where it is compiled and put into production. Now, Enterprise Server with MTO provides a robust production-quality environment in which to run production workloads on a high-end Windows platform.

Micro Focus needed to determine the level of production throughput the high-end Windows platforms could support. The process was made up of a simple five-steps. First, an appropriate test CICS transaction was picked such that it followed all the typical characteristics of a mainframe workload: presentation logic, business logic and database or file storage. Online transaction processing (OLTP) workloads were chosen because they have been the most studied and normalized over the years. The average mainframe shop runs a mix of 70% OLTP workloads and 30% batch transaction processing. It was important to identify a CICS transaction workload that had been verified by IBM researchers as typical for CICS customers worldwide, if not optimal use of mainframe or CICS resources as in many real-world workloads.

Second, the test workload was run on multiple environments and configurations without change. Since these are not tests of any one subsystem (e.g., the transaction system or the database management system), the goal was not to overly tune the environment for any subsystem. Although tests were intentionally conducted on different platforms (IBM zSeries mainframes and high-end Intel Microsoft Windows platforms) many of the components remained the same or had similar development history. In other words, the COBOL application on each platform used CICS APIs to carry out commit processing, database processing and screen (I/O) processing in the same manner whether IBM CICS or Enterprise Server with MTO were used as the transaction manager. For simplicity, database management systems remained the same on each platform, DB2 on the mainframe and DB2 UDB for Windows. Note that other database management systems such as Microsoft SQL Server and Oracle RDBMS may be used with a migrated application. Where possible, the interlinking hardware subsystems were sourced from the same vendors to provide a level of compatibility in storage and networking. For example, EMC² disk arrays were used on the high-end Windows system in the form of a storage area network (SAN) and EMC² DASSD on the mainframe. The OLTP test chosen required a number of “dumb” terminal interfaces consisting of COBOL BMS screens on each environment. A TCP/IP network interlinking the terminal emulators and the system under test was used in each environment.
The third step involved simulating the transaction workload generated from hundreds to thousands of concurrent users. In both the mainframe and the Windows test beds, Micro Focus EnterpriseLink was used to drive the multiple COBOL BMS applications through a TN3270 protocol. EnterpriseLink is an application integration tool capable of interpreting screens sent from CICS applications and generating data to satisfy the data entry demands of the application. Measurements were also taken through the use of the EnterpriseLink tool and computed as a unit of total workload, “measured qualified throughput” in terms of transactions per minute.

The fourth step in the process was one of analysis. The performance of the test COBOL application was computed and then related to the mainframe measure of throughput, MIPS. IBM mainframe MIPS ratings are used for a number of purposes such as capacity planning, software contracts and price / performance evaluation. These are the first tests to measure Intel architecture and Windows operating system environments in terms of their ability to execute CICS transactions and relate the execution speed to mainframe MIPS.

In the final step the performance figures were related to the costs associated with migration and the benefits derived from hosting the application on a new platform. Instead of comparing list costs of the mainframe and new platform as a number of past studies have done; this paper discusses migration savings as a mechanism to stave off increased data center expansion. So, the relative price / performance ratios computed in this paper pit the cost savings of running a migrated application under Enterprise Server with MTO against not having to increase the size of a mainframe data center. Mainframe software leasing models that are based on MIPS utilization are also factored into the total cost of ownership of the migrated solution.
What is Mainframe Performance?

Initially linked to the clock speed of a processor, the mainframe MIPS (millions of instructions per second) ratings have been expanded to mean a certain workload. Machines with differing I/O subsystems, clustering interconnections and memory configurations can generate different MIPS ratings independent of the CPU speed. MIPS ratings of a particular platform may also be affected by software changes to the underlying system since improvements in database searching algorithms, for example, will improve the component score on that benchmark.

IBM provides other performance information in its Large Systems Performance Reference (LSPR). The LSPR changes over time based on how IBM believes their customers are using their systems. Beginning with the introduction of the z990 in 2003, IBM has changed the mix of the benchmarks to include an equal mix of (1) a traditional IMS transaction workload, (2) a workload that includes a traditional CICS/DB2 workload, (3) a WebSphere and DB2 workload, (4) commercial batch with long job steps, and (5) commercial batch with short job steps. Eventually, these configurations are related by third parties back to traditional MIPS ratings. IBM also uses them to generate a metric for Millions of Service Units (MSU), a rating that defines software license costs for various mainframe configurations.

IBM also succeeds to perturb the MIPS ratings of particular machines in other ways. The introduction of the zSeries Application Assist Processor (zAAP) allows a mainframe customer to in some ways use the power of an additional special-purpose processor to aid in executing certain portions of their workload. Since the zAAP (or, similarly, the IFL or ICF) do not add a general purpose CPU, the overall MIPS ratings of a box do not increase even though more work is accomplished. However, the special-purpose processors often take the place of a CPU and have costs similar to the cost of CPU. Thus, the price / performance computed for the platform may be roughly the same as in the case of a general purpose processor was used.

Transaction Processing Benchmarks

Since approximately half of the LSPR can be attributed to transaction benchmarks, it is appropriate to look at transaction processing benchmarks. The transaction processing and database community utilize a series of benchmarks by the Transaction Processing Performance Council (TPC) to measure relative throughput of a system. Since 1993, the TPC-C online transaction processing benchmark has been used to demonstrate the effectiveness of hardware platforms, database systems and transaction systems. One problem with the benchmark has been its popularity – it is now featured in Wall Street Journal advertisements when new records are reached.
TPC-C has become a highly tuned benchmarking vehicle to demonstrate a hardware or software vendor’s effectiveness of their product. And, that is the problem; the benchmark cannot really be used to show the relative strength of one platform against the other because each benchmark run is designed to meet different goals. One of the current performance leaders uses the figures to promote its UNIX database and transaction engine by offloading the business logic to 80 Windows PCs. Another TPC-C performance results show the database vendor stripping the benchmark of its business logic component, choosing to implement the whole of the transaction in procedures embedded in the database itself. The so-called clients merely “kick off” the transactions to execute within the database stored procedures. The TPC-C specification deals with these variations by forcing vendors to compute a total cost of ownership of the entire processing environment. So it means that one person’s TPC-C is a distributed processing benchmark where another’s is a database-only benchmark – the cost is roughly the same.

**Untuned TPC-C**

Not enough attention has been paid to keeping the implementation of the TPC-C benchmark static while only varying the hardware and software components. The TPC-C specification as it was written to mimic the data processing needs of a company that must manage, sell or distribute a product or service (e.g., car rental, food distribution, parts supplier, etc.). Although the TPC-C does not attempt to show how to build the application, the guidelines discuss a general-purpose set of order entry and query transactions, occasional “stock” manipulation and reporting functions, with varying inputs (including artificially injected errors) that play havoc on various systems. The TPC-C benchmark was written in such a way that as the simulated company’s business expands, new warehouses and warehouse districts increase as the workload generated by the expanding customers increases. In order to achieve an increase in transaction rate you must add data entry personnel, according to the spec.

The TPC-C specification as written lays out very simple steps to achieve the end-result of the five transaction types. Each transaction reads a half dozen or more records for various database tables, analyzes them, adds in simulated user input, and updates one or more database records. Each transaction begins from the end-user (data entry personnel) perspective from a menu screen. From there, the benchmark asks to simulate a never-ending session that chooses the 5 transaction types in random fashion with a certain weighting that will carry out a “new order” process about 43% of the time. It is these “new orders” that eventually dictate the transaction benchmark figure, measured qualified throughput (MqTh) specified in transactions per minute (tpmC).
The simple tuning database vendors often perform at this point reorders the list of actions in the specification that define a transaction. It might be to reduce lock contention or the time database records are held with exclusive locks. After this, the hardware or software vendors tune the system to make a point of stressing their component over others that are more or less involved in the benchmark, as a means of meeting the benchmarking criteria.

Micro Focus chose the TPC-C benchmark as a measure of workload but left it essentially untuned from the original specification. The TPC-C spec indicated (although did not mandate) that the application code, transaction control and data control reside on a single system and that network-attached users communicated with the application through a screen interface over a networking protocol. Micro Focus maintained this relationship among components because it duplicates application environments that have been used on the mainframe for years and are now subject to migration from the mainframe. We developed a COBOL implementation of the TPC-C business logic complete with embedded SQL statements that are handled by SQL preprocessors. In an IBM mainframe environment, the screen interface is handled through the use of BMS maps that layout the 24-line, 80-column, 3270 terminal screen used for data entry and report generation. In the Micro Focus implementation, it is the responsibility of the CICS environment to handle all commit coordination with the database management system (DB2) and report errors back to the application program when data entry errors cause transactions to fail (about 1% of the time as indicated in the TPC-C spec).

Certain optimizations that are typical in IBM environments were employed in the Micro Focus implementation of the TPC-C. For example, SQL statements removed from the COBOL source by a precompiler are entered into a DB2 package for faster execution. Standard primary and foreign keys were defined. IBM utilities to assist in calculating the access paths of data tables during transaction execution were used frequently. But, other optimizations that other vendors employ with the TPC-C were not used. The benchmark was not turned into a distributed transaction. Micro Focus Net Express® and Server Express™ assist in this process and the ultimate result may be faster execution of a COBOL TPC-C. But, since a direct comparison of a typical mainframe execution environment and a ‘Lift and Shift’ migrated environment was to be made, these techniques were not employed. This results in an apples-to-apples comparison of the benchmarking results.
IBM’s Interpretation of TPC-C

It is not just our opinion that a literal reading of the TPC-C specification describes typical CICS workloads. IBM said as much in an article in the IBM Systems Journal from April, 2001:

Our analysis indicates that in some cases, the TPC benchmarks fall reasonably within the range of real world behavior, and in other cases, they are not representative of real workloads. Some of our findings are that TPC-C tends to have longer transactions and fewer read-only transactions than the production workloads.

IBM also found that the TPC-C benchmarks demand a balanced I/O subsystem in addition to the CPU computational component. Specifically, the TPC-C follows Amdahl’s law of requiring about 1 Mb/s of I/O for every 1 MIPS that is typical of CICS workloads. Further, transaction size is approximately the same as that of production workloads.

The IBM researchers found that the TPC-C differs from production CICS workloads in their “burstiness” of I/O activity. In production, there are often cases of large amounts of I/O (batch) jobs intermingled with online transaction processing workloads. The ability of mainframe systems (e.g., job schedulers) to take advantage of system idle time to balance a workload over a period of time is key to overall system throughput.

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Relative Performance

Benchmarking Environment

The benchmarking test environment involved running the exact same COBOL implementation of the TPC-C transactions on each system. The components that stayed the same and changed for each test are shown below:

**Stayed the same**
- CICS COBOL Environment
- CICS Transaction APIs
- SQL Data Manipulation Statements
- Database Schema
- TN3270 Terminal Environment

**Changed each test**
- zSeries v. Intel
- z/OS v. Microsoft Windows 2003
- DB2 7.1 v. UDB 8.1 for Windows

The system-under-test in all tests was driven with the same testing software, Micro Focus EnterpriseLink. A series of EnterpriseLink integration Server machines handled the data generation for each of the transactions, transaction pacing (simulated user think time and user data entry time) as well as multiple-concurrent-user simulation. The testing environment is shown below:

The Windows system-under-test was based upon a Unisys ES7000, consisting of a logical partition of 8 Intel Xeon CPUs total, under control of Windows 2003 Standard Server. Note only 32-bit processors were tested; no EM64T (AMD64) tests were run. DB2 was on the same system, but data storage was handled by an EMC storage area network.

Multiple tests were performed under mainframe environments consisting of z800 model 2066 001 and Multiprise 7060 model H70 systems. Again, only 31-bit processors were tested, no zSeries 64-bit engines were employed.
The TPC-C benchmark requires that all online transactions complete within a five-second-response time. Where possible, each machine under test was driven to approximately 95%-100% CPU utilization while maintaining the five-second response time requirement. The benchmark contains five different transaction types, only one (New Order) is measured in transactions per minute. We won’t report the results of the TPC-C measured qualified throughput (see next section), but the relative TPC-C measures were compared across platforms for the number reported in the next sections.

**Benchmarking Results and Analysis**

Note that the TPC benchmark rules prohibit publicly disclosing TPC performance figures that have not been independently audited. Therefore, we withhold from this paper any data that may be used to derive our TPC metrics. This omission of TPC performance numbers should not compromise the understanding of the relative performance of two (or more) systems performing the same workload, which in this case happens to be one based on TPC-C.

TPC-C performance numbers were generated on each of the environments and compared against one another. Thus, the absolute TPC-C benchmarking numbers are immaterial, as we will not compare these numbers against the optimally tuned Windows, or DB2 for Windows, or even zSeries mainframe results. As was stated previously, the absolute numbers could doubtlessly be improved by altering the application architecture through excessive database tuning exercises. Based on the published MIPS ratings\(^4\) of one of the mainframe platforms in the tests, we can nonetheless compute the equivalent MIPS ratings for the remainder of the tests. The table is shown below:

<table>
<thead>
<tr>
<th>Machine Type</th>
<th>MIPS Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>7060 H70</td>
<td>200 (audited)</td>
</tr>
<tr>
<td>Z800 001</td>
<td>192 (audited)</td>
</tr>
<tr>
<td>Unisys ES7000, 8-CPU, 8GB</td>
<td>1347 (measured)</td>
</tr>
</tbody>
</table>

This table indicates that an eight processor configuration of the Unisys ES7000 (up to a 32-CPU box) is measured at 1347 mainframe MIPS and can handle the workload up to that level. So, the implication is that an existing mainframe online transaction processing workload under CICS up to 1347 MIPS it could run on Micro Focus Enterprise Server with MTO environment in this hardware configuration.

However, we cannot compute price / performance by simply taking the list price of these two systems. The assumption here is that workloads are being incrementally migrated from the mainframe to the Enterprise Server with MTO environment. You cannot “give back” a 100 MIPS chunk of an existing mainframe, although some hardware leasing models charge based on MIPS utilization. New Workload Licensing Charge (WLC) fees also apply to systems such as IMS and CICS. But, we will compute the cost of a 1347 MIPS hardware upgrade based on that amount on a typical 5000 MIPS mainframe system.

IBM hardware and software prices change considerably at this level and the ability to delay or eliminate the need for upgrades is one tremendous benefit with real dollars associated with mainframe migration. The cost for new installations of MIPS is approximately $2000 per MIPS but the incremental cost of processing hardware (where upgrade is within the same family of processors) is closer to $1000 per MIPS. An increase of 1347 in the 4000 MIPS area changes the MSU pricing structure at a like rate; about 180 MSUs are computed by IBM to be usable. That means that a like increase in DB2, CICS and zOS monthly charges on the order of 180 MSUs can be staved off with a mainframe migration to Enterprise Server with MTO. That translates roughly to a savings of $63,000 per month WCL for zOS and $56,000 per month WLC for savings in the 1000 to 2000 MIPS range.

<table>
<thead>
<tr>
<th>1000 MIPS equivalent component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>zSeries hardware upgrade</td>
<td>$1,000,000 (estimated)</td>
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<tr>
<td>zOS software cost</td>
<td>$63,000/mo. (estimated)</td>
</tr>
<tr>
<td>DB2 Software 180 MSUs</td>
<td>$56,000/mo (estimated)</td>
</tr>
<tr>
<td>Unisys ES7000, 8-CPU, 8GB</td>
<td>$156,000 (estimated)</td>
</tr>
<tr>
<td>Micro Focus Enterprise Server</td>
<td>$135,000 (estimated)</td>
</tr>
<tr>
<td>Micro Focus maintenance</td>
<td>$2500/mo. (estimated)</td>
</tr>
<tr>
<td>DB2 v 8.1 for Windows</td>
<td>$60,000 (estimated)</td>
</tr>
</tbody>
</table>

Where “/mo.” is shown in the table it indicates a software lease or maintenance fee per month is charged. The above table shows that for many sub-1000 MIPS workloads the new hardware and software costs of a mainframe migration can be recouped in a few months of operation.
Summary

This paper has discussed mainframe application workloads in general and the benchmarks that measure them. It has shown the relative performance of migrated platforms against the mainframe running the same workloads. Put another way, the costs associated with mainframe migration can be justified in a few months of reduced mainframe software expenses and/or delayed mainframe hardware upgrade charges.

Finally, the paper has concluded that improved price / performance is obtained by migrating applications to Micro Focus Enterprise Server with MTO even when including only those costs of delaying or eliminating the incremental increase of mainframe resources.

Author: Mark Haynie, VP Enterprise Extension Micro Focus, September 2004.
Glossary

**Legacy Systems**
Also referred to as Legacy Code, Business Systems, or just Legacy. This is a lazy industry term to describe older IT applications important to an organization; the common inference is that these systems are written in COBOL and execute on the IBM mainframe. This paper accepts this inference, and will regard it as a synonym of “Mainframe COBOL Applications”, which is a more accurate and helpful description.

**MIPS**
Million of instructions per second. Reference to common usage of mainframe performance now calculated through five transaction processing and batch workload benchmarks.

**TPC**

**TPC-C**
The name of one such transaction benchmark from TPC. It simulates an on-line order entry and query environment. It can be scaled to thousands of concurrent users.
Micro Focus

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