

# **SAP on IBM Z Performance**

## **Linux Application Server Comparison on z15**

**RHEL**  **redhat** versus **SLES**  **suse**

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## Feedback

Please send comments or suggestions for changes to Paul DeLessio at [delessio@us.ibm.com](mailto:delessio@us.ibm.com).

## 1.0 Introduction

IBM Z customers running SAP applications have options for their workload environments including the Linux distribution on their application servers. There are two major Linux Enterprise Server distributions supported for use with SAP on IBM Z, one is developed by SUSE based in Europe, the other is Red Hat Enterprise Linux (RHEL), an IBM U.S. based subsidiary. In part due to their origins SUSE Linux Enterprise Server (SLES) is widely used in Europe, and RHEL is popular in North America and Asia.

The purpose of this paper is to show that no matter the customer preference or geographic location, both RHEL and SLES are good options for SAP application servers running on IBM Z co-located environments. This was demonstrated using both SAP Banking Account Settlements which is a batch processing workload, and SAP banking Day Posting which is an online transaction processing (OLTP) or interactive workload.

The SAP on IBM Z Performance Team, located in Poughkeepsie, NY, specifically conducted this comparison effort to assess the performance of the (2) major Enterprise Linux Server distributions and resolve differences if necessary. This study was driven by SAP Banking workloads executing in a large application server processor configuration, co-located on an IBM z15. With 100 million SAP Banking accounts in a Db2 on Z database, the size of the environment was comparable to some of the largest banks in the world.

Measurements conducted in this effort were stress test in nature and not certified benchmarks. Results of the batch and interactive measurements used here should not be generally assumed for all possible workloads and environments without verification.

## 2.0 Overview of Linux Distribution Comparisons

The purpose of this effort was to compare how RHEL stacks up to SLES Linux Enterprise performance in an SAP on IBM Z co-located environment. If a Linux distribution showed performance discrepancies it would be important to resolve as both distributions combined represent the entirety of SAP on IBM Z Linux Enterprise application server (appserver) use. This comparison was made by using a comprehensive approach with batch and interactive processing, represented by SAP SBS 9.0 Banking Account Settlement and Day Posting workloads. SAP core banking workloads are typically dominated by application server usage making them key to overall performance. The latest available Linux Enterprise releases available for use with this IBM z15 effort were RHEL 8.2 and SLES15 SP2 so that's what was used in this study.

## 3.0 SAP Test Workloads

IBM Z has several financial and banking customers running SAP Banking Services, making workloads that use these core banking services appropriate for comparison tests. There is an Account Settlement (batch) workload and an interactive Day Posting (OLTP) workload. Measurements covered in this document are for both workload types.

### 3.1 SAP Account Settlement

The SAP Account Settlement workload, for this study, performed settlement activity on all accounts in a database, which for this effort was 100 million accounts. Periodic balancing is done against each account to calculate charges (fees) and interest as well as post these updates.

Normally account settlement is a series of batch jobs executed daily for a subset of accounts in the system, depending on a customer's service date and account type, but for this effort all accounts are processed in a worst-case scenario, all on the date of measurement, instead of a daily subset. Typically, account settlement batch processing has a critical period of time it must complete in, for instance off-peak, at night, when less activity of the business day is occurring. This type of workload tends to process each account once and in a sequential data access pattern that is insert/update intensive.

The workload used for this effort is part of the SBS application suite. There is an average of 20 items per account posted in a calendar month, which on average is 20 business days.

## 3.2 SAP Day Posting

The interactive workload used for this effort was the SAP Day Posting (DP) workload which simulates the daytime business transactions, called postings, of a retail bank. A typical example of a posting is a payment out of the account or a deposit into the account. The DP workload is an online transaction processing (OLTP) or interactive workload. It invokes simple to moderate SQLs and has a random data access pattern.

This workload is part of the SAP Banking Services (SBS 9.0) application suite and consists of interactive “users” going through repetitive cycles of 15 dialogue steps.

## 4.0 Test Environments

SAP landscapes commonly have three tiers: the presentation server, application server, and database server. The presentation server is a remote client machine that is used to trigger and control workload measurements but isn't itself measured. Then there are the application server and database server tiers which the workload runs on and are measured. The application server tier has one or more application servers carrying out the execution of applications such as SAP Banking Account Settlement or Day Posting, while the database server stores all data that these applications work with.

Most aspects of the test environment were the same, from SAP settings, to Db2 tuning to physical and logical attributes of the setup, differentiated by Linux distribution on the application servers. This Linux distribution variable was either to use Linux RHEL or SLES on application servers. Aside from the Linux distribution difference, Account Settlement measurements had additional SAP instances and SMT enabled measurements had SMT enabled. Tuning of the environment was minimal and equal for RHEL and SLES measurements.

## 4.1 Hardware Environment

The application server on IBM Z test environment was configured with an SAP database server and (4) application servers co-located on a single IBM z15 machine. Attached to the z15 was an IBM storage DS8886 which housed a Db2 on Z database server containing a 100 million account SAP 9.0 (SBS 9.0) banking services system.

Application Server measurements used (4) Linux images with 16 IFL processors and 64 GB of memory for each image. It was not the goal of this study to compare various Linux image sizes which can differ based on customer's needs. 16 IFL Linux Application servers were chosen because that was a well performing size for this effort which also made for easy comparison. SAP Application Server measurement scenarios were done with Simultaneous Multithreading (SMT) disabled, unless otherwise noted. Figure 1, is a logical representation of the measured part of the test environment and Figure 2 is a representation of all hardware needed to run measurements.

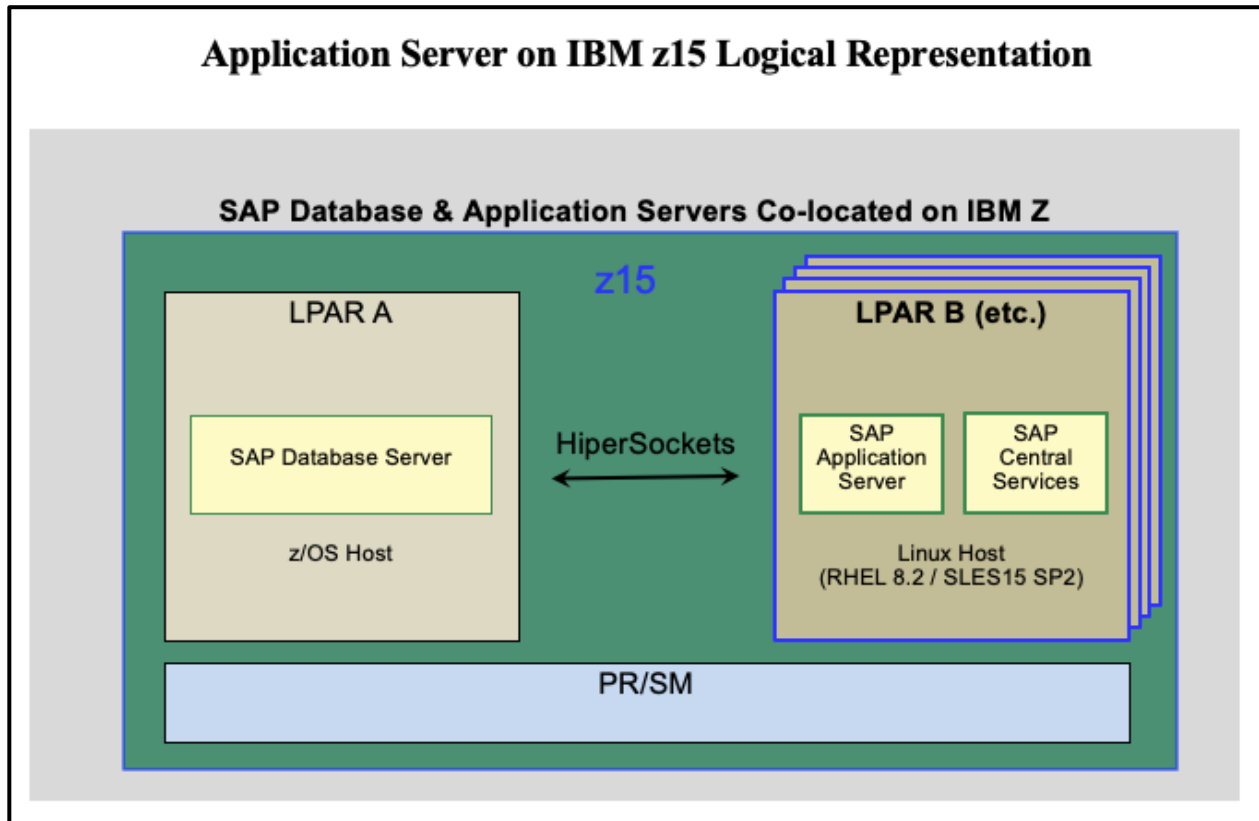
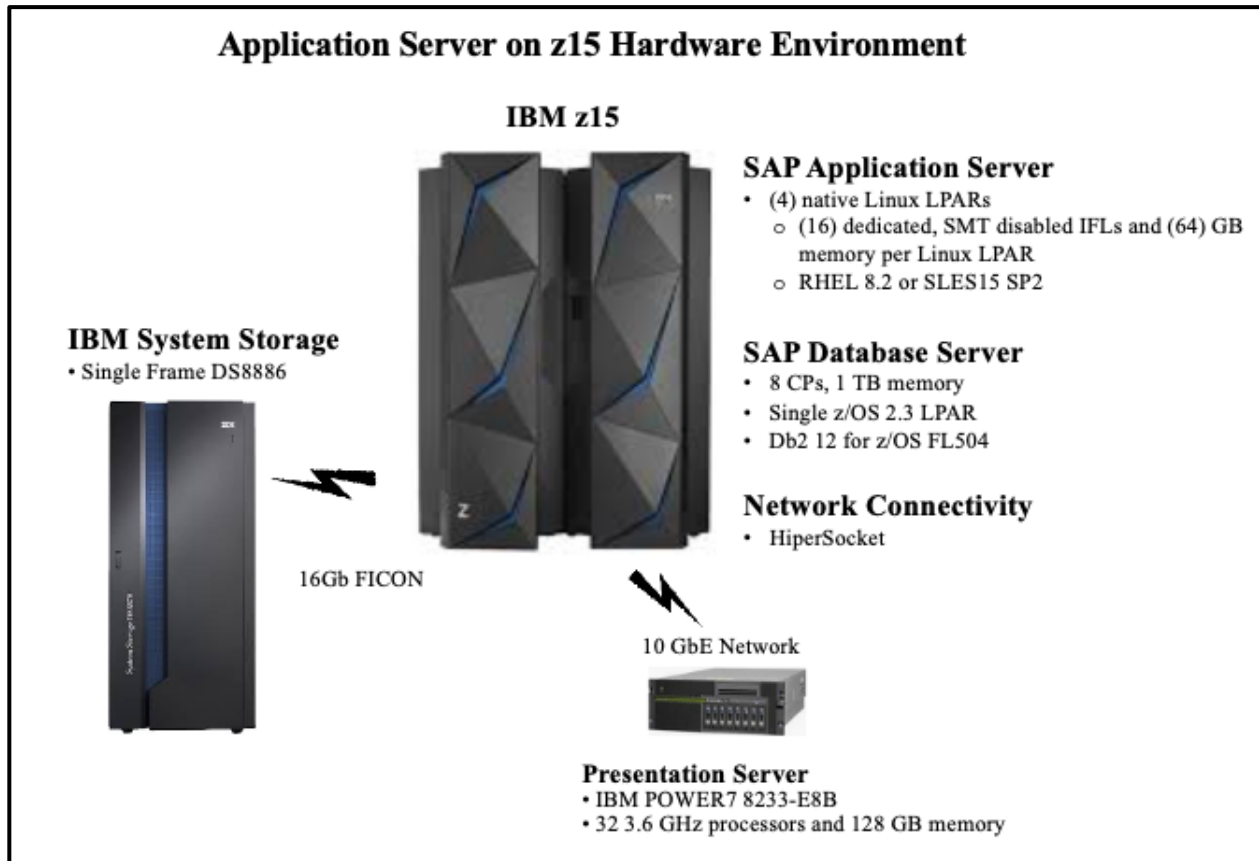


Figure 1: Application Server on IBM z15 Logical Representation





**Figure 2:** Application Server on IBM z15 Hardware Environment

### SAP Database Server

The SAP database server operated within an LPAR on an IBM z15. The LPAR was configured with 8 dedicated CPs and 1TB of memory.

### Database Storage

Database storage used for all measurements was an IBM System Storage DS8886 that held a 16TB Db2 on Z database containing an SAP SBS 9.0 installation with 100 million accounts. The number of accounts in this database were comparable to the number of accounts held by some of the largest banks in the world. The database was spread across (310) 3390-mod54 volumes and used a combination of Solid-State Drives (SSD) and 15K rpm drives. Db2 tables and indexes with heavier read/write activity were placed on the SSD drives to reduce any potential database constraints.

### SAP Application Servers

RHEL 8.2 or SLES15 SP2 application servers were used to drive measured elapsed time and throughput on IBM z15 and were the focal point of Linux distribution comparisons. A total of (4) Linux application servers, each with (16) dedicated IFLs, 64GB of memory and in separate LPARs, were used for all measurement points. This combination of application servers worked well for comparisons and was felt to be representative of a typical IBM Z customer choice.

IBM Z performance testing is typically done with SMT disabled IFLs on Linux application servers, so comparisons here were done with SMT disabled except where noted. No special tuning of Linux was done other than setting up Receive Packet Steering, mentioned under the network description.

### **SAP Presentation Server**

The SAP presentation server was on an IBM POWER7 machine type - model 8233-E8B with (32) 3.6GHz processors and 128GB of memory. The SAP Presentation Server is a workload driver and not measured.

### **Network**

HiperSocket connectivity was used between the SAP database and application server images. One tuning option that was set for all measurements was Receive Packet Steering (RPS) which helps improve network performance by distributing network traffic across multiple CPU cores in each application server. RPS tuning was not a focal point of test measurements and should have similar benefit to both Linux distributions.

## **4.2 Software Environment**

### **z/OS**

z/OS release 2.3

### **Db2 for z/OS**

Db2 12 FL504

### **Db2 Connect**

IBM Data Server Driver for CLI version 11.01.0404 build level special\_38143

### **LINUX (Enterprise Editions)**

SLES15 SP2 or RHEL 8.2

### **SAP**

SAP NetWeaver 7.5 SP6

SAP Banking Services 9.0 SP4

SAP Kernel 7.49 level 823

## 5.0 Test Methodology

For this effort there were (2) distinct goals when comparing Linux distributions. The Account Settlement or batch workload measurements used elapsed time for comparison while Day Posting or interactive workload measurements used throughput for comparisons. There was however some overlap in methodology. The overlap was that the batch and interactive measurements used the same physical landscape for comparisons. The overlap was intentional as it was felt customers would not change their physical environments between workloads. The only variable in comparisons was the Linux distribution on the application servers, RHEL 8.2 or SLES15 SP2.

All measurements were done using (4) Linux application servers configured with 16 IFL processors each to better drive the workloads for comparison. The application server CPU utilizations in this document are the averages of the (4) Linux images used.

### 5.1 SAP Account Settlement

The batch workload comparison methodology was to drive the SAP Banking Account Settlement workload to significantly high CPU utilization for a meaningful comparison. For this workload it meant account settlement activity for 100 million accounts, a number comparable to some of the largest banks in the world, while driving the Db2 on IBM Z database server CPU utilization above 50% busy and the Linux application server average above 70%. This was accomplished by adjusting the number of parallel batch workload processes and starting additional SAP instances.

From a performance standpoint, batch processing workloads are successful if they complete within a critical period of time, such as a business's designated batch processing window. An acceptable batch processing window is defined by unique customer needs and for this effort no assumption was made for how long this was. With the CPU utilization targets met, the "elapsed time" of completing all account settlement batch processing was the key comparison metric for SAP Account Settlement measurements of RHEL versus SLES Linux on Z application servers.

### 5.2 SAP Day Posting

The interactive workload objective was quite different from the batch workload objective, the "throughput" or ITR of application servers running SAP Banking Day Posting was the key metric for a fair comparison. Just like the batch comparison scenarios, measurements were differentiated only by Linux distribution on the IBM z15 LPARs. Throughput comparisons were done using IBM Z Large Scale Performance Reference or LSPR methodology, which is used for OLTP workloads. Basically, the goal of the methodology is to compare images under stress or running with a CPU utilization of 80% or higher. For this effort it meant running the Linux on Z application servers to 80% or higher. This was accomplished by using 10800 SAP workload users, executing tens of millions of Day Posting transactions against the same SAP Banking 100 million account, Db2 on IBM Z database server, that was used for the Account Settlement effort.

In the SAP Banking Day Posting effort, response time is not key to the Linux distribution comparison, the objective was simply to keep response times below 1 second, and measurements were all well below this. There are many reasons not to consider response time key to comparisons, some are that it's very much a function of networks, it's affected by DB tuning etc. and it's also related to whether the SAP functions are run as dialog or batch.

For the SMT enabled, SAP Banking Day Posting comparison measurements, there were no set expectations for CPU utilization, ITR or any other number. The same exact Day Posting workload of 10800 SAP users was repeated for both RHEL and SLES simply with only the SMT Enabled setting change. The only expectation was that results would be virtually the same.

## 6.0 Key Performance Indicators (KPIs)

To gauge the system resource requirements and to provide performance insights and comparisons, the following Key Performance Indicators (KPIs) were captured.

### 6.1 SAP Account Settlement

For batch workloads like SAP Account Settlement the primary KPI is the **elapsed time** of the workload. The application server **ITR** is also important to compare because it accounts for the size of the workload along with the application server CPU utilization in its calculation. It demonstrates a fair comparison of RHEL to SAP's long-established recommendation of SLES Linux for application servers. Key metrics for the SAP Account Settlement workload measurements are described as follows:

**CPU Utilization** - This refers to the CPU utilization on the application server. Processors can deliver performance differences at different utilization levels, so it was important to keep CPU utilization in close range for comparisons. For Account Settlement measurements CPU utilizations were targeted to 70%.

**External Throughput Rate (ETR)** - This is the observable throughput rate in a unit of time, for Account Settlement measurements ETR means the number of accounts processed per hour.

**Internal Throughput Rate (ITR)** - ETR can vary along with CPU utilization between measurements so the application server ITR is calculated to normalize comparisons to 100% application server CPU utilization. The formula for calculating the application server ITR for the SAP Account Settlement workload is as follows:

$$\text{Application server ITR} = (\text{ETR} / \text{Application server CPU utilization})$$

**Elapsed Time** of the workload - 128 parallel Account Settlement workload threads were executed, and elapsed time was from the beginning of the first parallel thread to the end of the last thread to complete.

## 6.2 SAP Day Posting

For the SAP Day Posting workload measurements a lot of the same named key metrics are captured but their context reflects values relevant to an OLTP workload as opposed to the batch Account Settlement workload. The key metric for the SAP Day Posting workload is the **Internal Transaction Rate (ITR)** which for SAP Day Posting is a normalization of **throughput** for fair comparisons of measurements. To calculate throughput for this workload, a few terms need to be understood from the perspective of comparing OLTP measurements.

**IBM Z Large Scale Performance Reference (LSPR) methodology** - This methodology, used for OLTP workloads, can be summed up as comparing ITR or throughput of a system under stress. It's a methodology that helps give general guidance for IBM Z performance.

**CPU Utilization** - For this effort the application server CPU utilization was targeted to fit LSPR methodology which calls for keeping CPU utilization high, at or above 80%, and within comparable utilization levels. Processors can deliver performance differences at different utilization levels, so it was important to keep CPU utilization in close range for comparisons.

**External Throughput Rate (ETR)** - ETR for the SAP Day Posting workload measurements was for observable transactions executed per a unit time of a second. The combination of ETR and ITR is key for Day Posting comparisons as it shows like sized workload measurements.

**Internal Throughput Rate (ITR)** - For the SAP Day Posting workload measurements the application server ITR or throughput is again calculated to normalize comparisons to 100% application server CPU utilization. With ETR that can vary along with CPU utilization between measurements, ITR is key for OLTP workload comparisons. The formula for calculating the SAP Day Posting workload application server ITR is the same as for the Account Settlement workload but here it is a factor of OLTP transactions instead of millions of accounts settled:

$$\text{Application server ITR} = (\text{ETR} / \text{Application server CPU utilization})$$

## 7.0 Measurement Results

SAP on IBM z15 application server measurements, using the latest releases of RHEL and SLES Linux Enterprise distribution code and executing SAP Banking Account Settlement and Day Posting workloads, were well-behaved and completing with virtually the same results. These IBM Z co-located measurement scenarios had application servers approximately at 80% busy for all measurements and a CPU utilization of the database server near 80% for Day Posting measurements, and no sign of inherent bottlenecks. IBM Linux on Z application server measurement numbers are typically released with Simultaneous Multithreading (SMT) disabled, so unless specified otherwise, results documented here are with SMT disabled.

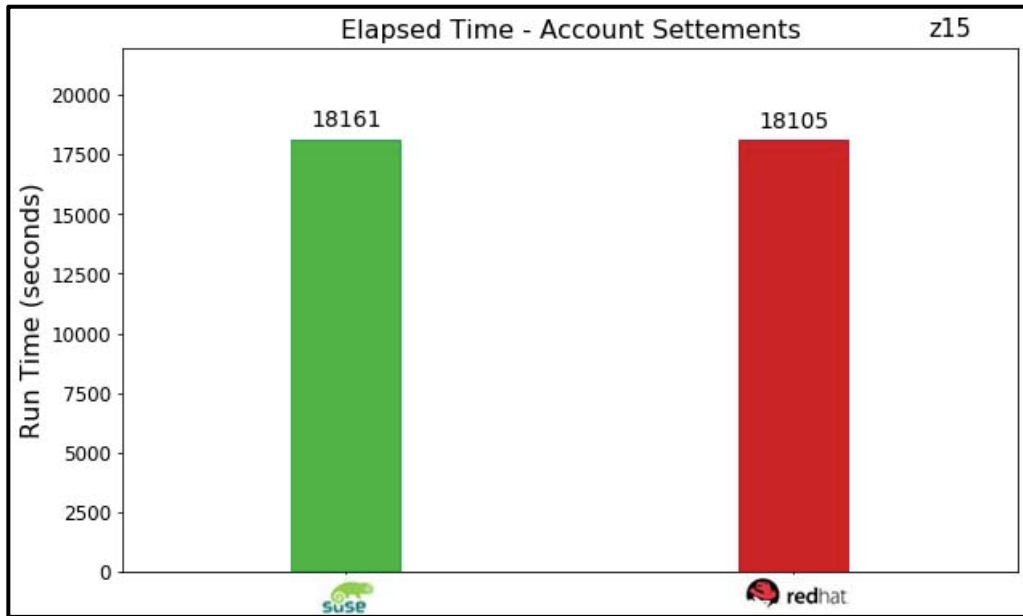
### 7.1 Account Settlement - Linux on Z - RHEL 8.2 versus SLES15 SP2 comparison

For this effort the goal of SAP SBS 9.0 Banking Account Settlement measurements was simply a comparison of elapsed time with the same physical landscape the Day Posting measurements used. Adjustments to the number of parallel batch job streams and number of SAP instances, were made to drive up the application server CPU utilization for a more meaningful comparison. The measured Account Settlement workload for both Linux distributions had virtually the same application server throughput (ITR) and total elapsed time.

SAP Banking Account Settlement on IBM Z		
	SLES15 SP2	RHEL 8.2
	-	-
Runid	S01006G1	S00913G1
# Accounts Processed	100,000,000	100,000,000
# Linux Appservers	4	4
# Cores / Appserver	16	16
Total batch streams	128	128
CPU Utilization - z/OS	59.2	59.3
CPU Utilization - Appserver	78.8	79.5
ETR (Million accounts processed / hour)	19.82	19.88
ITR (Linux application server average)	25.2	25.0
Elapsed Time (seconds)	18161	18105

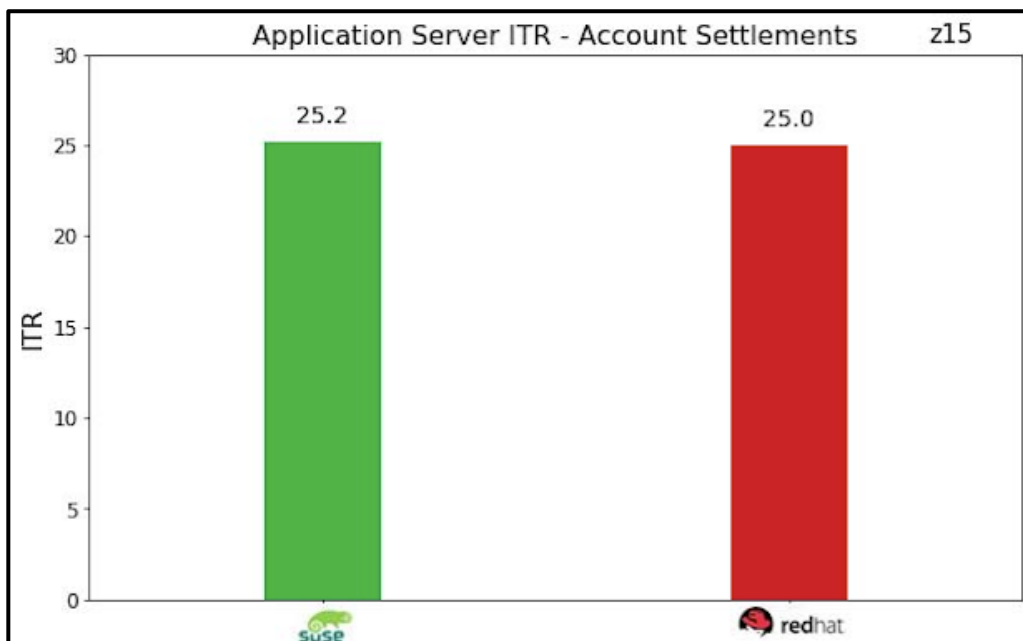
Table 1: SAP Banking Account Settlement on IBM Z

A graphical depiction of the key comparison metric for Account Settlement, elapsed time, shows essentially the same result. Lower is better but for elapsed times measured in hours and results within a minute, time differences are in normal measurement variability.



**Figure 3:** Elapsed Time - Account Settlement

The application server ITR is shown here to level set CPU cycles burned during the Account Settlement measurements. It shows RHEL application servers in a virtual draw with SLES15 SP2 application servers executing the SAP Banking Account Settlement workload. Higher is better but the difference is within normal measurement variability.



**Figure 4:** Application Server ITR - Account Settlement

## 7.2 Day Posting - Linux on Z - RHEL 8.2 versus SLES15 SP2 comparison

For the interactive SAP SBS 9.0 Banking Day Posting workload measurements the LSPR methodology was used and ITR results compared. IBM Linux on Z application server measurement numbers using LSPR methodology are typically released with SMT disabled and general throughput guidance expectations for SMT enablement. The goal of this effort however was simply to see how the RHEL Linux distribution stacked up against SLES, while driving the application server CPU utilization to a high rate of 80% or above for a more meaningful measurement. The fact that the database server also ran at about 80%, while systems were well-behaved and user transactions were at sub 1/2 second response time, highlighted the code stability of both Linux distribution options.

SAP Banking Day Posting on IBM Z		
	SLES15 SP2	RHEL 8.2
	-	-
<b>Runid</b>	S01008G1	S00917G1
<b># Users</b>	10,800	10,800
<b># Linux Appservers</b>	4	4
<b># Cores / Appserver</b>	16	16
<b>CPU Utilization - z/OS</b>	81.2	80.5
<b>CPU Utilization - Appserver</b>	80.3	81.3
<b>Response Time (millisecond)</b>	445	432
<b>ETR (transactions / second)</b>	1030	1032
<b>ITR (Linux application server average)</b>	321	317

Table 2: SAP Banking Day Posting on IBM Z



The ETR shown here demonstrates workload measurements with nearly identical transactions per second. This ETR is for the entire workload environment. Higher is better but results are within normal workload fluctuation.

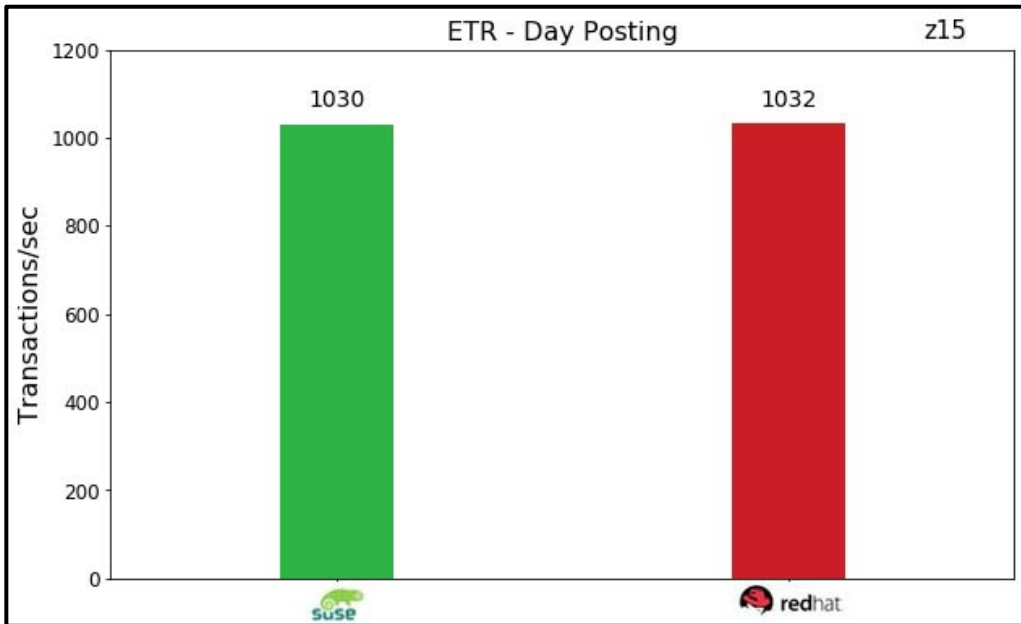


Figure 5: ETR - Day Posting

The application server ITR shown here, again shows RHEL and SLES application servers with virtually the same results. Higher is better but the difference is again normal measurement variability.

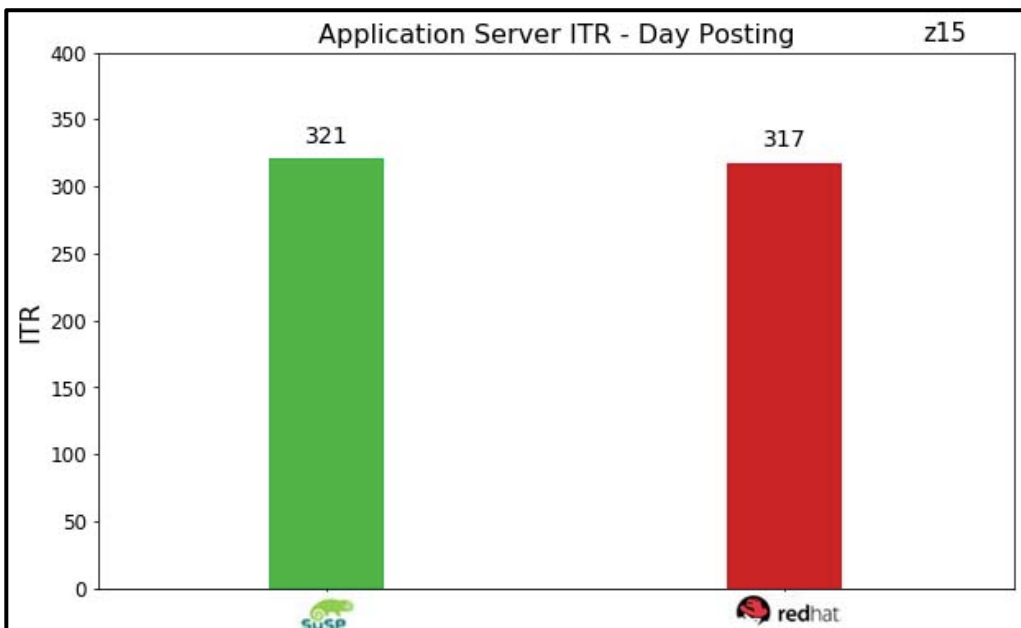


Figure 6: Application Server ITR - Day Posting

### 7.3 Day Posting - Linux on Z with SMT Enabled - RHEL 8.2 versus SLES15 SP2 comparison

This addendum to the RHEL versus SLES application server comparison effort took the same SAP SBS 9.0 Banking Day Posting workload of 10800 interactive users, previously executed with SMT disabled, and repeated them with SMT enabled across the same Linux images and using the same physical environment. When SMT disabled comparison measurements were executed the z/OS LPAR was already driven to a high CPU utilization, so enabling SMT and then pushing the application servers to 80% would likely over commit the database server. Since the goal of this effort was about comparing Linux distribution performance behavior, it was decided to make the SMT enabled comparison only with this SMT setting change and then checking if the RHEL and SLES application servers again performed similarly.

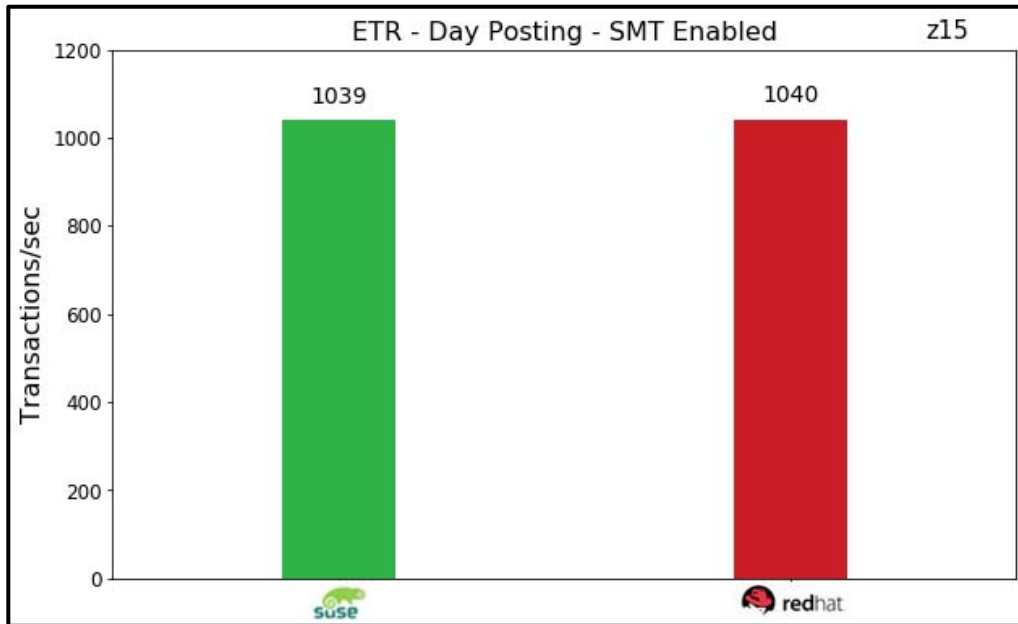
Using the same 10800 user workload the application server CPU utilization for both RHEL and SLES each fell from nearly 80% to just over 50% busy. The database server, which was not changed, also had lower CPU utilization numbers, dropping from around 80% busy to about 75% busy. With SMT enabled, and a workload kept the same size, the additional processor threads accounted for a large ITR throughput capacity benefit. The SMT enabled results are not meant for comparison with the SMT disabled Day Posting results that were measured using LSPR methodology guidelines. The goal of this comparison was simply to show with SMT enabled results would be similar, which they were.

Below in Table 3 are results from the SMT enabled Day Posting measurements.

SAP Banking Day Posting on IBM Z - SMT Enabled		
	SLES15 SP2	RHEL 8.2
	-	-
<b>Runid</b>	S01113G1	S01112G1
<b># Users</b>	10,800	10,800
<b># Linux Appservers</b>	4	4
<b># Cores / Appserver</b>	16	16
<b>CPU Utilization - z/OS</b>	75.2	74.1
<b>CPU Utilization - Appserver</b>	51.7	52.1
<b>Response Time (millisecond)</b>	353	344
<b>ETR (transactions / second)</b>	1039	1040
<b>ITR (Linux application server average)</b>	503	500

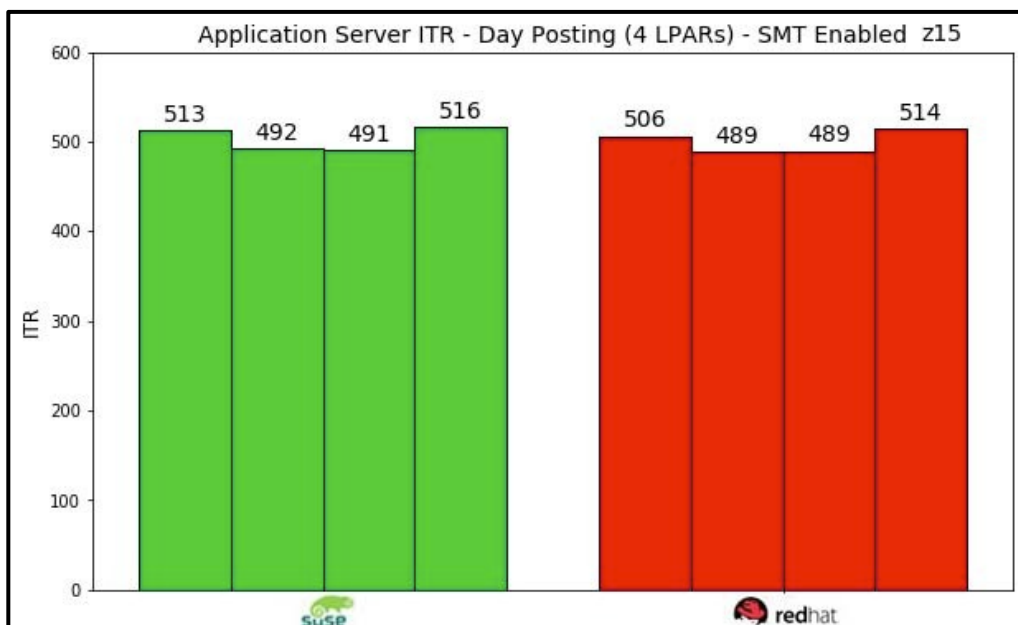
Table 3: SAP Banking Day Posting on IBM Z - SMT Enabled

With SMT enabled for Linux distribution comparisons, the ETR once again shows workload measurements with almost identical transactions per second. This ETR is for the entire workload environment. Higher is better but results are within normal workload fluctuation.



**Figure 7:** ETR - Day Posting - SMT Enabled

The SMT enabled application server ITR result again shows RHEL with normal measurement variability between it and the SLES Linux distribution. Figure 8 is a per LPAR breakdown of the “ITR (Linux application server average)” numbers from Table 3.



**Figure 8:** Application Server ITR - Day Posting (4 LPARs) - SMT Enabled

## 8.0 Conclusion

There are two major Linux Enterprise Server distributions supported for use with SAP on IBM Z which led to questions of whether there were performance differences. To find answers to these questions, comparisons were done using the latest RHEL 8 and SLES 15 Linux distributions while running SAP Banking Services 9.0. The workloads used for this effort were the SAP Banking Account Settlement and Day Posting workloads with SMT disabled and repeated for the Day Posting workload with SMT enabled.

The essential finding of this Enterprise Linux distribution comparison effort showed that RHEL and SLES had virtually identical batch elapsed times and interactive workload throughput results when used as SAP Banking application servers. What was also shown by this large-scale study was a high degree of code stability. In the SAP Day Posting with SMT disabled comparison the database server and all application servers were above 80% busy and no code stability or bottlenecks issues were found while using either Linux distribution.

It is outside of the scope of this project to study all Linux application server tuning options available to Linux on Z application servers, however SMT enablement was set for one additional Linux distribution comparison point. This measurement showed that even with SMT enabled both RHEL and SLES received the same throughput capacity benefit as reflected by much lower CPU utilization and higher ITR numbers while executing the SAP Banking Day Posting workload. Additional Linux on Z tuning options, including RPS which was set for all measurements, can be found in the reference section document links that follow.

In summary, while executing large-scale performance stress tests this effort demonstrated for batch and interactive workload comparisons, RHEL and SLES matched up well verses each other as SAP Banking application servers on IBM Z. It cannot be assumed all applications get the same results without verification, but for this specific effort, both RHEL and SLES were shown to be good options for SAP Banking application servers running in an IBM Z co-located environment.

## 9.0 References

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