

Microsoft Dynamics CRM
2013 Performance and
Scalability on Dell PowerEdge
R920 Servers with the Intel®
Xeon® processor E7 v2 family
and Solid State Drives



Performance

White Paper

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OVERVIEW

Microsoft Dynamics CRM 2013 is designed to help enterprise organizations get a 360-degree view of their customers and improve employee productivity by giving information to users in a more efficient way. With a completely redesigned user interface, users can perform common tasks more quickly and easily. CRM 2013 helps provide data anywhere and across a wide array of devices, ranging from phones and tablets to PCs, and through a wide array of client types, such as smartphone apps, tablet apps, and Microsoft Dynamics CRM for Outlook. CRM 2013 matches the way that users do business, and runs on a platform that provides enterprise levels of scalability and performance. This paper focuses on highlighting the scalability that can be achieved in terms of concurrent users, big data and feature functionality.

Microsoft, working with Intel, Dell, and F5 Networks, completed benchmark testing of Microsoft Dynamics CRM 2013 running on Dell PowerEdge R920 servers powered by the Intel Xeon processor E7 v2 family and configured with Peripheral Component Interconnect Express (PCIe) Dell PowerEdge Express Flash NVMe drives. The Intel Xeon processor E7 v2 family is specifically designed for heavy workloads and mission-critical environments. It provides up to 50 percent more cores and 25 percent more cache per socket than prior-generation processors, and supports up to three times more memory for data-intensive applications, such as Microsoft Dynamics CRM. Configuring the server with SSDs rather than traditional hard disk drives (HDDs) speeds storage access to provide more sustainable high performance in this parallel execution environment.

To provide useful benchmark results, preliminary research was performed to ensure that test workloads closely reflected those of a typical, large-scale enterprise organization. No extraordinary steps were taken to tune the solution stack. Only standard techniques to optimize the performance of Microsoft SQL were applied.

RESULTS SUMMARY

Performance testing was performed on a Microsoft Dynamics CRM 2013 implementation that included the latest versions of Windows Server and Microsoft SQL Server, in addition to Dell servers based on the latest Intel Xeon processor E7 v2 family and Dell PowerEdge Express Flash NVMe drives. In this test environment, Microsoft Dynamics CRM Server 2013 demonstrated the following performance characteristics:

Concurrent Users^a	Total Record Count	Average Page Response Time	Web Requests	Business Transactions	Average Microsoft SQL Server Utilization	Average Microsoft CRM Server 2013 Utilization
150,000	1.26 billion	0.44 seconds	6.47 million/hour	1.0 million/hour	23.8 percent	58.4 percent

^a150,000 users, each performing a business transaction once every 6 minutes

Performance results demonstrate that a single CRM 2013 instance running on the Intel Xeon processor E7 v2 family can achieve sub-second response times with 150,000 concurrent users executing a heavy workload against a large, complex database.

This white paper details the results of the performance testing conducted on CRM 2013 running on Dell PowerEdge R920 servers powered by the Intel Xeon processor E7 v2 family and configured with Dell PowerEdge Express Flash NVMe drives. It provides:

- A description of the customer relationship management (CRM) implementation and the methods used to obtain the benchmark
- Details of the hardware configuration used in testing
- A summary of the key test parameters and results achieved

Important: These results reflect the scalability and performance achieved on a specific Microsoft Dynamics CRM 2013 implementation running on a particular test environment. Factors ranging from specific customizations deployed by enterprise organizations to geographic distribution of users can affect how enterprise organizations use the CRM system, so results will vary for each implementation. Customers might be able to achieve higher levels of performance by fine-tuning or optimization.

Also note that this benchmark focuses on server-side performance and metrics. The response times reported here are for the clients in a laboratory environment without network latency and bandwidth constraints and client-side rendering time that clients might face when they are connected remotely. As a result, response times here are in no way indicative of client responsiveness that might be seen when rendering in a browser.

TESTING METHODOLOGY

Microsoft, working with Intel, Dell, and F5 Networks, conducted testing to demonstrate the performance and scalability characteristics of a Microsoft Dynamics CRM 2013 implementation running with:

- Windows Server 2012 R2
- SQL Server 2012
- Dell PowerEdge R920 servers powered by the Intel Xeon processor E7 v2 family and configured with Dell PowerEdge Express Flash NVMe drives

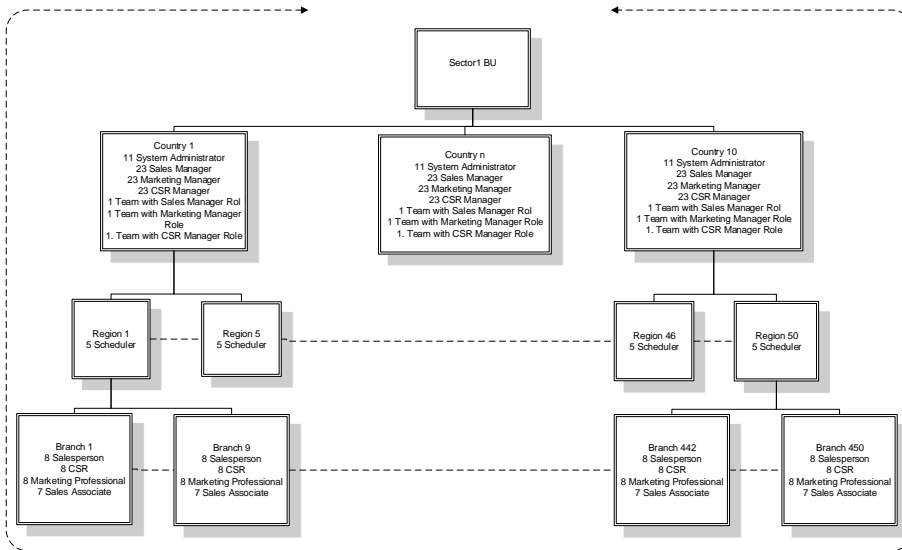
To conduct a realistic performance test, a realistic model of a large scale enterprise organization had to be designed. First, a business unit hierarchy that resembled a real-world organization was created. Then, data for each of the users in the organization was modeled and populated. Finally, business use cases were designed that users would run and a realistic load based on the model was calculated. The following sections describe the steps toward achieving a realistic load simulation.

ENTERPRISE ORGANIZATION STRUCTURE

Based on extensive customer research, an enterprise-class deployment of Microsoft Dynamics CRM organization was modeled. This organization has a business unit structure that resembles extremely large global organizations. It also has an extensive set of users in each business unit distributed across various security roles to give a realistic simulation of data security implemented by enterprise organizations. To test the scale of a business unit defined security model, a complicated business unit hierarchy with 5110 business units was created. The depth of business units was set to four. To test the performance of a CRM system in a realistic manner, each of the business units was assigned users of different security roles. Nine security roles were selected for all the users in the CRM organization, of which eight were security roles that come with Microsoft Dynamics CRM and one (Sales Associate) was a custom security role. The security roles are as follows:

- System Administrator
- Sales Manager
- Customer Service Representative Manager
- Marketing Manager
- Salesperson
- Customer Service Representative
- Marketing Professional
- Scheduler
- Sales Associate

The following diagram showcases the distribution of users and teams in each of the business units.



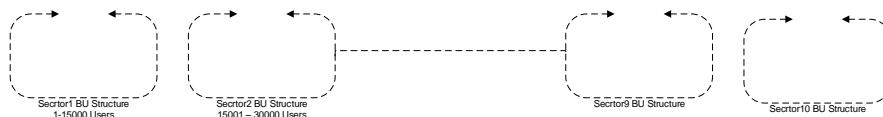
150000 Enterprise Organization 150,000 Users

User Counts in 1 Sector:

- System Administrators: 110
- Sales Managers: 230
- Marketing Managers: 230
- CSR Managers: 230
- Schedulers: 250
- Marketing Professionals: 3600
- Salespersons: 3600
- CSRs: 3600
- Sales Associates: 3150

150K User Organization Structure for Enterprise level Organization:

In order to have an incremental way of populating data, we will add more sector BU hierarchies to increase the size of the organization till we get to the required size



User Counts:

- System Administrator: 1100
- Sales Managers: 2300
- Marketing Managers: 2300
- CSR Managers: 2300
- Schedulers: 2500
- Marketing Professionals: 36000
- Salespersons: 36000
- CSRs: 36000
- Sales Associates: 31500

Figure 1: Business unit structure with user distribution

CUSTOMIZATIONS

In order to model a realistic enterprise, the organization was configured with specific customizations. Two custom entities were created. Commonly used entities such as account, contact, lead and task were modeled with custom attributes. Field-level security was also enabled on custom attributes to reflect a realistic enterprise organization.

USER DATA

Based on customer research, each user of a specific role was assigned a realistic set of data. The data that the user would own was based on the user's role. The total data in the test database included over 1,258 million business records with a total database size of 2.5 TB.

The following entities were the primary focus of scale, and data was populated for the record counts to exceed the largest known counts of our customers. The following table shows the record count of some commonly used entities.

Table Name	# Records
CustomerAddressBase	243,992,508
ActivityPartyBase	198,695,584
EmailSearchBase	172,185,209
ImageDescriptor	147,375,097
LeadAddressBase	100,078,158

ActivityPointerBase	79,564,478
ContactBase	76,949,906
ConnectionBase	50,760,972
LeadBase	50,039,079
OpportunityBase	48,407,505
AccountBase	45,046,348

Note: For a list of row counts for all tables and a comparison of row counts between testing conducted on CRM 2013 and previous testing conducted on CRM 2011, refer to [Appendix B: Benchmark Testing Detail, Table 3](#).

TRANSACTION WORKLOAD

The simulation of a real-world workload on a Microsoft Dynamics CRM system was conducted using load testing infrastructure provided by Microsoft Visual Studio Test Suite. Each workload comprises several test scenarios, each of which simulates the load generated by a particular category of users. Each of the scenarios comprises several business transactions, each of which is simulated by test cases. The workload also simulated loads from the following client types:

- Microsoft Dynamics CRM web client: 150,000 users
- Microsoft Dynamics CRM mobile assistant client: 74,300 users

The workload simulated 150,000 users each conducting a business transaction once every 6 minutes. This generated a load of 1,004,400 business transactions per hour and 6.47 million web requests per hour.

TEST SCENARIOS

Test scenarios were based on customer research and were created using the Microsoft Dynamics CRM 2013 Performance and Stress Toolkit (Performance Toolkit), which is designed to formalize performance testing of Microsoft Dynamics CRM by facilitating load testing of simulated customer environments. When available, the [Microsoft Dynamics CRM 2013 Performance Toolkit](#) (a free download) will allow organizations to evaluate the potential viability of Microsoft Dynamics CRM for their own business transactions on their own environments.

Each test scenario was designed to simulate the load of the set of users who have a particular business role. The sum total of all the users in all the scenarios was 150,000 users. The test scenario included the most relevant business transactions (test cases) that a user of a particular role would conduct. Each of the scenarios simulates the load of all the users of that particular role, with each user conducting all the steps in a business transaction once every 6 minutes. This would be equivalent to carrying out 10 business use cases in a span of one hour, which was the industry average from the customer research conducted.

Note: All test cases used in this benchmark are included in the Performance Toolkit, and can be used by customers as a basis for their own benchmarking.

Important: The test cases, metrics, and usage patterns contained in this document were defined by the Microsoft Dynamics CRM product team. Only test scenarios that are defined in this document were provided for testing and evaluated for performance. The tests can't predict how additional scenarios might affect system performance.

BUSINESS TRANSACTIONS

Test scenarios were designed to model heavy usage of a real-world Microsoft Dynamics CRM 2013 configuration by a large scale enterprise organization. A mixture of Microsoft Dynamics CRM web clients and Microsoft Dynamics Mobile Assistant clients were simulated. Simulated users in the benchmark executed business transactions that touched capabilities across Microsoft Dynamics CRM functionality. A total of 191 business transactions were used to simulate the use cases conducted by the CRM users. Each business transaction in the testing consisted of several discrete atomic interactions between the user and the CRM system.

For example, the business transaction "Update Account" consisted of the following interactions:

1. Start at sales homepage.
2. Select **My Active Accounts View**.
3. Search for an account using quick find by entering data in the quick find search box and clicking **Find**.
4. Open an account.
5. Enter data in a field in the account form.
6. **Save** and **Close** account.

In this business transaction, each of the discrete CRM interactions comprised one or more atomic Microsoft CRM commands, with each command taking approximately 0.44 seconds to execute. The total number of commands sent to the Microsoft Dynamics CRM system corresponded to 6.47 million commands per hour.

TUNING AND OPTIMIZATION

Standard optimization techniques were applied per guidelines contained in the white papers "*Optimizing and Maintaining Microsoft Dynamics CRM 2011 Server Infrastructure*" and "*Improving Microsoft Dynamics CRM Performance and Securing Data with Microsoft SQL Server 2008 R2*." Depending on the specific business processes involved, higher levels of performance and scalability might be possible through customization to meet specific business and performance requirements, and through deeper optimization.

Standard SQL scripts were used to help ensure that table indexes on the database weren't fragmented and that the statistics were up-to-date, which helped to ensure efficient database operation. Early test runs of the scripts identified several areas in which new or modified indexes could improve query performance. SQL Server Profiler was used to identify long-running queries that were executed frequently, and this information was used to carry out additional tuning of the database server.

Note: For more information, see the following white papers:

- "*Optimizing and Maintaining a Microsoft Dynamics CRM 2011 Server Infrastructure*":

<http://www.microsoft.com/en-us/download/details.aspx?id=27139>

- “Improving Microsoft Dynamics CRM Performance and Securing Data with Microsoft SQL Server 2008 R2”:

<http://go.microsoft.com/fwlink/?LinkId=226926>

Note: The techniques mentioned in the referenced white papers are applicable even though the white papers refer to older versions of Microsoft Dynamics CRM and SQL Server products. The white papers are being updated for Microsoft Dynamics CRM 2013 and SQL Server 2012 and will be published soon.

HARDWARE ENVIRONMENT

The hardware environment used in the testing is illustrated in Figure 2.

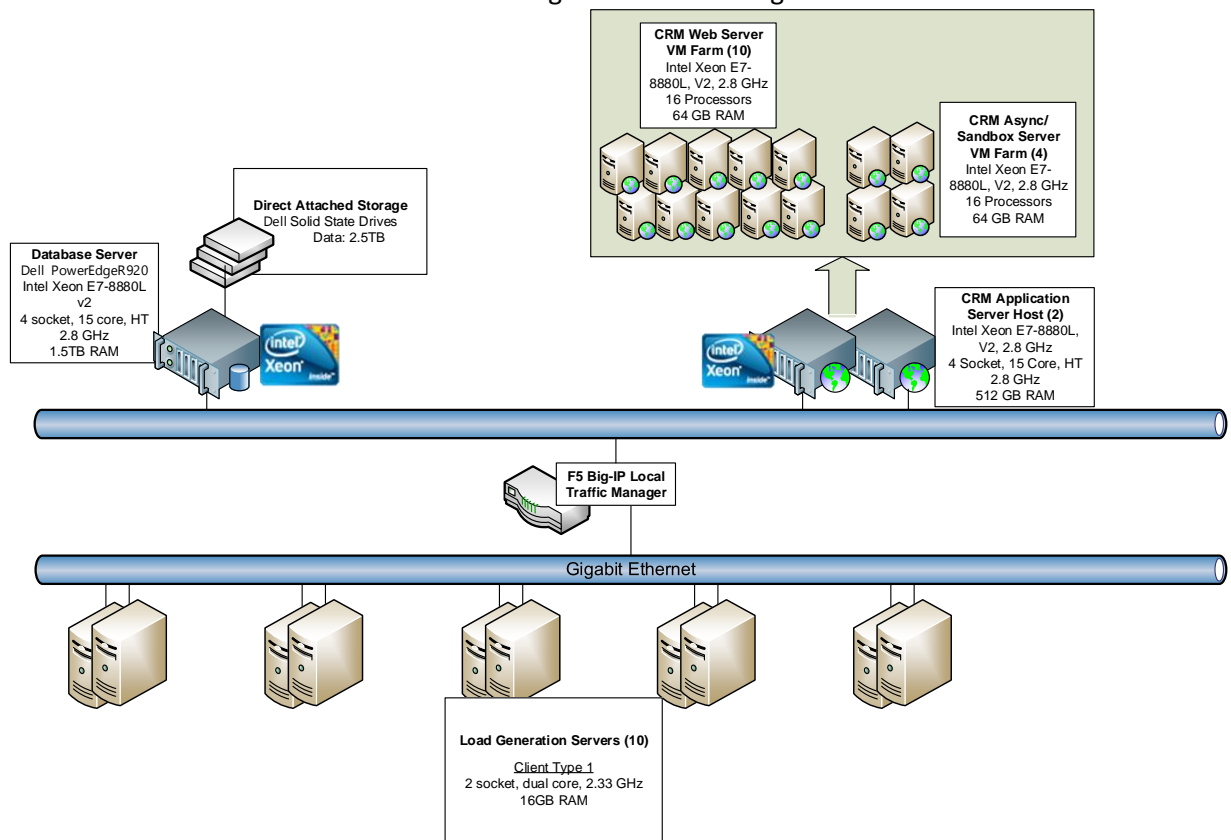


Figure 2. Hardware environment.

MICROSOFT SQL SERVER

SQL Server was deployed on a Dell PowerEdge R920 server configured with four processors from the Intel Xeon processor E7-4880 v2 family, each of which provides fifteen cores and two threads per core (Intel Hyper-Threading Technology was turned on). The fully-configured database server provided a total of 60 cores and 120 threads operating at 2.8 GHz. It was configured with 1.5 TB of memory and four Dell PowerEdge Express Flash NVMe drives.

Microsoft SQL Server	
Manufacturer	Dell
Model	Dell PowerEdge R920
Operating System	Microsoft Windows Server 2012 Enterprise 64-bit
Processor	4 x Intel Xeon processor E7-4880 v2 (15-core, 30-thread, 2.8 GHz)
RAM	1.5 TB
Direct Storage	
Dell PowerEdge Express Flash NVMe drives	4 x 1.6 TB
Serial ATA (SATA) Intel SSDs	2 x 400 GB
SATA Intel SSDs	4 x 800 GB
SATA HDDs	8 x 600 GB at 15,000 RPM
Disk Space (Operating System)	2 x 400 GB = 800 GB, SATA Intel SSDs in RAID 1
Disk Space (SQL Data and Log Drive)	4 x 1.6 TB = 6.4 TB, PCIe Gen 3 NVMe SSDs in RAID 0
Disk Space (SQL Data and Log Drive) Option II	4 x 800 GB = 3.2 TB, Intel SATA SSDs in RAID 0
Disk Space (Storage)	8 x 600 GB = 4.8 TB, SATA HDDs in RAID 0
Network Adapters	Intel 10Gb SFP+ rNDC with 2 x 1 Gb NIC and 2 x 10 Gb NIC

MICROSOFT DYNAMICS CRM SERVERS

The Microsoft Dynamics CRM servers were deployed on Hyper-V virtual machines hosted on two Dell PowerEdge R920 servers, each configured with four processors from the Intel Xeon processor E7-8880L v2 product family. Intel Hyper-Threading Technology was turned on, so each of the two servers provided 60 cores and 120 threads, operating at 2.2 GHz. Each of these Microsoft Dynamics CRM servers was also configured with 512 GB of memory and four Serial ATA (SATA) Intel SSDs, and each ran Windows Server 2012 R2. There were a total of 10 front-end Microsoft Dynamics CRM servers and 4 servers running the asynchronous and sandbox services.

Microsoft Dynamics CRM Servers (Physical)	
Manufacturer	Dell
Model	Dell PowerEdge R920
Operating System	Windows Server 2012 Enterprise 64-bit
Processor	4 x Intel Xeon processor E7-8880L v2 (15-core, 30-thread, 2.2 GHz)
RAM	512 GB
Direct Storage	
SATA Intel SSDs	4 x 400 GB
Disk Space (Operating System)	4 x 400 GB = 1.6 TB, SATA Intel SSDs in RAID 0
Network Adapters	Intel 10Gb SFP+ rNDC with 2 x 1 Gb NIC and 2 x 10 Gb NIC

Microsoft Dynamics CRM Servers (Virtual)	
Virtual CPUs	16 virtual dedicated processors
Memory	64 GB dedicated memory
Disk Space	128 GB dedicated disk space
Network Connection Speed	1 GB network connection

LOAD BALANCER HARDWARE

The BIG-IP from F5 Networks was used as a load balancer for the client traffic. The specifications of the load balancer are as follows.

Load Balancer	
Manufacturer and Model	F5 BIG-IP Local Traffic Manager
Balancing Algorithm	Least connections (member)

CLIENT SERVERS

There were a total of 10 client servers, and each simulated a load of 15,000 virtual users. The client servers were HP ProLiant DL 380 G5 servers powered by the Intel Xeon processor LV 5148 series with 16 GB of memory. Each server was running Windows Server 2012 R2 and generated transactional loads using load testing infrastructure from the Visual Studio Test Suite.

TEST RESULTS

The results of the benchmark study validate that a Microsoft Dynamics CRM 2013 implementation that includes Windows Server 2012 R2 and SQL Server 2012 Enterprise Edition running on Dell PowerEdge R920 servers powered by the Intel Xeon processor E7 v2 family with Dell PowerEdge Express Flash NVMe PCIe drives can support up to 150,000 concurrent users on a single instance, with average response times of 440 ms. With 150,000 concurrent users, the application executed 1.00 million business transactions per hour. The results are summarized in the following table.

Metric Measured	Value
Web Requests/Second	1,799
Average Page Time	0.44 seconds
Business Transactions/Second	279
Avg. Microsoft SQL Server CPU Utilization	23.8 percent
Avg. SQL Transactions/second	1,837
Avg. Disk Sec/Read (SQL Data and Log Partition)	0.000240
Avg. Disk Sec/Write (SQL Data and Log Partition)	0.000077
Avg. Disk Queue Length	0.064
Avg. Microsoft Dynamics CRM Server Utilization	58.4 percent

With 150,000 concurrent users, the application executed a projected transaction rate of 24,105,600 business transactions per day. Figure 3 illustrates the average page response times over the course of the run and the user load over the course of the run.

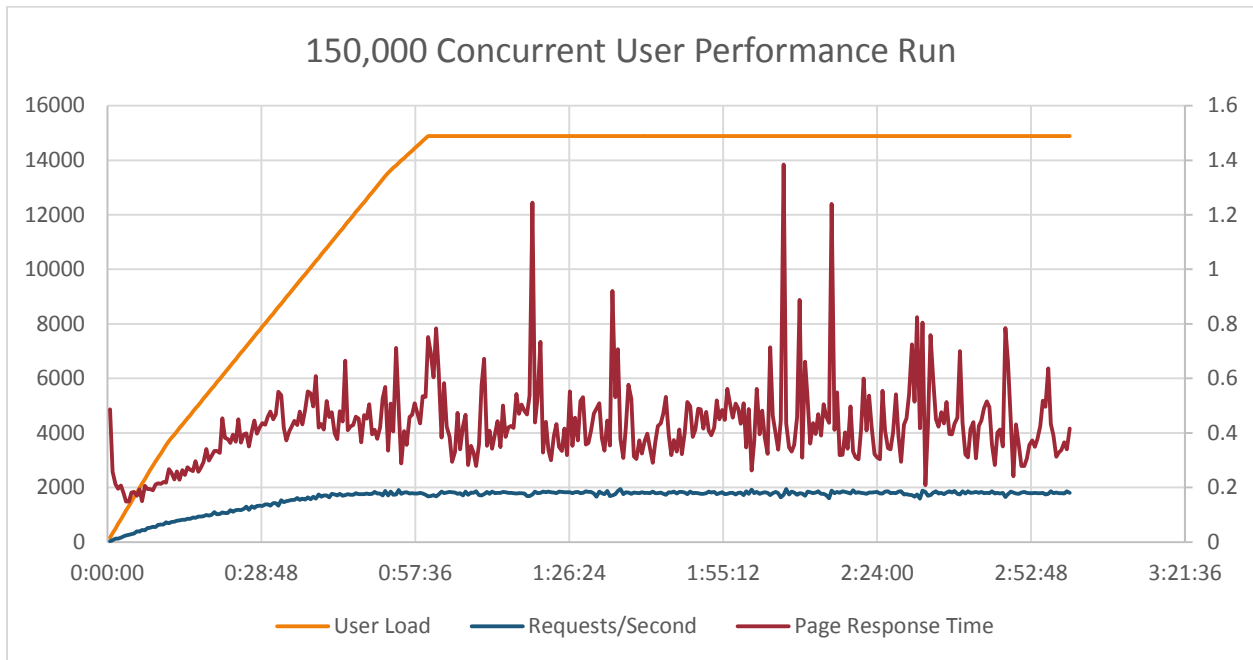


Figure 3. Average page response times and user load over the course of the run

Note: The two counters of initial focus are average disk seconds per read and average disk seconds per write. The following range is a standard typically used to evaluate disk reads per second and disk writes per second:

- Very Good: less than 0 .010
- Adequate: 0.010 - 0.020
- Slow: 0.020 - 0.050
- Poor: greater than 0 .050

Note: The test results were achieved with minimal tuning and optimization. Advanced tuning and optimization might deliver better user scalability.

Note: For more details on the effects of storage devices on the performance of Microsoft CRM 2013 with different numbers of concurrent users, see [Appendix C](#).

Important: This benchmark focuses on server-side performance and metrics. Response times in this document are in no way indicative of client responsiveness, for example, in loading a form or performing a complete transaction.

CONCLUSION

This benchmark demonstrates that a single instance of Microsoft Dynamics CRM 2013 running on servers powered by the Intel Xeon processor E7 v2 family and configured with Dell PowerEdge Express Flash NVMe PCIe drives can scale to support an enterprise implementation of 150,000 concurrent users, while achieving discrete atomic response times under one second. Enterprises often deploy multiple Microsoft Dynamics CRM instances to serve the diverse needs of different business units and geographies.

Based on these results, an organization with a similar data and transaction volume can expect similar results. However, no two enterprise implementations of Microsoft Dynamics CRM are the same. Multiple factors can affect performance, including the following:

- Number of records in the database
- Number, type, and frequency of transactions
- Processing power dedicated to workflows or plug-ins
- Proper maintenance and regular performance tuning

While this benchmark demonstrates scalability under high transaction rates, customers should evaluate the requirements of their own environments before undertaking a large-scale deployment. The Microsoft Dynamics CRM 2013 Performance and Stress Testing Toolkit provides tools to assist companies in this effort.

APPENDIX A: ADDITIONAL RESOURCES

MICROSOFT

- Microsoft Dynamics CRM
<http://www.microsoft.com/dynamics/crm/default.aspx>
- Microsoft Dynamics CRM 2013 Implementation Guide
[http://technet.microsoft.com/en-us/library/hh699811\(v=crm.6\).aspx](http://technet.microsoft.com/en-us/library/hh699811(v=crm.6).aspx)
- Performance Toolkit for Microsoft Dynamics CRM 2013 (when available)
<http://go.microsoft.com/fwlink/?LinkID=393000>

Note: Much of the following *Microsoft Dynamics CRM 2011* documentation is also relevant for Microsoft Dynamics CRM 2013. These documents are expected to be updated for Microsoft Dynamics CRM 2013 soon.

- “Optimizing and Maintaining a Microsoft Dynamics CRM 2011 Server Infrastructure”
<http://go.microsoft.com/fwlink/?LinkId=213093>
- “Improving Microsoft Dynamics CRM Performance and Securing Data with Microsoft SQL Server 2008 R2”
<http://go.microsoft.com/fwlink/?LinkId=226926>

INTEL

- Intel Xeon Processor E7 v2 Family
 - <http://www.intel.com/content/www/us/en/processors/xeon/xeon-processor-e7-family.html>
- Intel Cache Acceleration Software
 - <http://www.intel.com/content/www/us/en/software/intel-cache-acceleration-software.html>
- Intel Cache Acceleration Software Product Brief
 - <http://www.intel.com/content/www/us/en/software/intel-cache-acceleration-software-product-brief.html>
- Intel Cache Acceleration Software 30-Day Free Trial
 - <https://www-ssl.intel.com/content/www/us/en/forms/cache-acceleration-contact-us.html>
- Intel Solid-State Drives
 - <http://www.intel.com/content/www/us/en/solid-state-drives/solid-state-drives-ssd.html>
- Intel Mission Critical Technologies and Solutions
 - <http://www.intel.com/content/www/us/en/mission-critical/mission-critical-meeting-todays-it-challenges.html>

DELL

- Dell PowerEdge Express Flash
 - www.dell.com/poweredge/expressflash

F5 NETWORKS

- Deploying F5 for High Availability
<http://www.f5.com/pdf/deployment-guides/ltm-dynamics-crm-dg.pdf>
- F5 Solutions for Microsoft Applications
<http://www.f5.com/microsoft>

APPENDIX B: BENCHMARKING RESULTS COMPARISON CHARTS BETWEEN MICROSOFT DYNAMICS CRM 2011 AND MICROSOFT DYNAMICS CRM 2013

TABLE 1: KEY BENCHMARK TEST PARAMETERS

Test Parameters	Microsoft Dynamics CRM 2011 Testing	Microsoft Dynamics CRM 2013 Testing
Concurrent Users Tested	150,000	150,000
Business Transactions/Hour	703,080	1,004,400
Business Transaction Frequency	1 transaction/8 minutes/user	1 transaction/6 minutes/user
Web Requests/Hour	5.5 million	6.48 million
Average Page Time	0.46 seconds	0.44 seconds
Database Size	720 GB	2,500 GB

TABLE 2: KEY BENCHMARK RESULTS

Metric	Microsoft Dynamics CRM 2011 Testing	Microsoft Dynamics CRM 2013 Testing
Atomic Web Request Response Time	0.46 seconds	0.44 seconds
Average Microsoft SQL Server CPU Utilization	42 percent	23.8 percent
Average SQL Transactions/Second	-	1,837
Average Disk Sec/Read (SQL Data and Log Partition)	0.0032	0.000240
Average Disk Sec/Write (SQL Data and Log Partition)	0.0044	0.000077
Average Queue Length	1.88	0.064
Average Microsoft Dynamics CRM Server Utilization	42 percent	58.4 percent

TABLE 3: ROW COUNTS FOR TABLES WITH 10000+ ROWS

Table Name	Number of Records in Microsoft Dynamics CRM 2011	Number of Records in Microsoft Dynamics CRM 2013
CustomerAddressBase	8,180,034	243,992,508
ActivityPartyBase	77,984,427	198,695,584
EmailSearchBase	9,330,583	172,185,209
ImageDescriptor	0	147,375,097
LeadAddressBase	11,755,238	100,078,158
ActivityPointerBase	27,531,110	79,564,478
ContactBase	2,268,402	76,949,906

ConnectionBase	2,810,038	50,760,972
LeadBase	5,877,619	50,039,079
OpportunityBase	2,666,111	48,407,505
AccountBase	1,821,615	45,046,348
OpportunityProductBase	2,498,437	13,555,697
TaskBase	10,534,474	8,841,026
PrincipalObjectAccess	4,107,233	5,093,475
PrincipalEntityMap	2,082,166	2,525,550
SystemUserBusinessUnitEntityMap	2,340,727	1,829,486
AnnotationBase	14,010,354	1,804,050
IncidentBase	2,870,096	1,548,741
PrincipalAttributeAccessMap	2,291,960	1,302,880
QuoteDetailBase	1,048,732	670,884
SystemUserPrincipals	717,622	600,004
InvoiceDetailBase	929,163	590,640
QuoteBase	1,324,553	493,874
CampaignActivityItemBase	43,382	483,241
SalesOrderDetailBase	942,581	420,886
InternalAddressBase	300,210	310,238
MailboxBase	0	307,346
CalendarBase	300,323	300,323
CalendarRuleBase	300,322	300,322
SalesOrderBase	1,054,413	271,436
InvoiceBase	937,746	208,595
PostBase	0	192,495
PostRegardingBase	0	192,495
PostRoleBase	0	192,495
PostCommentBase	0	192,491
ListBase	269,309	175,367
PostFollowBase	0	171,866
QueueBase	262,260	157,345
OwnerBase	180,409	155,141
ResourceBase	150,165	150,165
SystemUserBase	150,003	150,003
TeamMembership	267,619	150,001
UserSettingsBase	150,001	150,001
SystemUserRoles	149,995	149,998
ListMemberBase	653,893	143,102
new_imBase	375,060	115,714

TABLE 4: BUSINESS SCENARIOS TESTED

Business Transactions	
Salesperson	
ActivityByMonthDueChart	MoCA_CreateNewAccount
AccountRecordWall	MoCA_CreateNewContact
ContactRecordWall	MoCA_CreateNewLead
CreateFollowingWallPost	MoCA_CreateNewOpportunity
LeadRecordWall	MoCA_FindAccounts
OpportunityRecordWall	MoCA_FindContacts
AddCompetitorToLead	MoCA_OpenAccount
AddCompetitorToOpportunity	MoCA_OpenAppointment
MoCA_AccountActivityRollup	MoCA_OpenContact
MoCA_AccountByOwnerChart	MoCA_OpenEmail
MoCA_AccountConnectionRollup	MoCA_OpenLead
MoCA_AccountOppRollup	MoCA_OpenOpportunity
MoCA_AccountSCRollup	MoCA_OpenTask
MoCA_ActivityByMonthDueChart	SalesPerformanceDashboard
MoCA_AddActivityToAccount	SalesActivityDashboard
MoCA_AddActivityToLead	OpenAccount
MoCA_AddCompetitorToLeadRF	OpenContact
MoCA_AddCompetitorToOpportunityRF	OpenLead
RefreshGridCampaignActivity	UpdateAccount
RefreshGridCampaignResponse	UpdateAccountWithCustomAttributes
RefreshGridIM	UpdateContact
GridFilterAccounts	UpdateContactWithCustomAttributes
GridFilterContacts	UpdateOpportunity
GridFilterLead	CreateNewAccount
GridFilterOpportunities	CreateNewAccountWithCustomAttributes
FindAccount	CreateNewContact
FindContact	CreateNewContactWithCustomAttributes
CreateIM	CreateNewNoteForOpportunity
AddActivityToAccount	UpdateLead
AddActivityToLead	UpdateTask
AdvancedFindAccount	UpdateTaskWithCustomAttributes
OpenLeadsMonthlyReport	RetrieveMultipleAccount
OpportunityByOwnerReport	RetrieveMultipleEmail
SalesPipelineReport	ShareAccounts
UpdateEmail	UpdateAppointment
UpdateFax	RefreshGridAccount
UpdatePhoneCall	RefreshGridActivities
MyCalendar	RefreshGridAppointment

OpenEmail	RefreshGridContact
RefreshGridFax	RefreshGridEmail
RefreshGridLetter	RefreshGridLead
RefreshGridPhoneCall	RefreshGridOpportunity
DeleteNoteOnAccount	RefreshGridTask
DeleteNoteOnContact	QuickCreateNewAccount
DeleteNoteOnLead	OpportunityGridWithSalesPipeline
DeleteNoteOnOpportunity	OpportunityGridWithTop10Opportunity
DeleteNoteOnTask	AdvancedFindContact
CreateFax	OpenAppointment
CreateNewNoteForAccount	OpenOpportunity
CreateNewNoteForContact	CreateTaskWithCustomAttributes
CreateNewNoteForLead	CreateTask
CreateNewNoteForTask	CreateNewQueue
CreatePhonecall	CreateNewLead
AdvancedFindAccountNotes	CreateEmail
AdvancedFindContract	CreateAppointment
MoCA_QuickCreateNewAccount	MoCA_AssignLeadToTeam
MoCA_RefreshGridAccount	MoCA_AssignContact
MoCA_RefreshGridActivity	MoCA_AssignLead
MoCA_RefreshGridAppointment	MoCA_AssignOpportunity
MoCA_RefreshGridContact	MoCA_AssignAccountToTeam
MoCA_RefreshGridEmail	MoCA_CreateAppointment
MoCA_RefreshGridLead	MoCA_CreateNewCompetitor
MoCA_RefreshGridOpportunity	MoCA_CreateNewNoteForAccount
MoCA_RefreshGridPhonecall	MoCA_CreateNewNoteForContact
MoCA_RefreshGridTask	MoCA_CreateNewNoteForLead
MoCA_UpdateAccount	MoCA_CreateNewNoteForOpp
MoCA_UpdateAppointment	MoCA_CreateNewNoteForTask
MoCA_UpdateContact	MoCA_CreatePhoneCall
MoCA_UpdateLead	MoCA_CreateTask
MoCA_UpdateOpportunity	MoCA_LeadWithChart
MoCA_UpdatePhoneCall	MoCA_OpenPhoneCall
MoCA_UpdateTask	AssignAccount
MoCA_CloseOpportunityAsLostRF	AssignAccountToTeam
MoCA_CloseOpportunityAsWonRF	AssignContact
	AssignLead
Sales Manager	
AccountRecordWall	AdvancedFindProduct
ContactRecordWall	AssignLeadToTeam
CreateFollowingWallPost	MoCA_LeadWithChart
LeadRecordWall	MoCA_OpenPhoneCall
OpportunityRecordWall	SalesPipelineReport

AddCompetitorToLead	AccountOverviewReport
AddCompetitorToOpportunity	MoCA_CloseOpportunityAsLostRF
MoCA_AccountActivityRollup	MoCA_CloseOpportunityAsWonRF
MoCA_AccountConnectionRollup	MoCA_CreateNewAccount
MoCA_AccountOppRollup	MoCA_CreateNewContact
MoCA_AccountSCRollup	MoCA_CreateNewLead
MoCA_ActivityByMonthDueChart	MoCA_CreateNewOpportunity
MoCA_AddActivityToAccount	MoCA_FindAccounts
MoCA_AddActivityToLead	MoCA_FindContacts
MoCA_AddCompetitorToLeadRF	MoCA_OpenAccount
MoCA_AddCompetitorToOpportunityRF	MoCA_OpenAppointment
MoCA_AssignAccount	MoCA_OpenContact
MoCA_AssignAccountToTeam	MoCA_OpenEmail
MoCA_AssignContact	MoCA_OpenLead
MoCA_AssignLead	MoCA_OpenOpportunity
MoCA_AssignLeadToTeam	MoCA_OpenTask
MoCA_AssignOpportunity	MoCA_OpportunityGridWithChart
MoCA_CreateAppointment	MoCA_OpportunityGridWithSalesPipeline
MoCA_CreateNewNoteForAccount	MoCA_QuickCreateNewAccount
MoCA_CreateNewNoteForContact	MoCA_RefreshGridAccount
MoCA_CreateNewNoteForLead	MoCA_RefreshGridActivity
MoCA_CreateNewNoteForOpp	MoCA_RefreshGridAppointment
MoCA_CreateNewNoteForTask	MoCA_RefreshGridContact
MoCA_CreatePhoneCall	MoCA_RefreshGridEmail
MoCA_CreateTask	MoCA_RefreshGridLead
RetrieveMultipleAccount	MoCA_RefreshGridOpportunity
ProductsByOpportunityReport	MoCA_RefreshGridPhonecall
ProductsByContactReport	MoCA_RefreshGridTask
OpportunityByOwnerReport	MoCA_UpdateAccount
OpenLeadsMonthlyReport	MoCA_UpdateAppointment
NeglectedLeadsReport	MoCA_UpdateContact
NeglectedAccountsReport	MoCA_UpdateLead
CreateNewCompetitor	MoCA_UpdateOpportunity
CompetitorWinLossReport	MoCA_UpdatePhoneCall
AdvancedFindAccount	MoCA_UpdateTask
AdvancedFindContact	UnitTest_MultiEntityQuickFindRequest
Customer Service Manager	
AssignServiceCase	ResolvedCaseSatisfactionChart
CreateNewCase	ServiceActivityVolumeReport
AddCaseToQueue	TopKnowledgeBaseArticlesReport
OpenQueueItem	OpenPhoneCall
CreateAppointment	OpenTask
CreateEmail	UpdateLetter

CreateServiceCaseAccount	UpdatePhoneCall
ProgressAgainstGoalsReport	CreatePhoneCall
Marketing Professional	
AddMembersToList	UpdateEmail
CopyListMembers	UpdatePhoneCall
CreateCampaignActivity	UpdateTask
CreateNewCampaign	FindAccount
CreateNewList	CreateEmail
CreatePlanningTask	CreatePhoneCall
DisplayListMembers	CreateTask
OpenAppointment	CreateAppointment
OpenEmail	RefreshGridCampaignActivity
OpenPhoneCall	RecurringTagTM
OpenTask	CampaignComparisonReport
RefreshGridContact	CampaignActivityStatusReport
Customer Service Representative	
CreateAppointment	UpdatePhoneCall
CreateLetter	UpdateTask
CreateNewCase	CreateNewNoteForTask
CreatePhoneCall	RefreshGridActivities
CreateTask	RecurringTagTM
UpdateAppointment	FindContact
UpdateEmail	FindAccount
UpdateLetter	OpenQueueItem
Scheduler	
DisplaySchedule	OpenTask
DisplayWorkHours	UpdateAppointment
CreateAppointment	UpdateEmail
CreateTask	UpdateTask
OpenAppointment	
Marketing Manager	
MarketingDashboard	CreateCampaignResponse
AddMembersToList	CreateNewCampaign
AdvancedFindProduct	CreateNewCompetitor
AssignLeadToTeam	CreateNewList
CampaignActivityStatusReport	CreatePlanningTask
CampaignComparisonReport	DisplayListMembers
CampaignPerformanceReport	DistributeCampaignActivity
CopyListMembers	RefreshGridCampaignActivity
CreateCampaignActivity	RefreshGridCampaignResponse
Sales Associate	
ActivityByMonthDueChart	MoCA_CreateNewLead

AccountRecordWall	MoCA_CreateNewOpportunity
ContactRecordWall	MoCA_FindAccounts
CreateFollowingWallPost	MoCA_FindContacts
LeadRecordWall	MoCA_OpenAccount
OpportunityRecordWall	MoCA_OpenAppointment
AddCompetitorToLead	MoCA_OpenContact
MoCA_AccountActivityRollup	MoCA_OpenEmail
MoCA_AccountByOwnerChart	MoCA_OpenLead
MoCA_AccountConnectionRollup	MoCA_OpenOpportunity
MoCA_AccountOppRollup	MoCA_OpenTask
MoCA_AccountSCRollup	SalesPerformanceDashboard
MoCA_ActivityByMonthDueChart	SalesActivityDashboard
MoCA_AddActivityToAccount	OpenAccount
MoCA_AddActivityToLead	OpenContact
RefreshGridCampaignActivity	OpenLead
RefreshGridCampaignResponse	UpdateAccount
RefreshGridIM	UpdateAccountWithCustomAttributes
GridFilterAccounts	UpdateContact
GridFilterContacts	UpdateContactWithCustomAttributes
GridFilterLead	UpdateOpportunity
GridFilterOpportunities	CreateNewAccount
FindAccount	CreateNewAccountWithCustomAttributes
FindContact	CreateNewContact
CreateIM	CreateNewContactWithCustomAttributes
AddActivityToAccount	CreateNewNoteForOpportunity
AddActivityToLead	UpdateLead
AdvancedFindAccount	UpdateTask
OpenLeadsMonthlyReport	UpdateTaskWithCustomAttributes
OpportunityByOwnerReport	RetrieveMultipleAccount
SalesPipelineReport	RetrieveMultipleEmail
UpdateEmail	ShareAccounts
UpdateFax	UpdateAppointment
UpdatePhoneCall	RefreshGridAccount
MyCalendar	RefreshGridActivities
OpenEmail	RefreshGridAppointment
RefreshGridFax	RefreshGridContact
RefreshGridLetter	RefreshGridEmail
RefreshGridPhoneCall	RefreshGridLead
DeleteNoteOnAccount	RefreshGridOpportunity
DeleteNoteOnContact	RefreshGridTask
DeleteNoteOnLead	QuickCreateNewAccount
DeleteNoteOnOpportunity	OpportunityGridWithSalesPipeline
DeleteNoteOnTask	OpportunityGridWithTop10Opportunity

CreateFax	AdvancedFindContact
CreateNewNoteForAccount	OpenAppointment
CreateNewNoteForContact	OpenOpportunity
CreateNewNoteForLead	CreateTaskWithCustomAttributes
CreateNewNoteForTask	CreateTask
CreatePhoneCall	CreateNewQueue
AdvancedFindAccountNotes	CreateNewLead
AdvancedFindContract	CreateEmail
MoCA_QuickCreateNewAccount	CreateAppointment
MoCA_RefreshGridAccount	MoCA_AssignLeadToTeam
MoCA_RefreshGridActivity	MoCA_AssignContact
MoCA_RefreshGridAppointment	MoCA_AssignLead
MoCA_RefreshGridContact	MoCA_AssignOpportunity
MoCA_RefreshGridEmail	MoCA_AssignAccountToTeam
MoCA_RefreshGridLead	MoCA_CreateAppointment
MoCA_RefreshGridOpportunity	MoCA_CreateNewNoteForAccount
MoCA_RefreshGridPhoneCall	MoCA_CreateNewNoteForContact
MoCA_RefreshGridTask	MoCA_CreateNewNoteForLead
MoCA_UpdateAccount	MoCA_CreateNewNoteForOpp
MoCA_UpdateAppointment	MoCA_CreateNewNoteForTask
MoCA_UpdateContact	MoCA_CreatePhoneCall
MoCA_UpdateLead	MoCA_CreateTask
MoCA_UpdateOpportunity	MoCA_LeadWithChart
MoCA_UpdatePhoneCall	MoCA_OpenPhoneCall
MoCA_UpdateTask	AssignAccount
MoCA_CloseOpportunityAsLostRF	AssignAccountToTeam
MoCA_CloseOpportunityAsWonRF	AssignContact
MoCA_CreateNewAccount	AssignLead
MoCA_CreateNewContact	

TABLE 5: CRM DATABASE SERVER HARDWARE

Microsoft SQL Server	
Manufacturer	Dell
Model	Dell PowerEdge R920
Operating System	Windows Server 2012 Enterprise 64-bit
Processor	4 x Intel Xeon processor E7-4880 v2 (15-core, 30-thread, 2.5 GHz)
RAM	1.5 TB
Direct Storage	
Dell PowerEdge Express Flash NVMe PCIe drives	4 x 1.6 TB
SATA Intel SSDs	2 x 400 GB
SATA Intel SSDs	4 x 800 GB
SATA HDDs	8 x 600 GB @ 15,000 RPM
Disk Space (Operating System)	2 x 400 GB = 800 GB, SATA Intel SSDs in RAID 1
Disk Space (SQL Data and Log Drive)	4 x 1.6 TB = 6.4 TB, PCIe Gen 3 NVMe SSDs in RAID 0
Disk Space (SQL Data and Log Drive) Option II	4 x 800 GB = 3.2TB, SATA Intel SSDs in RAID 0
Disk Space (Storage)	8 x 600 GB = 4.8TB, SATA HDDs in RAID 0
Network Adapters	Intel 10Gb SFP+ rNDC with 2 x 1 Gb NIC and 2 x 10 Gb NIC

TABLE 6: CRM WEB SERVER HOSTS (2 PHYSICAL SERVERS)

Microsoft Dynamics CRM Server Hosts	
Manufacturer	Dell
Model	Dell PowerEdge R920
Operating System	Windows Server 2012 Enterprise 64-bit
Processor	4 x Intel Xeon processor E7-8880L v2 (15-core, 30-thread, 2.2 GHz)
RAM	512 GB
Direct Storage	
SATA Intel SSDs	4 x 400 GB
Disk Space (Operating System)	4 x 400 GB = 1.6 TB, SATA Intel SSDs in RAID 0
Network Adapters	Intel 10Gb SFP+ rNDC with 2 x 1 Gb NIC and 2 x 10 Gb NIC

TABLE 7: CRM SERVERS (10 CRM APPLICATION SERVERS, 4 CRM ASYNC/SANDBOX SERVERS)

Microsoft Dynamics CRM Servers	
Virtual CPUs	16 virtual dedicated processors
Memory	64 GB dedicated memory
Disk Space	128 GB dedicated disk space
Network Connection Speed	1 Gb network connection

TABLE 8: LOAD BALANCER HARDWARE

Load Balancer	
Manufacturer	F5 BIG-IP Local Traffic Manager
Balancing Algorithm	Least connections

TABLE 9: LOAD GENERATION SERVER

Load Generation Servers	
Manufacturer and Model	HP ProLiant DL380 G5
Operating System	Windows Server 2012 R2
Processor	2 socket, dual core, 2.33 GHz
Network Adapter	1 GB NIC
RAM	16 GB
Software	Microsoft Visual Studio 2010 SP1

APPENDIX C: EFFECTS OF HARDWARE CONFIGURATION ON PERFORMANCE

EFFECT OF STORAGE DEVICES ON PERFORMANCE

To understand the effect of storage devices on the performance of Microsoft Dynamics CRM, various storage types were used to store the SQL data, log data, and temp DB. Workloads with 30,000 to 150,000 concurrent users were run with each storage configuration. To isolate the effect of storage, the memory available for SQL Server was reduced to 96 GB, which forces SQL Server to access data from the storage devices. The various configurations were as follows.

1. All HDDs (at 15,000 RPM)
2. SATA Intel SSDs
3. Dell PowerEdge Express Flash NVMe PCIe drives

Performance results are shown in the following table. In each case, the use of SSDs increased the number of business transactions performed per second by approximately two times, while reducing the average response time by more than six seconds.

TABLE 10: EFFECTS OF STORAGE DEVICES ON PERFORMANCE

User Count	Description	Average Processor Time	Business Transactions/Sec	Page Requests/Sec	Average Response Time in Seconds
30,000 Users	96 GB Memory, HDD Storage	11.6%	41.9	244	6.4
	96 GB Memory, SATA SSD Storage	17.2%	82.3	553	0.12
	96 GB Memory, Dell PowerEdge Express Flash NVMe drives	14.0%	82.3	554	0.12

INTEL CACHING ALGORITHM SOFTWARE OPTIMIZATION

Intel CAS is a server-side caching application that automatically moves the most active data onto SSDs, and is transparent to applications. It offers a way to achieve some of the performance benefits of SSDs using a small number of SSDs, rather than deploying a more costly, all-SSD storage configuration.

Performance tests were performed to measure the relative benefits of using a single SSD with Intel CAS versus using all SSDs. The results showed that a full SSD deployment was required to realize the full performance potential of the server. When the server was configured with all SSDs, the average page time response was well under one second. However, combining HDDs with one SSD and Intel CAS increased the average number of business transactions per second by 23 percent and decreased the average response time by 49 percent compared with the HDD-only configuration—at a much lower cost.

Based on these results, using existing HDD storage with Intel CAS and a small SSD footprint can increase performance significantly, without the expense of a full transition to SSD storage. The results are summarized in the following table.

TABLE 11: EFFECTS OF INTEL CAS SOFTWARE WITH SSDS ON PERFORMANCE

User Count	Description	Average Processor Time	Business Transactions/Sec	Page Requests/Sec	Average Response Time in Seconds
30,000 Users	96 GB memory, HDD storage	11.6%	41.9	244	6.4
	96 GB memory, HDD storage with Intel CAS and one SATA Intel SSD	12.5%	54.2	335	3.28
	96 GB memory, SATA SSD Storage	17.2%	82.3	553	0.12

Note: The performance of the CRM system in these tests is for the constrained case in which 96 GB of memory is provided for SQL Server. The performance of Microsoft Dynamics CRM would be more optimal if more memory were available.

APPENDIX D: KEY BENCHMARK COMPONENT DETAILS

The key hardware components used in the testing of Microsoft Dynamics CRM are detailed in the following sections.

INTEL XEON PROCESSOR E7 v2 FAMILY

The demands on enterprise databases continue to increase as businesses are challenged to support growing workloads and data volumes and to integrate advanced analytics to improve strategic planning and tactical execution. The Intel Xeon processor E7 v2 family is designed to address these growing challenges. Servers based on these processors offer leadership performance and scalability for demanding enterprise workloads, along with advanced reliability, availability, and serviceability (RAS) features that rival those of high-end RISC-based architectures.

In combination with advances provided in Windows Server 2012 and SQL Server 2012, servers based on these processors provide a powerful platform for next-generation database, analytics, and business intelligence (BI) applications across native, virtual, and cloud deployment models.

Up to Two Times Higher Performance

The Intel Xeon processor E7 v2 family provides major improvements in performance and scalability, with up to 50 percent more cores and threads and 25 percent more cache than the previous generation Intel Xeon processor E7 family. A single eight-socket server provides up to 120 cores and 240 threads to support high-volume transactional workloads and complex analytics for large user populations.

To enable sustainable high performance under heavy workloads, these processors include integrated PCIe 3.0, which helps increase system bandwidth by up to 400 percent versus previous generation processors.¹ Data flows faster to keep the large number of cores and threads operating at high utilization. Intel internal tests have confirmed the performance benefits of these improvements, demonstrating up to two times average performance gains across a range of workloads versus servers based on the Intel Xeon processor E7 family.

Three Times Higher Memory Capacity

Two major trends are generating a need for dramatically higher memory capacity in enterprise-class servers. One is the move toward virtualizing tier-1 applications; the other is the transition toward in-memory computing to support real-time analytics acting on large datasets. The Intel Xeon processor E7 v2 family offers up to three times the data capacity of previous-generation processors to support these memory-intensive use cases.

A four-socket server based on the Intel Xeon processor E7 v2 family can be configured with up to 6 TB of memory and an eight-socket server with up to 12 TB. In most IT and business environments, this is more

¹ Up to 4x I/O bandwidth claim based on Intel internal estimates of the Intel Xeon processor E7-4890 v2 performance normalized against the improvements over the dual-I/O Hub (IOH) Intel Xeon processor E7-4870 based on internal bandwidth tool running the 1R1W test.

than enough memory to support multiple large databases running on a single, virtualized server platform. It is also enough to implement in-memory computing on an enterprise scale. Many of today's largest databases can now be contained within the memory of a single server based on the Intel Xeon processor E7 v2 family. As the transition to in-memory computing accelerates, these servers offer an ideal hardware platform.

Advanced RAS for Mission-Critical Applications

For several years now, server platforms based on the Intel Xeon processor E7 family and the Windows Server operating system have been delivering uptime levels that are comparable with those provided by best-in-class RISC and UNIX platforms.² The mission-critical capability of the combined platform continues to increase with every new product release.

The Intel Xeon processor E7 v2 family includes Intel Run Sure Technology³, which includes more than 40 reliability features to improve data integrity and system uptime. Resilient Memory Technologies continuously scan the memory subsystem, and Resilient System Technologies enable the server to automatically recover from complex errors, even when they occur in the execution path or PCIe links.

The Intel Xeon processor E7 v2 family also provides enhanced error log information for improved diagnostics and predictive failure analysis. Intel and Microsoft have worked together to provide optimized support for these hardware features throughout the solution stack, so hardware and software work together to optimize data integrity and uptime.

Hardware-Enhanced Security

The Intel Xeon processor E7 v2 family provides hardware-enhanced security features that help protect systems, applications, and data more effectively. New features include the following.

- **Intel Data Protection Technology with Secure Key⁴** helps provide high quality security keys for more secure data encryption. Secure Key is transparent to applications and is automatically detected and used by Windows Server and other leading operating systems. Intel Data Protection Technology also includes Intel Advanced Encryption Standard New Instructions (Intel AES-NI),⁵ which offloads the most compute-intensive algorithms of the AES encryption and

² Information Technology Intelligence Consulting (ITIC): "Intel Xeon processor E7 Family Reaches Reliability Parity with RISC/UNIX, Delivers 99.999% Reliability, Availability, and Serviceability" July 2013.

<http://www.intel.com/content/dam/www/public/us/en/documents/white-papers/xeon-e7-ras-itic-paper.pdf>

³ No computer system can provide absolute reliability, availability, or serviceability. Requires an Intel® Run Sure Technology-enabled system, including an enabled Intel® processor and enabled technology. Built-in reliability features available on select Intel processors may require additional software, hardware, services, and/or an Internet connection. Results may vary depending upon configuration. Consult your system manufacturer for more details.

⁴ No system can provide absolute security. Requires an Intel Secure Key-enabled platform, available on select Intel processors, and software optimized to support Intel Secure Key. Consult your system manufacturer for more information.

⁵ Intel AES-NI requires a computer system with an AES-NI enabled processor, as well as non-Intel software to execute the instructions in the correct sequence. AES-NI is available on select Intel® processors. For availability, consult your reseller or system manufacturer. For more information, see <http://software.intel.com/en-us/articles/intel-advanced-encryption-standard-instructions-aes-ni/>

decryption protocols. Together, these technologies allow strong data encryption to be applied pervasively without slowing application performance.

- **Intel Platform Protection Technology with OS Guard**⁶ provides improved protection against malware attacks, by blocking execution of code from unauthorized memory locations. Intel Platform Protection Technology also includes Intel Trusted Execution Technology (TXT),⁷ which can be used to ensure that servers and hypervisors only boot into “known good states.” TXT helps to ensure that no malware of any kind has been inserted into the system prior to or during launch.

These built-in technologies are designed to complement existing enterprise security and compliance applications to enable more robust protection and reduced business risk in mission-critical computing environments.

For more information about the Intel Xeon processor E7 v2 family, go to:

<http://www.intel.com/content/www/us/en/processors/xeon/xeon-processor-e7-family.html>

INTEL CACHE ACCELERATION SOFTWARE

Intel Cache Acceleration Software (CAS) is server-side caching software that automatically moves the most active data onto high-performance SSDs to accelerate application performance. By adding Intel CAS and one or more SSDs to an application server, enterprises can get near flash performance at a fraction of the cost of migrating all back-end storage to SSDs. This innovative approach solves the storage I/O bottleneck while enabling better utilization of existing storage infrastructures.

Intel CAS is available for Windows and Linux and requires no changes to applications or back-end storage. As an application, such as Microsoft Dynamics CRM, reads data from storage, Intel CAS copies the data to the cache, which serves subsequent reads at higher speeds. Meanwhile, all data is written synchronously to back-end storage.

For more information about Intel CAS, go to <http://www.intel.com/content/www/us/en/software/intel-cache-acceleration-software.html>

DELL POWEREDGE EXPRESS FLASH NVME DRIVES

Listed here are some of the specifications of the PCIe Gen NVMe Solid-state drives.

- The 1.6TB drive is spec'ed at 20PB of write life (measured in TBW – Total Bytes Written)

⁶ No system can provide absolute security. Requires an Intel OS Guard-enabled platform, available on select Intel processors, and an enabled operating system. Consult your system manufacturer for more information.

⁷ No computer system can provide absolute security under all conditions. Intel Trusted Execution Technology (Intel® TXT) requires a computer with Intel Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). Intel TXT also requires the system to contain a TPM v1.s. For more information, visit <http://www.intel.com/technology/security>.

- Over Provisioning of NAND - This overprovisioning increases the endurance of the PCIe SSD by distributing the total number of writes and erases across a larger population of NAND flash blocks and pages over time. It also improves performance by giving the flash controller additional buffer space for managing program/erase (P/E) cycles and improving the probability that a write operation will have immediate access to a pre-erased block. In the Dell Express Flash NVMe devices, we include almost 30% overprovisioning.
- MTBF (Mean Time Between Fails)
 - for a typical HDD = 1 Million hours
 - for a Express Flash NVMe PCIe-SSD = 2 million hours
- BER (Bit Error Rate)
 - for PCIe specifications = 1.0×10^{-12}
 - for Express Flash NVMe PCIe-SSD = 1.0×10^{-18}
- Device Life Monitoring & SMART
 - Self-Monitoring Analysis and Reporting Technology (SMART) is a storage feature-set devices attempt to predict early degradation or fault conditions. Combined with Dell software management applications, users will be notified when a predicted failure is detected.
 - Device Write Life - NAND SSDs (industry wide) have a finite number of program and erase cycles. Dell warrants the Express Flash NVMe PCIe SSD to a maximum amount of data written to the device in total bytes written (TBW). Dell software management applications will proactively notify the user when approaching and reaching this limit. The program erase cycles supported per Express Flash NVMe capacity:
 - 400GB: 5PB
 - 800GB: 10PB
 - 1.6TB: 20PB
 - Device Write Status - NAND SSDs having a finite number of spare sectors and once exhausted, triggers the device and enters the Write-Protect Mode (Read-Only) to preserve existing data present. In Write Protect Mode, the user will only perform read operations to the device. Dell software management applications notify the user when this limit has reached

F5 BIG-IP LOCAL TRAFFIC MANAGER

Microsoft Dynamics CRM provides the ability to segment and cluster the specific server roles to facilitate the introduction of traffic management devices that deliver the networking support needed to provide mission-critical CRM application delivery.

Leveraging BIG-IP Local Traffic Manager (LTM) provides:

- High Availability
 - BIG-IP LTM is designed to be CRM system aware, sending users to CRM front end servers that are currently serving valid content. When a CRM front end is down, or otherwise unable to deliver the appropriate content, the BIG-IP LTM sends all users to

other front ends that are currently available. This ensures that users will always be sent to the most available CRM resources.

- Scalability

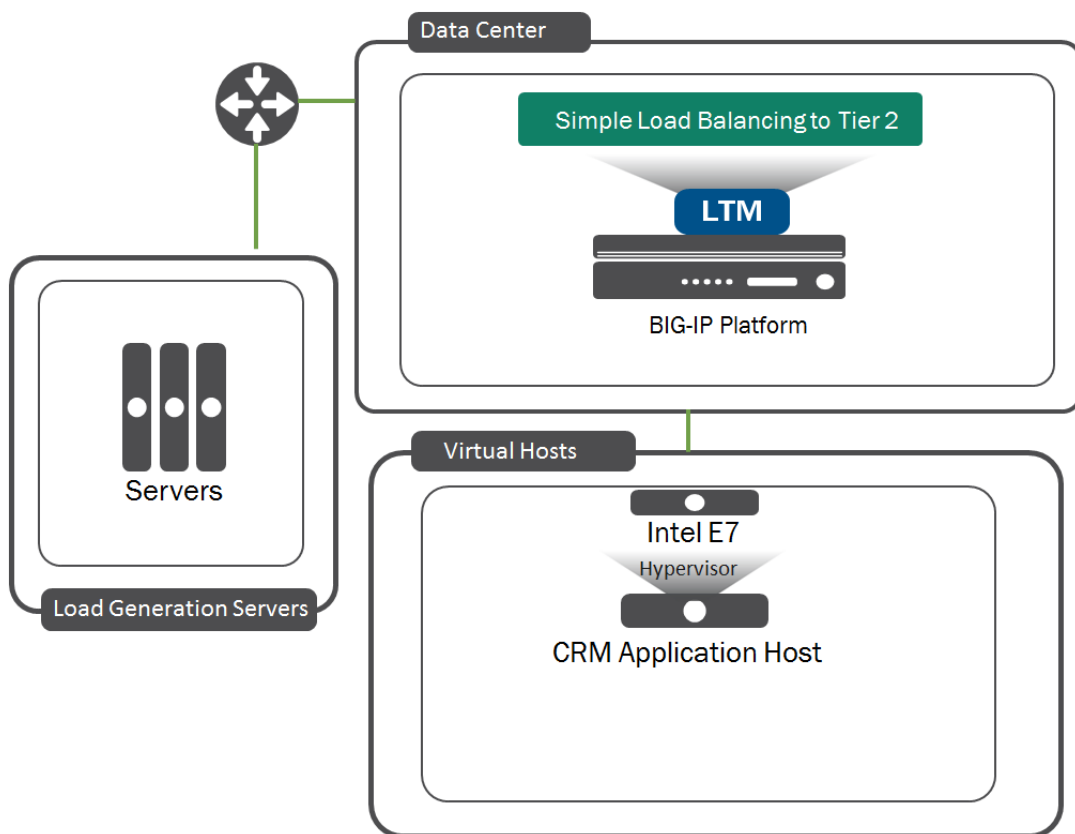
By providing the necessary traffic management, BIG-IP LTM facilitates deploying Microsoft Dynamics CRM in a distributed fashion, further allowing customers to meet the requirements of enterprise-class deployments.

- Performance

Built into every BIG-IP LTM is TMOS, F5's proprietary network operating system. TMOS provides unparalleled network traffic optimization, making sure network performance works for you, and not against you. HTTP-based acceleration, such as intelligent caching, compression, and SSL termination further accelerate performance for the end user.

- Security

BIG-IP APM module helps secure your solution with pre-authentication. The BIG-IP can act as a secure doorway on the perimeter of the organization and prevent unauthenticated and un-trusted traffic from accessing resources residing on the private internal corporate network.



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These benchmark results were performed in a controlled lab environment, in which Microsoft Dynamics CRM was the only running application (that is, no other applications running on these servers). The benchmark was executed on optimized hardware, using Microsoft Dynamics CRM without reporting activity during execution. Performance tests and ratings are measured using computer systems and/or components (e.g., non-customized version of Microsoft Dynamics CRM, the transaction mix, data composition, and indexes) specified in this report and reflect the approximate performance of Microsoft Dynamics CRM as measured by those tests. Any difference in system hardware, software design or configuration, customizations, transaction mix, data composition, or indexes may affect actual performance. The transaction mix and data composition affects sizing and hardware requirements. Customer or partner should consult other sources of information to evaluate the performance of systems or components they consider purchasing.

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