TPC-E testing of Microsoft SQL Server 2016 on Dell EMC PowerEdge R830 Server and Dell EMC SC9000 Storage

Performance Study of Microsoft SQL Server 2016

Dell Engineering
February 2017

Table of contents

Revisions....4

Executive Summary....5

1 Introduction....6

1.1 Scope....6

1.2 Audience....6

2 Solution overview....7

2.1 Dell EMC PowerEdge R830 server....8

2.2 Dell EMC Networking S4048-ON....8

2.3 Brocade 6505....9

2.4 Dell EMC Storage SC9000....9

2.5 Microsoft Windows Server 2016....9

2.6 Microsoft SQL Server 2016....9

3 Performance testing....11

3.1 Performance testing tool....11

3.1.1 TPC-E benchmark....11

3.2 Performance metrics....12

3.3 Benchmark testing methodology....12

4 Performance benchmarking results and analysis....14

4.1 R830 consolidation report....14

4.1.1 Large workload profile (~1 TB)....14

4.1.2 Medium workload profile (~500 GB)....14

4.1.3 Small workload profile (~250 GB)....15

4.2 R830 performance report....16

5 Conclusion....18

6 References....19

Tables

Table 1 Solution Configuration 8
Table 2 Key features of Windows Server 2016 9
Table 3 Key features of SQL Server 2016 10
Table 4 TPC-E vs. TPC-C database schema 11
Table 5 Acceptable scenario/range table 12
Table 6 CPU and Memory configuration for workload profiles 13

Figures

Figure 1 Comprehensive Design Overview 7
Figure 2 TPS and User Load graph for large profile 14
Figure 3 TPS and User Load graph for medium profile 15
Figure 4 TPS and User Load graph for small profile 15
Figure 5 CPU Utilization 16
Figure 6 Cumulative Graph for TPS and CPU Utilization 17

Revisions

Date	Description
February 2017	Version 1.0

Executive Summary

IT is the backbone of all major enterprises. Currently, IT needs to do more than ever by supporting mission-critical applications, managing complex and heterogeneous workloads, and fulfilling demanding service level agreements (SLAs). To support these requirements, data centers face the following challenges:

- High total cost of ownership
- Underutilized infrastructure
- Limited scalability options
- Sizing/Infrastructure planning for heterogeneous workloads

To address these data center challenges, Dell EMC offers compelling end-to-end virtualized solutions for customers. These solutions help customers lower the total cost of ownership, improve resource utilization and scalability. Our recent addition to the end-to-end solution portfolio supports Microsoft SQL server 2016.

In this study, we explore the performance of the PowerEdge R830 server, a compute-intensive platform designed for virtualization deployments, while deploying Microsoft SQL server 2016. We have conducted TPC-E benchmark testing for workloads with different sizes in an OLTP environment. This performance study includes hardware configurations, testing methods, and results.

This study concludes with a recommendation to deploy Microsoft SQL Server 2016 on the Dell EMC PowerEdge R830 server.

1 Introduction

Microsoft SQL Server 2016 brings forth a new set of technologies, features, and services. SQL server is a relational database platform for a wide variety of customer applications. SQL Server 2016 includes the following features:

- Mission critical high availability
- Enhanced in-memory performance for all workloads
- Unparalleled data security
- End-to-end mobile business intelligence (BI)
- In-database advanced analytics

To assist customers planning to deploy SQL Server 2016, we have tested an infrastructure that includes PowerEdge R830, Dell EMC Networking S4048-ON, Brocade 6505 and Dell EMC Storage SC9000. This study also explores tools and procedures required for the testing.

1.1 Scope

This study:

- Evaluates the performance of SQL Server 2016 on PowerEdge R830
- Determines the VM consolidation factor for different workload profiles

1.2 Audience

This paper is intended for IT administrators and architects who are interested in implementing a virtualized infrastructure to consolidate Microsoft SQL Server databases. Readers are expected to have some knowledge of Microsoft SQL Server and the benefits of consolidating databases in virtual environments.

2 Solution overview

The solution deployed on Hyper-V 2016 virtualized datacenter environment uses the following components:

- Dell EMC PowerEdge R830 server
- Dell EMC Storage SC9000 and Brocade 6505
- Dell EMC Networking S4048-ON

Figure 1 shows an overview of the solution components.

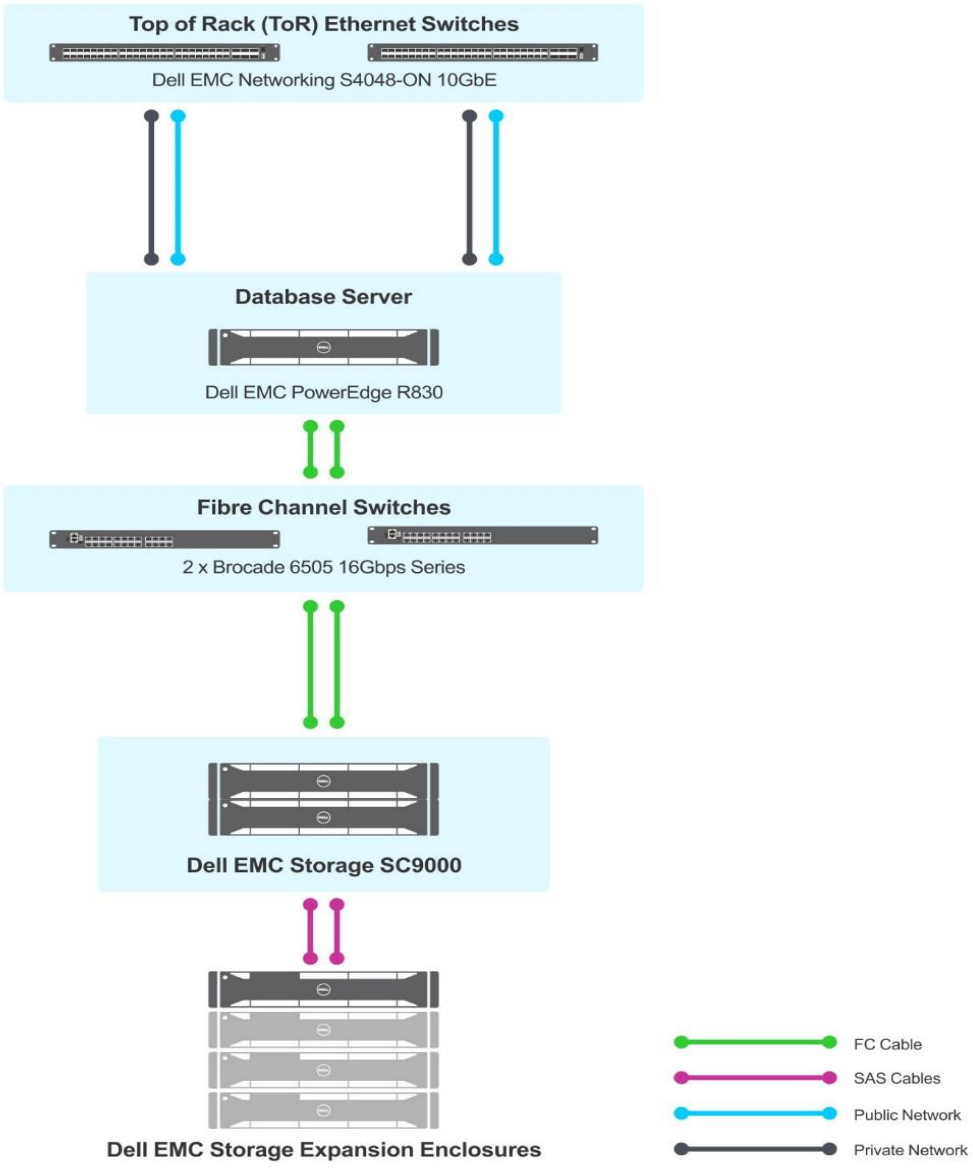

Figure 1 Comprehensive Design Overview

Table 1 Solution Configuration

Component	Configuration
BIOS	1.0.2
Processor	4 x Intel Xeon E5-4669 v4 2.2 GHz, 22 cores
Total cores/Logical threads	88/176
Memory	1.5 TB (48 x 32 GB 2400 MT/s DIMM)
Network Interface	1x QLogic 5720 quad port Network Daughter Card (NDC)
	1x QLogic NetXtreme 10 GbE SFP+ dual port card
FC HBA	2 x QLogic QLE2662 16 Gb FC adapter
Power Supply Units	2 x 1600 W
Operating System	Microsoft Windows 2016 Datacenter Edition
Network switches	2 x Dell EMC Networking S4048-ON 10 GbE
FC switches	2 x Brocade 6505 16 Gbps
External Storage	Dell EMC Storage SC9000 with two SC420 enclosures 18 x 1.6 TB Write intensive SSDs 12 x 3.84 TB Read intensive SSDs

The following subsections describe the hardware and software components used in this study.

2.1 Dell EMC PowerEdge R830 server

The Dell EMC PowerEdge R830 server is a high-performance four-socket, 2U rack server optimized for database applications on a scale-out virtualized environment. It offers a balance between dense memory and compute capacity, making it an ideal platform for medium or large sized enterprises. The PowerEdge R830 server:

- Supports Intel Xeon processor E5-4600 v4 product family with up to 22 cores
- Supports up to 3 TB memory in 48 DIMM slots, with DDR4 memory running at a speed of up to 2400 MT/s
- Supports up to 16 SSDs or HDDs, well suited for data-intensive workloads

2.2 Dell EMC Networking S4048-ON

The Dell EMC Networking S4048-ON 10/40 GbE is a top-of-rack, high-density 1U switch with forty eight 10 GbE uplinks. It offers ultra-low-latency and line rate performance that is optimized for data centers.

2.3 Brocade 6505

The Brocade 6505 is a flexible, easy-to-use, enterprise-class SAN switch that enables storage connectivity. It supports a maximum of 24 ports and operates at a maximum speed of 16 Gbps, all in a 1U footprint. It comes with Gen 5 Fiber Channel and Brocade Fabric Vision technology.

2.4 Dell EMC Storage SC9000

The Dell EMC Storage SC9000 is the ideal solution for large-scale systems and distributed enterprise environments. It is designed and optimized for using flash storage. It supports multiple SSD tiers to optimize write-intensive and read-intensive SSDs as well as less expensive HDDs. In addition, it supports up to 1024 drives that can be added by using enclosures.

2.5 Microsoft Windows Server 2016

Windows Server 2016 is Microsoft's new cloud ready operating system that provides enhanced security, built-in containers, and support for new software defined capabilities for modern data centers. The following table lists some of the key features of Windows Server 2016:

Table 2 Key features of Windows Server 2016

Feature	What's new
Storage Spaces Direct	Enables easy creation and management of redundant and flexible disk storage
ReFS (Resilient File System)	Enables faster placement of VMs on the file system
Software defined networking	Includes enhanced policies to control both physical and virtual networks
Hyper-V	Supports nested virtualization

For a complete list of new features of Windows Server 2016, see Microsoft article, What's New in Windows Server 2016.

2.6 Microsoft SQL Server 2016

SQL Server 2016 brings industry leading OLTP capabilities, new encryption features, greater support for In-Memory databases and an all new end-to-end Business intelligence (BI) solution. The following are some of the key features of Microsoft SQL Server 2016:

Table 3 Key features of SQL Server 2016

Feature	What's new
Memory optimized tables	Provides enhanced compute resource utilization, optimized query plan, and extended functionality for in-memory OLAP tables
Mobile Business Intelligence (BI) platform	Captures insights from online or offline data
MAXDOP, Parameter Sniffing, Hotfixes	These settings can now be configured at a database level
R services	This feature can now be integrated directly into the SQL Server database
Temporal tables	Provides historical view of tables and their values
QueryStore	Provides comparison of different queries over time

For further details regarding Microsoft SQL Server 2016 and its complete list of features, see Microsoft article, What's New in SQL Server 2016.

3 Performance testing

In this study, the solution including Dell EMC PowerEdge R830 server, Dell EMC SC9000 storage, and Dell EMC networking products was benchmarked. This section talks about the testing tool, performance metrics, and methodology used during the solution testing.

The overall testing process was divided into the following phases:

1. Find the maximum performance delivered by PowerEdge R830.
2. Find the system behavior of PowerEdge R830 for different workload profiles, which are categorized based on the database size into large (~1 TB), medium (~500 GB), and small (~250 GB).
3. Find the scalable performance of PowerEdge R830 by simulating TPC-E like SQL Server Workload across multiple VMs.

3.1 Performance testing tool

Benchmark Factory is a simplified database testing tool that allows users to verify database performance. Benchmark factory can be used to conduct database load generation, database code scalability testing, virtual user and transaction load simulation as well as industry standard benchmark testing. In this study, the TPC-E benchmark has been used.

3.1.1 TPC-E benchmark

TPC-E benchmark is an OLTP workload specification developed by the TPC organization. TPC-E can be used to benchmark the database environment while replicating natural data skews of the real world which reflect real world data distribution. It is technically more sophisticated in comparison to the older TPC-C benchmark. In addition, TPC-E benchmark incorporates capabilities such as check constraints and referential integrity.

The following are the major differences between TPC-E and TPC-C benchmark:

Table 4 TPC-E vs. TPC-C database schema

Attribute	TPC-E	TPC-C
Business Model	Brokerage House	Wholesale Supplier
Number of Columns	188	92
Number of Tables	33	9
Read Only Queries	6	2
Read-Write Queries	4	3
Data Generation	Pseudo-real	Random
Number of Check Constraints	22	0
Referential Integrity Present	Yes	No

3.2 Performance metrics

In the testing process, the following metrics were collected for further study and analysis. For an OLTP environment, the most commonly used metrics are transactions per second (TPS) and average query response time (AQRT). Along with TPS and AQRT, CPU and memory utilization data were also collected during the testing.

- **TPS**: The total number of database transactions executed per second.
- **AQRT**: Query response time in an OLTP database environment is the total time taken for an OLTP transaction to complete. AQRT is the average time taken to complete a transaction. AQRT is one of the most important factors when it comes to meeting end-user requirements, and it establishes the performance criteria for an OLTP database. A 25 milliseconds response time metric was selected as the basis for our testing. This metric was maintained throughout the testing period.
- **CPU utilization**: CPU utilization data is used to understand the saturation levels of the database server, and indicates how the server is performing with an increase in load. This data is useful when monitoring a system for CPU-related bottlenecks.
- **Memory utilization**: This parameter is used to allocate appropriate amount of memory to SQL Server. It can be used to identify and eliminate any memory-related bottlenecks.

For an OLTP environment, it is important to define acceptable ranges for the above mentioned metrics. Acceptable value for relevant metrics can be found in the following table:

Table 5 Acceptable scenario/range table

Metric	Acceptable scenario/range
TPS	Increasing TPS graph
AQRT	Lower than 25 milliseconds
CPU utilization	80%-85%
Memory utilization	Not applicable

3.3 Benchmark testing methodology

The benchmark testing was performed by using the following steps:

1. The Quest Benchmark Factory TPC-E workload profile was used to populate the data. The VM OS, SQL log file, and data volumes are placed on Dell EMC Storage SC9000 for high availability.
2. A VM template was created for each workload profile. These templates were categorized based on the database size into large (~1 TB), medium (~500 GB), and small (~250 GB). Benchmark tests were performed on each VM template.
3. Test iterations were performed with increasing user loads until values of TPS or AQRT were within the acceptable scenario/range mentioned in Table 4.
4. Different combinations for vCPUs and amount of memory were tested. The highest performance was found for the following configurations:

Table 6 CPU and Memory configuration for workload profiles

VM sizes	Large (~1 TB)	Medium (~500 GB)	Small (~250 GB)
vCPUs	42	20	10
Memory (GB)	380	180	90

5. To test the scalability of PowerEdge R830, we benchmarked a single VM and subsequently continued benchmarking by adding VMs until the CPU utilization reached its saturation point.

4 Performance benchmarking results and analysis

The performance metrics mentioned in section 3.2 were recorded for the best performing benchmark tests. The results were analyzed and consolidated into two reports:

- R830 consolidation report
- R830 performance report

4.1 R830 consolidation report

The following sub-sections provide information about the maximum supported user load and TPS. These parameters were used to determine the consolidation factor and maximum performance of Dell EMC PowerEdge R830 infrastructure.

4.1.1 Large workload profile (~1 TB)

As seen from the following graph, the system supports:

- 11,200 TPS
- 1600 concurrent users
- 4 VMs with active dataset of 4 TB

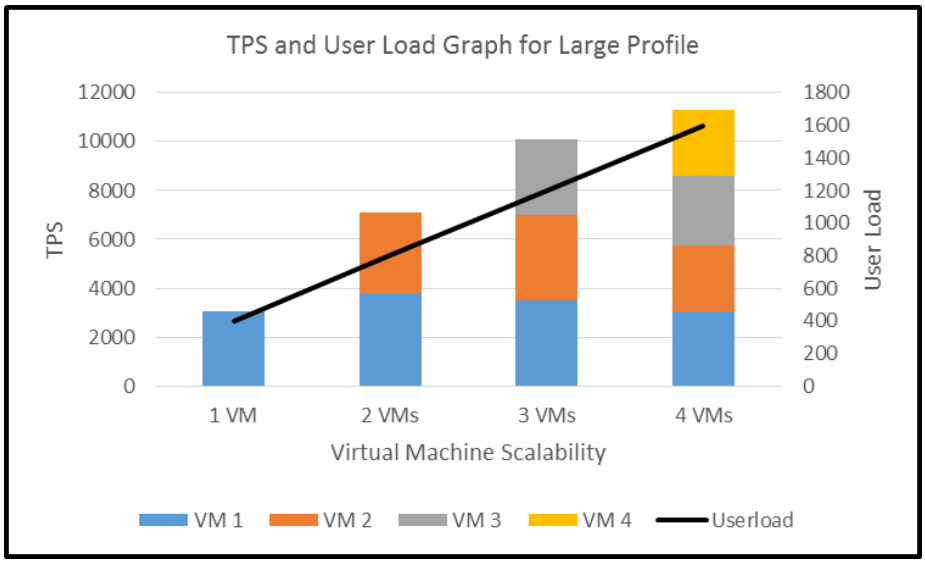

Figure 2 TPS and User Load graph for large profile

4.1.2 Medium workload profile (~500 GB)

As seen from the following graph, the system supports:

- 10,967 TPS
- 1200 concurrent users

- 8 VMs with active dataset of 4 TB

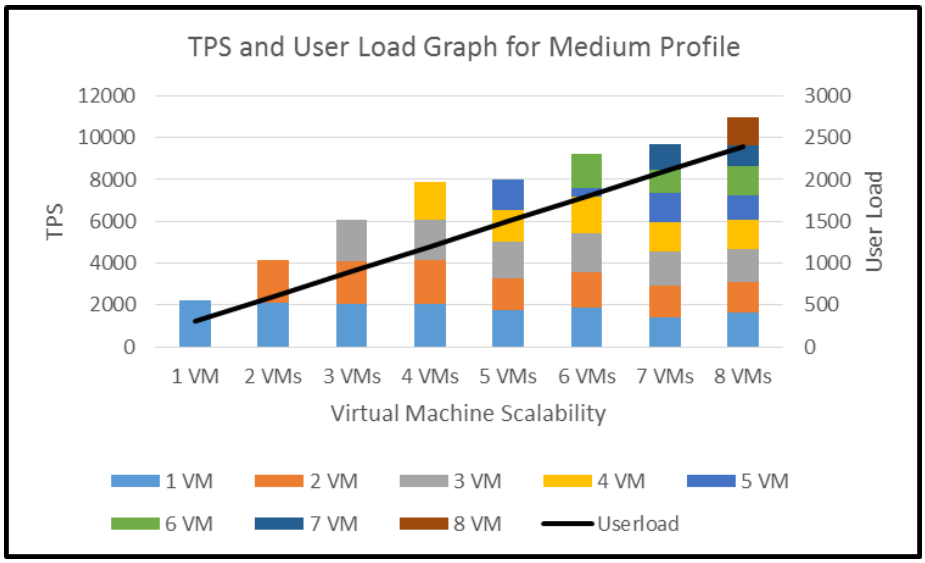

Figure 3 TPS and User Load graph for medium profile

4.1.3 Small workload profile (~250 GB)

As seen from the following graph, the system supports:

- 10,300 TPS
- 720 concurrent users
- 8 VMs with active dataset of 2 TB

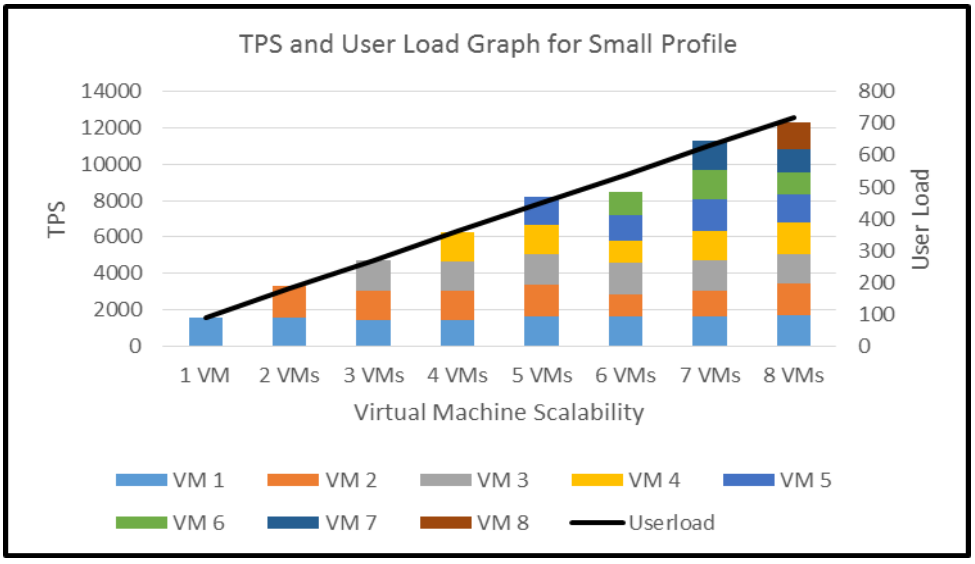

Figure 4 TPS and User Load graph for small profile

Based on the results of different workload profiles and trend analysis, it can be extrapolated that a total of sixteen small workload profile VMs can be generated, delivering ~10,300 TPS.

4.2 R830 performance report

The following graph shows the maximum number of VMs for each workload profile supported by the solution. It is evident from the graph that an increase in CPU utilization is directly proportional to the increase in the number of VMs.

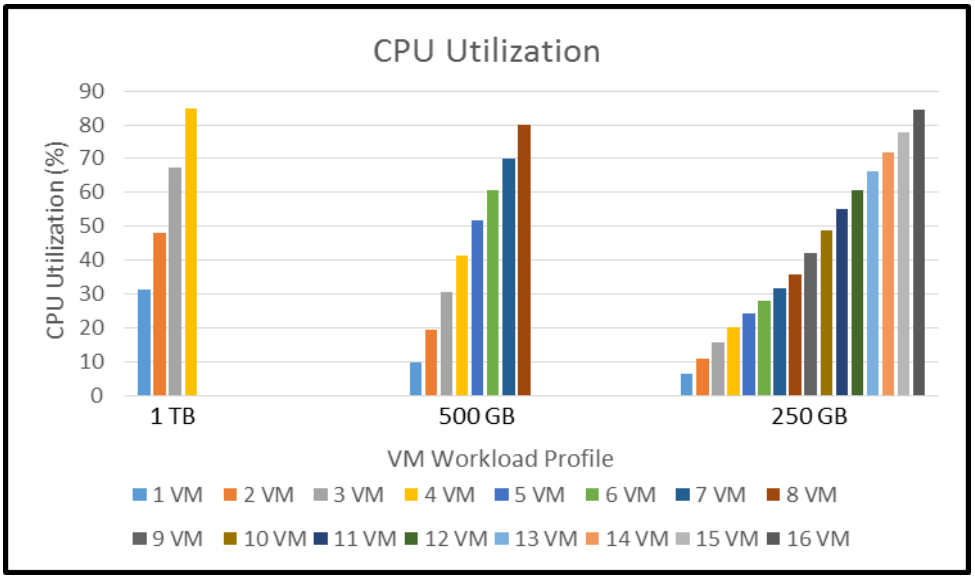

Figure 5 CPU Utilization

The following graph shows the host performance for different workload profiles. It can be observed that the maximum TPS delivered is almost the same across all the profiles. A minimal performance depreciation of 6% was observed due to an increase in the number of VMs and associated overhead.

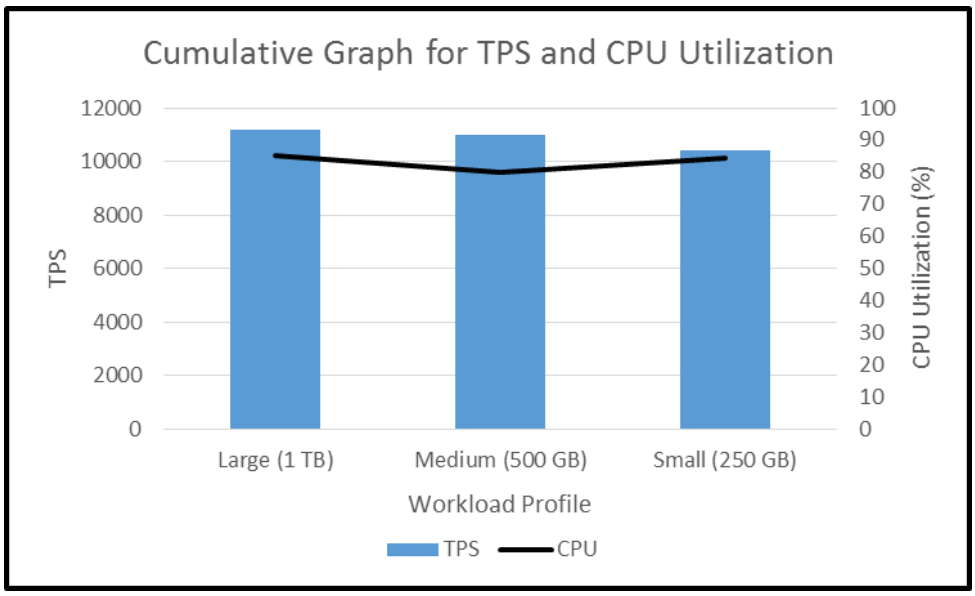

Figure 6 Cumulative Graph for TPS and CPU Utilization

5 Conclusion

In this study, we explored the performance of a virtualized SQL Server 2016 environment running on the PowerEdge R830 server. The solution was powered by Intel E5-4600 v4 product family and includes best-in-class Dell EMC Storage SC9000, Brocade 6505, and Dell EMC Networking S4048-ON.

Our test results show that the R830 solution delivers high performance and scalability and is the right choice for customers deploying or upgrading to SQL Server 2016.

Based on our study, the R830 solution:

- Delivers a maximum of 11,200 transactions per second (TPS)
- Supports a maximum of 1600 concurrent users
- Provides 4 to 1 consolidation factors for large workload profiles, 8 to 1 for medium workload profiles, and 16 to 1 small workload profiles

6 References

See the following referenced or recommended resources related to this study.

Referenced or recommended Dell publications:

- Migrating to SQL Server 2016

Referenced or recommended Microsoft publications:

- What's new in SQL Server 2016
- What's new in Windows Server 2016
- Monitoring Performance By Using the Query Store

Referenced or recommended independent publications:

- Brent Ozar's Blog SQL Server 2016: The Death of the Trace Flag
- TPC-E and TPC-C Technical Comparison