Upgrade to Microsoft SQL Server 2016 with Dell EMC infrastructure

Generational Comparison Study of Microsoft SQL Server

Dell Engineering
February 2017

Revisions

Date	Description
February 2017	Version 1.0

The information in this publication is provided “as is.” Dell Inc. makes no representations or warranties of any kind with respect to the information in this publication, and specifically disclaims implied warranties of merchantability or fitness for a particular purpose.
Use, copying, and distribution of any software described in this publication requires an applicable software license.
Copyright © 2017 Dell Inc. or its subsidiaries. All Rights Reserved. Dell, EMC, and other trademarks are trademarks of Dell Inc. or its subsidiaries. Other trademarks may be the property of their respective owners. Published in the USA [02/17] [White Paper]
Dell EMC believes the information in this document is accurate as of its publication date. The information is subject to change without notice

Table of contents

Tables

Figures

Executive summary

As the volume of data and number of users continue to grow in an OLTP environment, older technologies and infrastructure are unable to keep up with the increased demands. Upgrading to new technologies is not only necessary but also provides better performance for mission-critical applications.

Often, an upgrade can result in an infrastructure overhaul—involving servers, storage, switches and their relevant platforms. Dell EMC offers compelling end-to-end solutions for customers to incorporate new technologies and remain current. These solutions, based on Dell EMC's 13th generation of servers and Dell EMC storage, help customers improve performance, lower the total cost of ownership, and accelerate time to value. Our recent addition to this end-to-end solution portfolio supports Microsoft SQL Server 2016 that offers a whole host of new capabilities. As quoted by Microsoft, SQL Server 2016 is "the biggest leap forward in Microsoft's data platform history".

To help customers upgrade to SQL Server 2016, the Dell EMC Enterprise Solutions team has conducted a study to evaluate the performance of SQL Server on Dell EMC infrastructure. This generational comparison study:

- Describes the solution components.
- Demonstrates performance improvements of the Dell EMC PowerEdge R730 infrastructure when compared to the Dell EMC PowerEdge R710 infrastructure.

This study concludes with a recommendation for upgrading to SQL Server 2016 by using the latest Dell EMC infrastructure.

1 Introduction

Microsoft SQL Server 2016 brings forth a new set of technologies, features, and services to the database domain. It 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 upgrade to SQL Server 2016, we have tested an infrastructure that includes Dell EMC PowerEdge R730, Dell EMC Networking S4048, Brocade 6505 and Dell EMC Storage SC4020. This study also explores tools and procedures required for the testing.

1.1 Scope

This study examines:

- The performance comparison of SQL Server 2005 running on PowerEdge R710 to SQL Server 2016 running on PowerEdge R730
- PowerEdge R730 server as the appropriate platform to upgrade to SQL Server 2016

1.2 Audience

This guide is intended for IT professionals, database administrators, and consultants interested in deploying or upgrading to the latest SQL Server database infrastructure.

2 Solution overview

For this study, the legacy test solution including PowerEdge R710 was compared to the upgrade target solution including PowerEdge R730. The other hardware components remained the same for both these solutions.

Figure 1 shows a combined overview of the legacy and upgrade target solution deployed in the test environment:

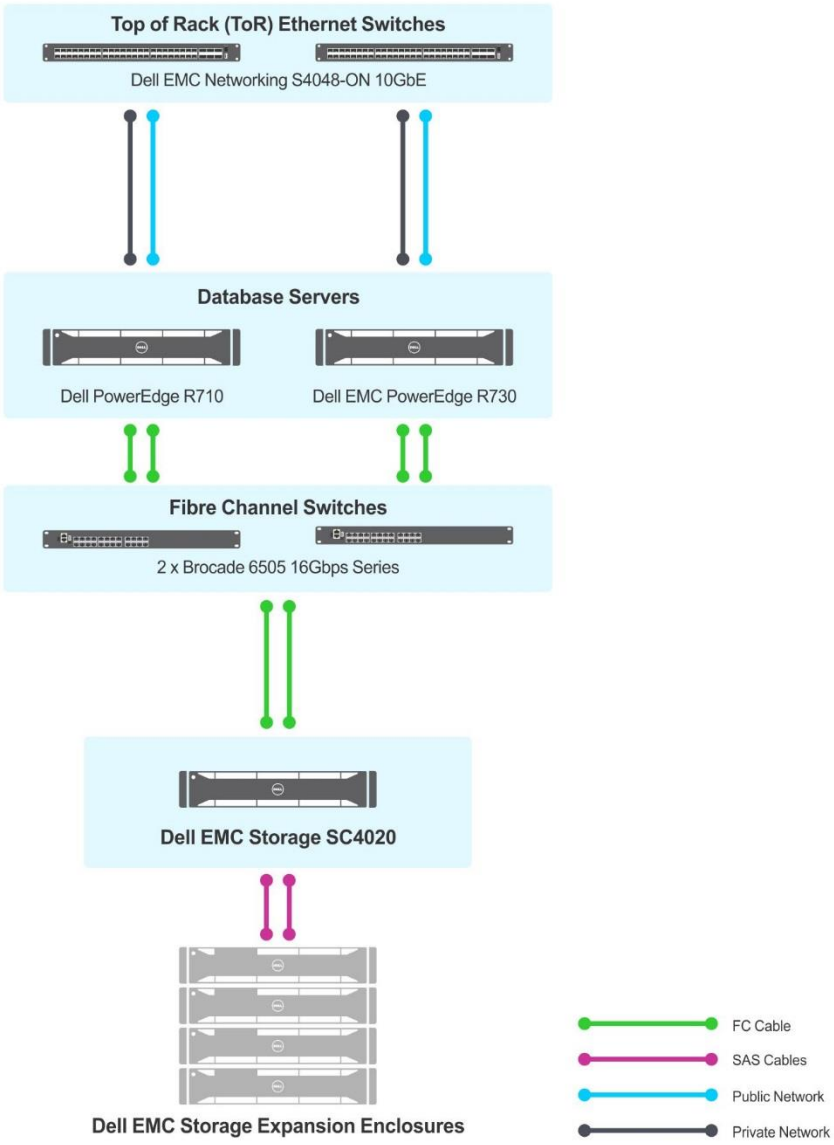

Figure 1 Test environment overview

Table 1 Solution component details—R710 vs. R730

Component	Legacy Environment (R710)	Upgrade Target Environment (R730)
BIOS	6.4.0	2.1.6
Processor	2 x 6C Intel Westmere X5675 3.7 GHz	2 x Intel Xeon E5-2698 v4 2.2 GHz, 20 cores
Memory (RAM)	144 GB (18 x 8 GB DDR3 1333 MT/s DIMM)	1.5 TB (24 x 64 GB 2400 MT/s DIMM)
Network Interface	1 x Broadcom NetXtreme II 5709c Gigabit Ethernet NIC	1 x QLogic 57800 2x10Gb DA/SFP+ + 2 x 1 Gb BT Network Daughter Card
	1 x QLogic 10 GbE 2P 57810S Adapter	1 x QLogic 57810 Dual Port 10Gb DA/SFP+ Converged Network Adapter
FC HBA	2 x QLogic 8 Gb QLE2562 Dual Port FC HBA	2 x QLogic QLE2662 16 Gb Dual Port FC HBA
Power Supply Units	2 x 575 W	2 x 1100 W
Operating System	Microsoft Windows 2008 R2 Enterprise edition	Microsoft Windows 2016 Data Center edition
Database	Microsoft SQL Server 2005	Microsoft SQL Server 2016 Enterprise Edition
Network Switches	2 x Dell EMC Networking S4048-ON	2 x Dell EMC Networking S4048-ON
FC Switches	2 x Brocade 6505	2 x Brocade 6505
External Storage	1 x Dell EMC Storage SC4020 (12 x RI +12 x WI SSD)	1 x Dell EMC Storage SC4020 (12 x RI +12 x WI SSD)

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

2.1 Dell EMC PowerEdge R710 server

The PowerEdge R710 server was selected as the legacy environment. The 2U PowerEdge R710 server supports the Intel Xeon processor 5500 and 5600 series. It supports a maximum of 288 GB memory across 18 DIMM slots with DDR3 up to 1333 MT/s.

2.2 Dell EMC PowerEdge R730 server

The PowerEdge R730 server is designed for a wide variety of workloads in midsized and large enterprises, all in a 2U footprint. The R730 server:

- Supports Intel Xeon processor E5-2600 v4 product family with up to 22 cores
- Supports up to 1.5 TB memory in 24 DIMM slots, with DDR4 memory running at a speed of up to 2400 MT/s
- Provides up to 64 TB of internal storage with 3.5” hard drives, ideal for database and business intelligence solutions

2.3 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.

2.4 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.

2.5 Dell EMC Storage SC4020

The Dell EMC Storage SC4020 is an intelligent, self-optimizing array in a 2U form factor. 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 24 internal drives and 168 external drives that can be added by using enclosures.

2.6 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.

2.7 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

To compare the legacy and upgrade target solution, the PowerEdge R710 and R730 servers were benchmarked. This section talks about the testing tool, performance metrics, and methodology used during solution testing.

The overall testing process was divided into the following phases:

1. Find the maximum performance delivered by the PowerEdge R710 server.
2. Find the maximum performance delivered by the PowerEdge R730 server.
3. Conduct a comparative performance analysis of the PowerEdge R710 server and PowerEdge R730 servers.

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 standards:

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 reporting 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 to complete an OLTP transaction. 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.
- Power consumption: This parameter refers to the amount of energy consumed in watts.

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%-90%
Memory utilization	Not applicable
Power consumption	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 with a scale factor mentioned in Table 6 to create a database of the required size.
2. Test iterations were conducted until server CPU utilization reached the acceptable range mentioned in Table 5.
3. The test iterations were started with a load of 100 users. Subsequently, the user load was incremented by 100 users. With increasing user load, test iterations were performed until values of TPS or AQRT were within the acceptable scenario/range mentioned in Table 5.
4. Steps 2 and 3 were repeated to ensure that the results were consistent.

The configuration details for Legacy and Migration target environments are listed in the following table:

Table 6 Test configuration details—R710 vs. R730

Component	Legacy Environment (R710)	Upgrade Target Environment (R730) Detail/VM
Logical CPUs	24 Cores	18 Cores
Memory for OS	144 GB	192 GB
Database Size	600 GB	600 GB
TempDB Drives	2 x 300 GB 10k SAS (Raid 1)	50 GB LUN on Dell EMC Storage SC4020
Database+Log Drives	700 GB LUN on Dell EMC Storage SC4020	700 GB LUN on Dell EMC Storage SC4020
Virtual Network Interface	NA	1
Virtual FC Channel ports	NA	2
Test Workload	Quest Benchmark Factory TPC-E	Quest Benchmark Factory TPC-E
Scale Factor	41	41
User Load	100-400	100-400
Inter-arrival Time	40 ms	40 ms

3.3.1 Benchmark testing PowerEdge R710 server

For this study, PowerEdge R710 was tested in an environment where virtualization is disabled. PowerEdge R710 was benchmarked using the testing process mentioned in section 3.3.

3.3.2 Benchmark testing PowerEdge R730 server

The following steps were performed to benchmark the PowerEdge R730 server:

1. PowerEdge R730 was tested on a virtualized platform by deploying Hyper-V role on Windows Server 2016. The virtualization best practices from the Dell EMC Ready Bundle for Microsoft SQL Server 2016were followed.
2. Different combinations for number of VMs, vCPUs and amount of memory per VM were tested. The highest performance for R730 infrastructure was found with four VMs running simultaneously with 18 vCPUs and 192 GB memory per VM.
3. The PowerEdge R730 server was benchmarked again with the four VM configuration to monitor metrics and bottlenecks at both the physical and VM level.

4 Performance benchmarking results and analysis

The best performing test cases for the legacy environment (PowerEdge R710) and the upgrade target environment (PowerEdge R730) are explored here. The metrics at saturated user loads for these environments were recorded. The performance metrics mentioned in section 3.2 are further analyzed in the following sub sections.

4.1 Transactions per second

As seen from the following graph, the upgrade target environment provides ~2.7 times the performance of legacy environment in terms of TPS at the saturated user load.

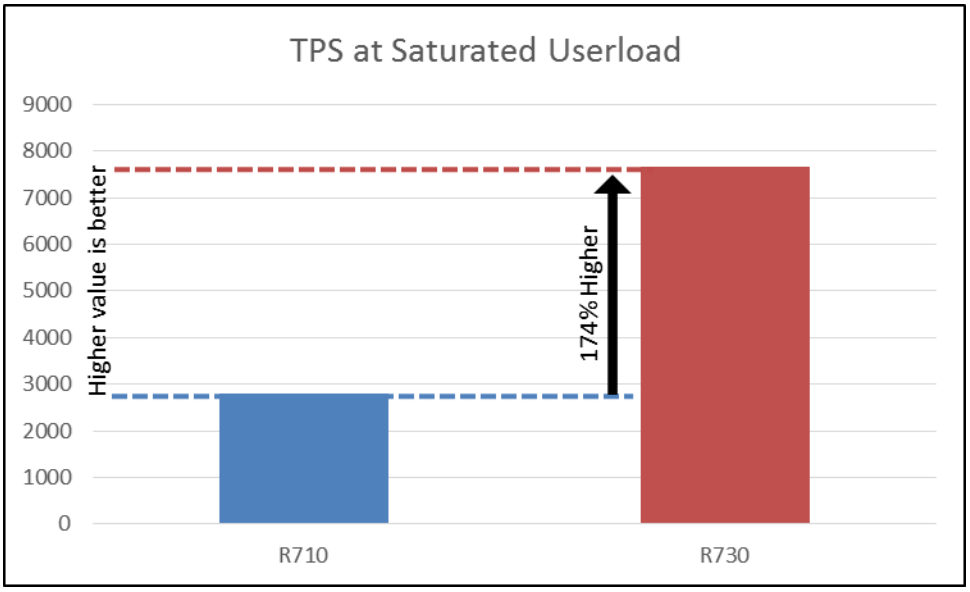

Figure 2 TPS comparison of R710 and R730

4.2 User load supported

Within the considered CPU threshold limit, the upgrade target environment supported 4 times the user load as compared to the legacy environment.

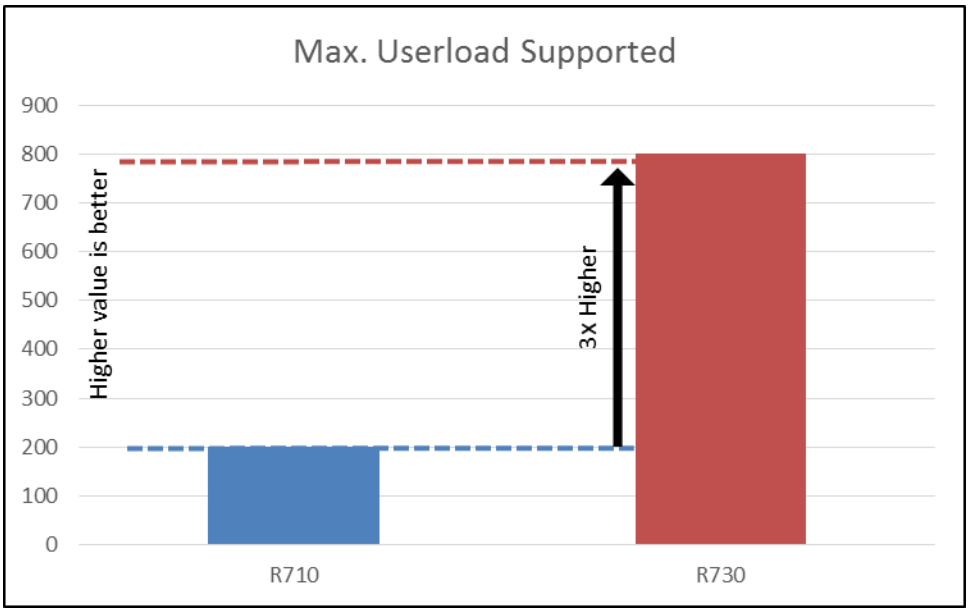

Figure 3 Maximum User load comparison of R710 and R730

4.3 Active dataset supported

The active dataset is the total size of the database benchmarked during the tests. It is visualized as shown in the following graph:

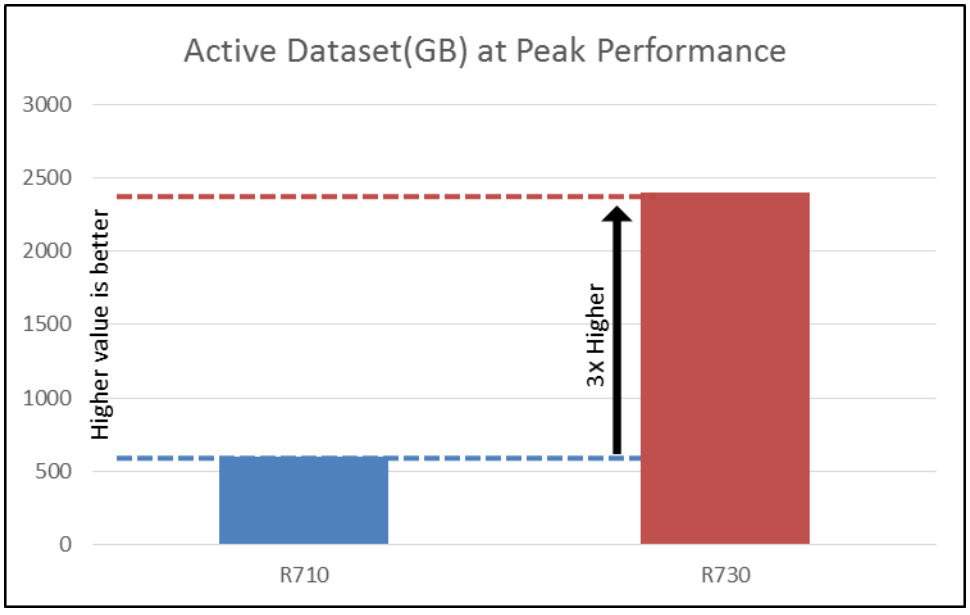

Figure 4 Active Dataset comparison of R710 and R730

The target migration environment can support up to ~4 times the active dataset supported by the legacy environment.

4.4 Power consumption

The power consumption was monitored for the legacy and the upgrade target servers. The average power consumption at saturated user loads is compared in the following graph:

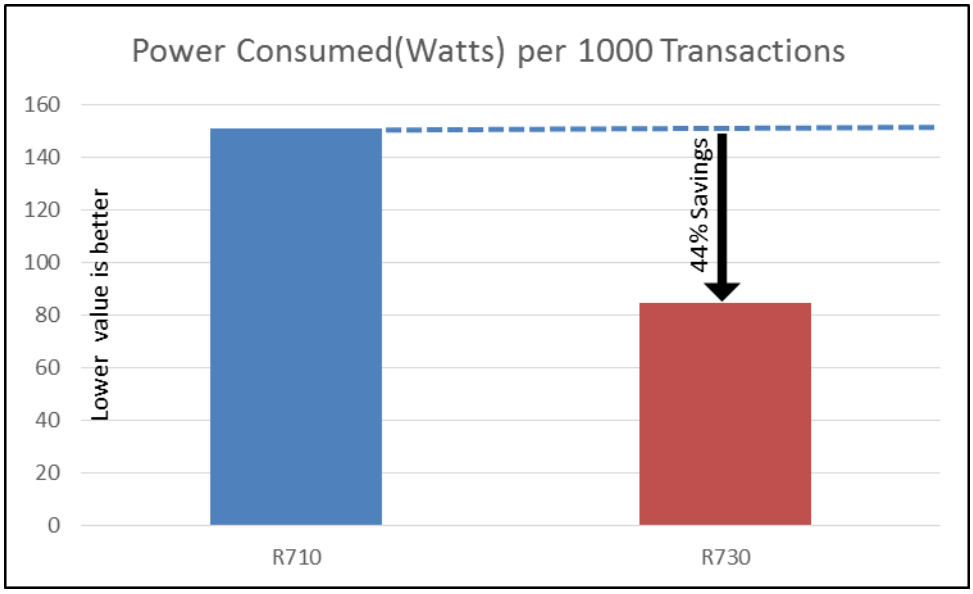

Figure 5 Power Consumption comparison of R710 and R730

The preceding graph shows that the PowerEdge R710 consumes ~78% more power than the PowerEdge R730. In other words, upgrading from legacy to upgrade target environment results in 44% reduction in power consumed for every 1000 transactions. Note that actual energy savings may vary.

4.5 Rack space savings

In this study, it was found that using PowerEdge R730 resulted in 66-75% rack space savings. For this calculation, we determined the number of PowerEdge R710 servers required to obtain the same performance as that of a single PowerEdge R730 server.

The rack space requirements and savings are listed in the following table:

Table 7 Rack space details—R710 vs. R730

Performance Metric	Number of R730 servers	Number of R710 servers	Space required – R730 server	Space required – R710 server	% Rack space savings
TPS	1	3	2U	6U	66.66
Userload supported		4		8U	75
Active dataset supported		4		8U	75

5 Conclusion

In this study, we compared the performance of the legacy environment running SQL Server 2005 on PowerEdge R710 to the upgrade target environment running SQL Server 2016 on PowerEdge R730. The upgrade target environment is powered by Intel E5-2600 v4 product family and includes best-in-class Dell EMC Storage SC4020, Brocade 6505, and Dell EMC Networking S4048-ON.

The upgrade target infrastructure eases management tasks and delivers better performance, higher scalability, and more efficiency. Therefore, it is the right choice for customers to upgrade from their legacy environment.

When compared to PowerEdge R710 infrastructure, the PowerEdge R730 infrastructure:

- Supports 2.7x transactions per second
- Supports 4x active dataset
- Supports 4x user load
- Delivers 44% energy savings. Note that actual energy savings may vary.
- Delivers 66-75% rack space savings

For references and guidance on migrating from legacy SQL Server versions like 2005 to Microsoft SQL Server 2016, see the Dell wiki, Migrating to SQL Server 2016.

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