IBM Technical Brief

IBM z Systems®:
Performance Report on
Exploiting SMT for SAP Application Servers on z13®

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Feedback

Please send comments or suggestions for changes to vengly@us.ibm.com

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1.0 Introduction

With the recent availability of the z13 machine, the new processor chip offers intelligently implemented 2-way simultaneous multithreading. Simultaneous multithreading (SMT) allows two active instruction streams per core, each dynamically sharing the core’s execution resources. The SMT feature is available in IBM z13 for workloads running on the Integrated Facility for Linux (IFL) and the z Integrated Information Processor (zIIP).

SAP on z Systems is an excellent candidate in employing zIIP processors for the SAP database server, and IFL processors for SAP application servers. Therefore, it can exploit SMT and potentially see performance gains from using it.

There are several options for running SAP application servers with a z System SAP database server. One of the more intriguing options is running the SAP application server on a z System with Linux. This option is of particular interest because it exploits both the hardware and virtualization capabilities intrinsic to z Systems. In which case, customers have the options to run these application server functions on native Linux LPARs or as Linux guests on z/VM for further virtualization and management capabilities.

z/VM provides significant virtualization support for Linux virtual servers, including exploitation of the z Systems’ capabilities, non-disruptive dynamic addition of memory and processors, improved systems management, ease of use enhancements, performance improvements for Linux guests, and enhanced networking for guests. See reference [7] on page 17.

The IBM SAP on z Systems Performance Team, located in Poughkeepsie, NY, conducted a number of experiments to evaluate the performance effects of enabling SMT on IFLs for SAP application servers, running on Linux as z/VM guests. At the time of our study, the SMT feature was not available for Linux running as native LPARs.

We used the SAP Banking Services (SBS) Day Posting workload, which is a good representation of a customer online transaction processing (OLTP) workload. On the application server side, this workload is CPU intensive with minimal file I/O activity. See section 3.0 Workload Description for details of this workload.

We started with baseline measurements on a zEC12 system. Then we ran on a new z13 system for core to core comparison and SMT benefit evaluation.

This paper documents our tests and findings. The measurements that were done were stress tests, not certified benchmarks.
2.0 Executive Summary

The z13 machine offers a vast array of functional and performance features which are well suited for the SAP business solutions on z Systems. Simultaneous Multi-.Threading (SMT) is one of the key performance features on the z13 machine. This hardware feature is available on both IFL and zIIP specialty engines.

Our measurements showed up to a 40% ITR improvement with SMT enabled for 16 IFL engines configured in a z/VM LPAR running SAP application servers as Linux guests as compared to zEC12.

Note that in this document, the terms Internal Throughput Rate (ITR) and External Throughput Rate (ETR) are used. ETR is the transaction rate. ITR is the ETR normalized to 100% CP utilization and it gives a relative CPU time per transaction.

We ran the SAP Banking Services (SBS) Day Posting workload, which represents typical OLTP processing in an SAP banking customer environment. Both the SAP application server and the SAP database server were running in one z System CEC. The SAP application servers were configured as three Linux guests under a single z/VM LPAR with 16 IFLs. The SAP database server was in a separate z/OS LPAR with 2 general purpose CPs and 2 zIIPs. The focus of this study was the SAP application servers. Three measurements at approximately 90% CPU utilization were completed, which included the zEC12 baseline, z13 without SMT enabled, and finally z13 with SMT enabled.

For a typical SAP customer workload, the processing capacity needed for the application servers is generally several multiples of that needed by the database servers. The larger SAP customer installations can exceed hundreds of processor cores for their SAP application servers. For multi-threaded OLTP workloads such as SAP Day Posting, the more and faster cores combined with the SMT boost in the z13 machine can readily accommodate the customer’s growing demand for capacity required for SAP solutions on z Systems. In addition, the cost of consolidating work on Linux under z/VM with the z13 requires less floor space, power or cooling, translating into energy and facilities cost saving.
3.0 Workload Description

The SAP Banking Services Day Posting workload was used in these tests. It is an online transaction processing (OLTP) workload. We have been running this workload for many years. We have quite a bit of experience with it. See reference [4] on page 17.

In this workload, a posting is a deposit or a withdrawal from a customer’s account. Typical examples of a posting are a payment out of the account or a deposit into the account. This workload was developed by SAP to simulate customer environments. The workload consists of interactive “users” going through repetitive cycles of 15 dialogue steps.

<table>
<thead>
<tr>
<th>Step</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Create a total of 150 postings via five BAPI calls</td>
</tr>
<tr>
<td>2</td>
<td>Create five postings</td>
</tr>
<tr>
<td>3</td>
<td>Create bank statement</td>
</tr>
<tr>
<td>4</td>
<td>Read postings for account</td>
</tr>
<tr>
<td>5</td>
<td>Read details of postings</td>
</tr>
<tr>
<td>6</td>
<td>Create five postings</td>
</tr>
<tr>
<td>7</td>
<td>Create one bank statement for account</td>
</tr>
<tr>
<td>8</td>
<td>Create five postings</td>
</tr>
<tr>
<td>9</td>
<td>Create one bank statement for account</td>
</tr>
<tr>
<td>10</td>
<td>Create five payment orders</td>
</tr>
<tr>
<td>11</td>
<td>Read balances of account</td>
</tr>
<tr>
<td>12</td>
<td>Create five postings</td>
</tr>
<tr>
<td>13</td>
<td>Create one bank statement for account</td>
</tr>
<tr>
<td>14</td>
<td>Read balances for account</td>
</tr>
<tr>
<td>15</td>
<td>Read master data for account</td>
</tr>
</tbody>
</table>

Table 1: SAP Banking Day Posting Workload
4.0 Test Environment

The following figure provides an overview of our test environment with z13.

![z13 Test Environment Diagram]

**IBM System Storage**
- 4 Single Frame DS8870s w/ 8 GB FICON for database
- Single Frame DS8700 w/ 8 GB FICON for DB2 logs

**z System SAP Application Server**
IBM z13 2964-NE1
- 16 IFLs with and without SMT
- Single z/VM LPAR with 256 GB memory
- z/VM 6.3 with APAR VM65586
- 3 Linux SLES 11 SP3 guests

**z System SAP Database Server**
IBM z13 2964-NE1
- 2 CPs, 2 zIIPs
- Single z/OS LPAR with 512 GB memory
- z/OS 2.1
- DB2 11 for z/OS

**Presentation Server**
- IBM 9133-55A
- 4 2.1 GHz processors and 32 GB memory

**Figure 1: z13 Test Environment**
The following is the baseline test environment with system zEC12. Note that it is the same test environment as the z13 test environment, except for the z System CEC.

**zEC12 Test Environment**

**IBM System Storage**
- 4 Single Frame DS8870s w/ 8 GB FICON for database
- Single Frame DS8700 w/ 8 GB FICON for DB2 logs

**IBM System SAP Application Server**
*IBM zEC12 2827-HA1*
- 16 IFLs with and without SMT
- Single z/VM LPAR with 256 GB memory
- z/VM 6.3 with APAR VM65566
- 3 Linux SLES 11 SP3 guests

**z System SAP Database Server**
*IBM zEC12 2827-HA1*
- 2 CPUs, 2 zILPs
- Single z/OS LPAR with 512 GB memory
- z/OS 2.1
- DB2 11 for z/OS

**Presentation Server**
- IBM 9133-56A
- 4 2.1 GHz processors and 32 GB memory

**Figure 2: zEC12 Test Environment**
The test environment was a physical 2-tier configuration which used only one z System CEC. Both the SAP application servers and the database server resided in the same physical CEC. The following figure shows our logical test configuration on z System.

![Figure 3: z System LPAR Configuration](image)

The SAP application servers resided on a z System LPAR, running as the three Linux guests under a single z/VM LPAR with 16 IFLs, as illustrated in Figure 3. The first Linux guest was configured as an SAP Message and Enqueue Server, with 4 logical CPs and 8 GB memory. It had one SAP instance. The second Linux guest was configured as a SAP Central and Dialog Instance server, with 16 logical CPs and 24 GB memory. It had 6 SAP instances. The third Linux guest was configured as a SAP dialog instance server, with 16 logical CPs and 24 GB memory. It had 6 SAP dialog instances.

The database server resided on another z System LPAR, on the same CEC as the LPAR where the SAP application servers resided. It was configured with 2 CPs and 2 zIIPs. Note that zIIP engines can also exploit SMT like IFL engines can. However, for our study, we did not exploit SMT on the zIIPs. We focused on exploiting SMT on IFL engines.
4.1 Hardware

z System SAP Database Server/ SAP Application Servers

An IBM z Systems 2964-NE1 (z13) or 2871-HA1(zEC12) was used depending on the test scenario. The SAP database server was in an LPAR with 2 dedicated CPs, 2 dedicated zIIPs, and 512 GB of memory. The SAP application servers were running as three Linux SLES 11 SP3 guests on a z/VM LPAR. The z/VM LPAR was configured with 16 dedicated IFLs and 256 GB memory.

Database DASD

A SBS 7.0 database with 60M accounts was used for these tests. It resided on four single frame IBM System Storage DS8870s (2423-961) server, each with 16 ranks of 240 15K-RPM 300 GB Hard Disk Drives (HDDs) configured as RAID 5. Each frame has total of 72 TB. The unit has 256 GB regular cache, 8 GB non-volatile storage (NVS), and 16 long wave FICON Express8S attachments. The DB2 subsystem, the database, and two flash copies were contained on 834 emulated 3390-mod54 volumes.

The DB2 active logs resided on a separate DASD unit from the database. The active logs were striped across four 3390-mod54 volumes on separate ranks of a single frame IBM System Storage DS8700 (2107-941) server.

Presentation Server

One IBM 9133-55A server with four 2.1 GHz processor cores and 32 GB of memory running AIX was used as the presentation server to drive the workload.

Network

A dedicated 10 Gb Ethernet network was used to connect the presentation server to the application servers, and the database server to the application servers. Four shared OSA-Express4S adapters were used to connect the SAP DB server and the SAP application servers. The Optimized Latency Mode (OLM) option of the OSA-Express4S adapters was used to improve the elapsed time of this communication. HiperSockets is recommended for network intensive batch workloads. We did not use them since our workload was an interactive (OLTP) type.
4.2 Software

z/OS
z/OS release 2.1

DB2 for z/OS
DB2 11

DB2 Connect
IBM Data Server Driver for CLI that is shipped as part of DB2 Connect 10.1 FP2

z/VM
z/VM 6.3 with APAR VM65586

Linux
SLES 11 SP3

SAP
SAP NetWeaver 7.1 Enhancement Package 1
SAP kernel level 720 EXT, 64-bit, patch number 400
5.0 Measurement Results and Analysis

We executed three measurements: zEC12 baseline, z13 without SMT enabled, and z13 with SMT enabled. Our methodology was to hold the processor utilization consistent at approximately 90% across the measurements. This is to stress the system, and to see the effects of the z13 and SMT on throughput. The processor utilization which is listed as “Average %CPU on application servers” in the following table is the percent utilization of the z/VM LPAR where all our Linux guests were running application servers. Specifically, it was from the PERFKIT Reports, see reference [9] on page 17.

The details of these measurements are summarized in the following table.

<table>
<thead>
<tr>
<th>Run id</th>
<th>S41030B1</th>
<th>S41107B2</th>
<th>S41114B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>z System</td>
<td>zEC12</td>
<td>z13</td>
<td>z13</td>
</tr>
<tr>
<td>SMT enabled</td>
<td>n/a</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Number of z/OS LPARs</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of processors per z/OS LPAR</td>
<td>2 CPs + 2 zIIPs</td>
<td>2 CPs + 2 zIIPs</td>
<td>2 CPs + 2 zIIPs</td>
</tr>
<tr>
<td>Real Storage Configured per z/OS LPAR</td>
<td>512 GB</td>
<td>512 GB</td>
<td>512 GB</td>
</tr>
<tr>
<td>z/OS Level</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Number of z/VM LPARs</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of processors per z/VM LPAR</td>
<td>16 IFL</td>
<td>16 IFL</td>
<td>16 IFL</td>
</tr>
<tr>
<td>Real Storage Configured per z/VM LPAR</td>
<td>256 GB</td>
<td>256 GB</td>
<td>256 GB</td>
</tr>
<tr>
<td>z/VM Level</td>
<td>6.3 APAR VM65586</td>
<td>6.3 APAR VM65586</td>
<td>6.3 APAR VM65586</td>
</tr>
<tr>
<td>Number of Users</td>
<td>1968</td>
<td>2240</td>
<td>2856</td>
</tr>
<tr>
<td>Average %CPU on application servers</td>
<td>92.30%</td>
<td>91.00%</td>
<td>90.50%</td>
</tr>
<tr>
<td>ETR (DS/sec)</td>
<td>175.34</td>
<td>188.29</td>
<td>241.69</td>
</tr>
<tr>
<td>ITR (DS/sec) on application server</td>
<td>189.97</td>
<td>206.91</td>
<td>267.06</td>
</tr>
</tbody>
</table>

Table 2: Detailed Measurement Results
Figure 4 below shows the external throughput rate (ETR), illustrating the processing capacity improvement with z13 and SMT. Our results showed that SAP application servers running as Linux guests under z/VM on z13 with SMT can process a 38% higher ETR when compared with a zEC12 machine configured with the same number of 16 IFLs. For core to core comparison, at the same processor utilization, without SMT enabled, the z13 can process a 7% higher ETR as compared to zEC12.

Figure 4: Processing Capacity Improvement with z13 and SMT
Figure 5 shows z13 and SMT effects on ITR. Again, ITR is the ETR normalized to 100% CP utilization and it gives a relative CPU time per transaction. Our results showed that SAP application servers running as Linux guests under z/VM on z13 with SMT can gain up to 40% in transactions per CPU second when compared with zEC12 machine configured with the same number of 16 IFLs. For core to core comparison, z13 showed a 9% ITR gain as compared to zEC12.

Figure 5: z13 and SMT Effects on ITR
6.0 Conclusions

SMT is one of the many key features in the IBM z13. It can provide up to a 40% ITR improvement per core as compared to zEC12, when SAP application servers are running as Linux guests under z/VM on the IBM z13.

The performance benefits of SMT may vary depending on the characteristics of the workload. Very highly computation intensive batch workloads which require total core resource for each thread may not see significant performance benefits with SMT. The capacity and throughput gain per core depends on the overlap and interference between two threads. An overlap can result from many core resources being replicated so that each thread can make progress, or while one thread waits for cache miss, other thread can continue to run. Interference can be from some serialization points within the core. It can be threads sharing the same caches, thus cache misses can increase, or cause contention. See reference [8] on page 17.

The IBM z13 has more capacity per core without requiring appreciably more space, power or cooling than the previous generation processor with single-threaded cores. It is designed to offer the capacity and processing power to improve business performance and growth demanded by explosive amounts of analytics data and rapid proliferation of mobile applications and transactions, estimated to grow to 40 trillion transactions per day by 2025. See reference [6] on page 17.
7.0 References

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