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Avanade is the leading technology integrator specializing in the Microsoft enterprise platform. Our people help customers around the world maximize their IT investment and create comprehensive solutions that drive business results. Additional information can be found at www.avanade.com.

Scaling Microsoft® Dynamics™ CRM

Avanade® Takes Microsoft CRM 3.0 to the Enterprise: Scalability and Performance Testing and Tuning Results

Executive Summary

This white paper summarizes the scaling characteristics of Microsoft Dynamics™ CRM 3.0 with a medium to heavy sales force automation transaction load supporting 3,000 concurrent users. Avanade Inc., a global system integrator of Microsoft technologies, initiated performance testing in 2006 at its technology infrastructure lab in Seattle, Washington.

Avanade's goal for this benchmark was to demonstrate Microsoft Dynamics CRM as a viable solution for our typical enterprise-class customers with demanding transaction requirements. The testing did not attempt to determine the maximum application load nor were limits to scalability encountered. The testing methodology was similar to that used to achieve the Microsoft performance test results published by Microsoft Corporation in the *Microsoft Dynamics CRM 3.0 Performance Report White Paper, 2006*.

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Avanade: Scaling CRM for the Enterprise

Avanade engaged in a performance testing initiative to evaluate the performance of Microsoft Dynamics CRM 3.0 at various user levels on enterprise-class hardware with system-level and application-level performance tuning to maintain full system functionality and sub-two-second response times.

Hardware Configuration

This testing used a hardware configuration that included three dual-processor web servers in a web farm and a single 8-processor, 64-bit SQL server with a fiber channel disk array.

Performance Tuning

The performance tests used a default installation of Microsoft CRM with no customizations. Default options were chosen for the installation and configuration of the application. As part of the testing process, database tuning was performed and several indexes were added to the database to optimize performance.

Test Approach

The testing used Microsoft Visual Studio® Team Suite 2005 and the Microsoft CRM Performance and Stress Testing Toolkit. The toolkit provides a utility for loading data into the database as well as many pre-defined test cases. It also provides a utility for pre-loading the database with a representative data volume.

Results Overview

Summary Test Statistics ¹				
Concurrent Users		1,000	2,000	3,000
Test Duration		1:25:00	1:25:00	1:35:00
Wait Time between Transactions		6 mins	6 mins	8 mins
CRM Business Transactions	Total	12,952	25,658	31,541
	Peak Hour	9,929	19,670	22,276
Avg CRM Business Transaction Time	Total	2.03 secs	4.73 secs	4.33 secs
	Peak Hour	2.05 secs	4.33 secs	3.78 secs
HTTP Transactions	Total	141,496	281,307	346,532
	Peak Hour	108,501	215,812	244,904
Avg HTTP Transaction Response	Total	184 ms	429 ms	392 ms
	Peak Hour	185 ms	392 ms	341 ms
Avg Web Server Utilization	Total	6.3%	13.5%	17.0%
	Peak Hour	6.2%	12.7%	16.3%
Avg DB Server Utilization	Total	21.4%	72.8%	63.6%
	Peak Hour	21.0%	73.8%	66.5%

¹ Two tests were performed at each load level. Results shown represent the average for the two runs.

Hardware Architecture

The key hardware components in the test environment were selected for their enterprise-class characteristics. These characteristics address common concerns such as scalability, availability, and reliability.

The database server employed in this test was a Sun Microsystems Sun Fire™ V40z; a high-performance Windows® server. The V40z uses AMD Opteron™ processors and can scale from one to four processor sockets. The V40z has enterprise class features such as redundant power supplies, remote management facilities, an expandable I/O architecture as well as other availability and reliability features found in high-end equipment.

For this test, the database server was equipped with four dual-core AMD Opteron processors as well as 16GB of RAM. The AMD processors have an x64 architecture and support both 32-bit and 64-bit workloads. The x64 version of Windows Server™ 2003 Enterprise Edition was used to take full advantage of the x64 hardware architecture.

The database server also used two 2Gbps Fibre Channel storage area network (SAN) connections for all database storage communications. Fibre Channel provides an extremely low-latency, high-throughput connection and is extremely well suited for the storage communications channel.

The two Fibre Channel adapters were connected to a fully meshed SAN fabric, which in turn had eight paths to the EMC® Symmetrix 8430 storage array. EMC's PowerPath® Multipath I/O (MPIO) technology was used to provide load balancing as well as path failover protection between the database server and the storage array.

The storage array used in the test was a Symmetrix 8430; a highly scalable and highly available SAN storage array from EMC. The Symmetrix series of arrays is EMC's flagship storage line, and while the 8430 is an older-generation device, it still shares the many of the same ultra high performance and availability features intrinsic to Symmetrix storage.

Detailed Server Hardware Configurations

Server Role	Database Server (Quantity 1)
Manufacturer	Sun Microsystems
Model	Sun Fire™ V40z
Operating System	Microsoft® Windows Server™ 2003 Enterprise x64 Edition
Processor	4 x Dual-core 2.2 GHz AMD Opteron (Model 875)
RAM	16 GB
Software	Microsoft SQL Server 2005 Enterprise x64 Edition
Disk Configuration	OS: RAID 1 (local 72 GB 15k RPM drives) Database: EMC® Symmetrix SAN-Attached, multi-path load balanced and protected via dual 2Gbps Fibre Channel Connections SQL Database and Tempdb – 220 GB RAID 10 (spread across 32, 72 GB 10k RPM drives) SQL Log Files – 40 GB RAID 10 (spread across 4, 72 GB 10k RPM drives)
Network Adapter	1 Gbps Ethernet

Server Role	Web/Application Server (Quantity 3)
Manufacturer	IBM®
Model	BladeCenter HS20
Operating System	Microsoft® Windows Server™ 2003 Enterprise Edition
Processor	2 x 3.0 GHz Intel® Xeon™ (1MB Cache) (Hyperthreading Enabled)
RAM	5 GB
Software	Internet Information Services (IIS) 6.0, Microsoft Dynamics CRM Server 3.0
Network Adapter	2 x 1 Gbps Ethernet. Hardware load balancing via F5 BIG-IP

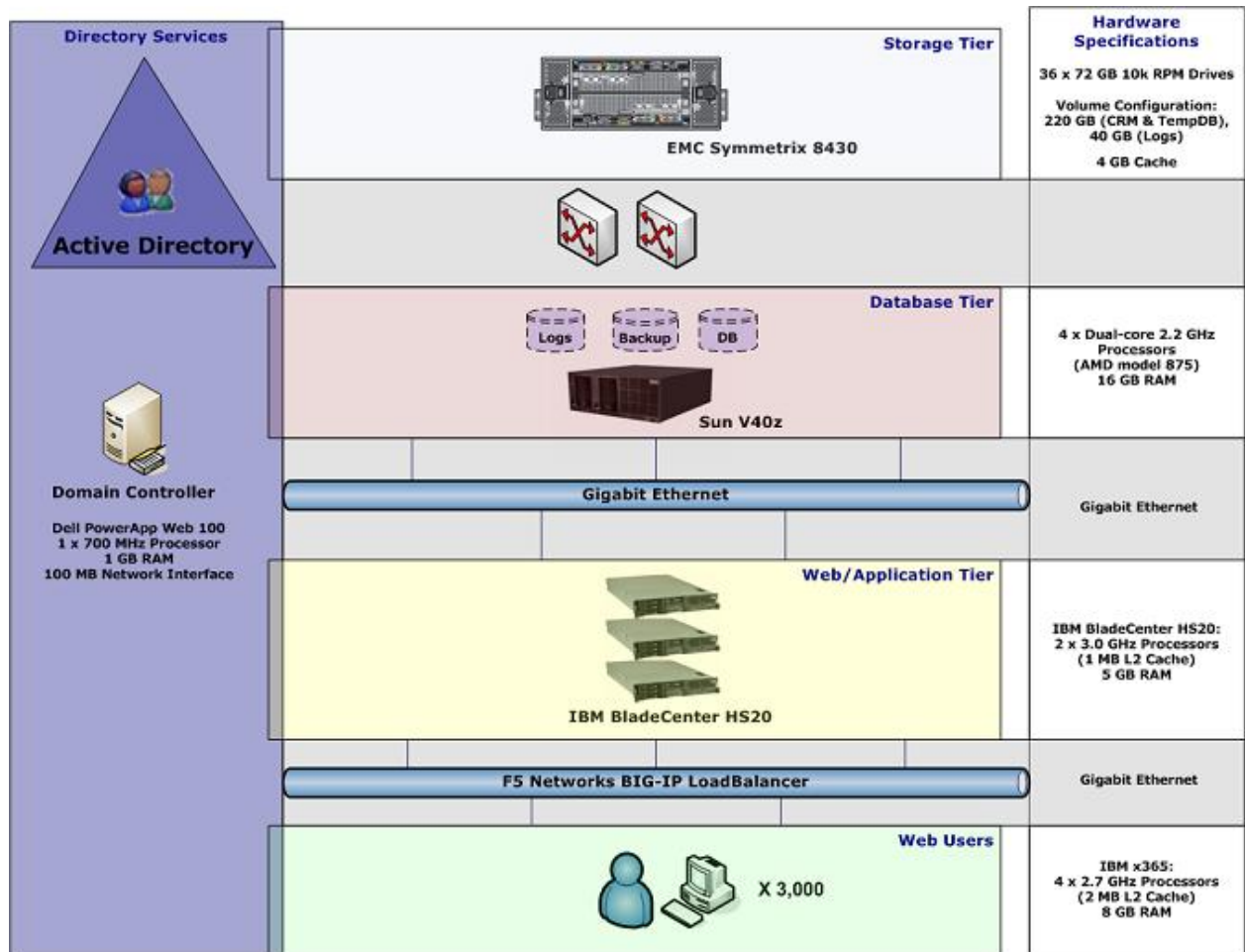
Server Role	Domain Controller
Manufacturer	Dell™
Model	PowerApp Web 100
Operating System	Microsoft® Windows Server™ 2003 Enterprise Edition
Processor	1 x 700 MHz Pentium III
RAM	1 GB
Software	Microsoft® Windows® 2003 Active Directory®
Network Adapter	1 x 100 Mbps Ethernet

Server Role	Virtual Client Simulator
Manufacturer	IBM®
Model	xSeries x365
Operating System	Microsoft® Windows Server™ 2003 Enterprise Edition
Processor	4 x 2.7 GHz Intel Xeon (2 MB Cache) (Hyperthreading Enabled)
RAM	8 GB
Software	Microsoft Virtual Server 2005 R2, Microsoft Visual Studio® Team Suite 2005
Network Adapter	2 x 1 Gbps Ethernet

Performance Test Approach

The Avanade CRM Infrastructure

To maximize scalability, availability, and reliability for the Microsoft CRM performance testing, Avanade designed and deployed the multi-tier infrastructure depicted in this diagram using the hardware described in the previous section. Specific configuration information for each server is described in detail in the section "Detailed Server Hardware Configurations."



Microsoft Dynamics CRM 3.0 Application Configuration

For testing, Avanade performed a basic installation of Microsoft CRM. None of the entities or forms was customized.

The application was configured for web clients only. Avanade installed Microsoft CRM across three load-balanced web/application servers with an F5 load balancing solution controlling the web traffic. A fourth web server was deployed to host the Microsoft SQL Server Reporting Services (SRS) instance for the application, leaving all three web servers dedicated to the Microsoft CRM application itself. During the tests, the Microsoft CRM Deletion Service was disabled.

Performance Workload Simulation

During the test, Microsoft Visual Studio Team Suite 2005 was used to randomly generate a transaction mix for each user. The test profile consists of a mix of transactions that simulates a relatively heavy workload concentrated on the sales functionality of the Microsoft CRM application. The core functions tested center on the Lead, Opportunity, Account, and Contact objects as well as on associated activities.

The test case simulates a complete business transaction that involves several screens in the Microsoft CRM application. For example, the "UpdateAccount" test case simulates this screen flow:

1. Start at Sales homepage
2. Select Accounts
3. Select My Active Accounts View
4. Enter a random string and click "Find"
5. Open an account and edit data
6. Save and Close account

Each test represents 5 to 10 atomic CRM HTTP commands and, depending on the test run, each simulated user was configured to wait either 6 or 8 minutes between test executions, resulting in an average of 10 or 7.5 business transactions per hour.

Database Profile

While the Workload simulation is a critical part of the performance test, the amount of data loaded into the system is an equally important component. The CRM Views displaying a list of records that meet certain criteria are the most affected as the number of records in the database grows. Therefore, the Avanade team applied real-world experience in devising a database load that was representative of one year of activity for the number of users for each test.

The Performance Test toolkit contains a utility for loading data for each user, and this toolkit was used to load data into the system for each user. The following table outlines the number of records that existed in the database for each of the user levels. Tables with fewer than 20,000 records are not shown.

Object	1,000 Users	2,000 Users	3,000 Users
Account	108,425	216,840	325,386
Annotation	464,445	928,847	1,393,536
Contact	211,207	422,508	633,742
CustomerAddress	639,264	1,278,696	1,918,256
Invoice	107,571	215,136	322,810
InvoiceDetail	215,120	430,308	645,603
Lead	316,163	632,613	948,624
LeadAddress	632,326	1,265,226	1,897,248
Opportunity	108,166	216,323	324,604
OpportunityProduct	163,924	327,855	491,753
PrincipalObjectAccess	2,985,081	5,972,842	8,956,644
Quote	107,606	215,205	322,915
QuoteDetail	215,183	430,433	645,793
SalesOrder	107,605	215,203	322,912
SalesOrderDetail	317,746	635,764	953,447
ActivityParty	7,119,391	14,234,969	21,368,098
ActivityPointer	2,588,467	5,176,730	7,765,620
Appointment	307,011	613,782	920,762
Email	817,413	1,634,829	2,451,735
Fax	61,416	122,801	184,269
Letter	102,075	204,163	306,239
OpportunityClose	92,355	184,752	276,948
OrderClose	92,323	184,688	276,852
PhoneCall	615,730	1,231,956	1,847,729
QueueItem	121,295	242,895	364,163
QuoteClose	92,321	184,684	276,846
Task	407,478	814,886	1,223,000

Performance Tuning

CRM Application Tuning

The Microsoft CRM test environment was tuned using a series of best practices developed by Avanade CRM field consultants based on experience from real-world customer engagements.

Application tuning included:

- ⇒ IIS optimizations for .NET applications
- ⇒ .NET Framework CLR tuning
- ⇒ Contact Lookup & Quick Find view search field modifications.

Database Tuning

After loading data for each of the user loads, the database indexes were checked for excessive fragmentation. Indexes that showed a high level of fragmentation were either reorganized or rebuilt using the ALTER INDEX command in SQL 2005. In addition, table statistics were updated to reflect current database metrics.

During the testing, Avanade monitored the database performance and the effect of new indexes on the query performance. The following indexes were added to the tables in the Microsoft CRM database:

Table	Index Columns
ActivityPartyBase	PartyId, ActivityId, ActivityPartyId, ParticipationTypeMask
ActivityPartyBase	PartyId, ParticipationTypeMask, ActivityId, ActivityPartyId
ActivityPointerBase	DeletionStateCode, Subject ActivityTypeCode
ActivityPointerBase	DeletionStateCode, ActivityTypeCode, ActivityId, OwningUser, OwningBusinessUnit
CustomerAddressBase	ParentId, AddressNumber, CustomerAddressId Include(Name, City, Telephone1, Fax)
LeadBase	StateCode, DeletionStateCode, Subject, CompanyName, FirstName, LastName
ContactBase ²	DeletionStateCode, StateCode, LastName, FirstName, MiddleName, EMailAddress1
AccountBase	DeletionStateCode, Name, AccountId, StateCode, OwningUser, OwningBusinessUnit

Avanade Connected Architecture® (ACA®) Infrastructure for .NET

ACA Infrastructure for .NET is a methodology and roadmap developed from Avanade's extensive experience establishing enterprise-class infrastructures for our customers.

ACA Infrastructure for .NET provides prescriptive rules and guidance for the optimal configuration of highly available and highly scalable application infrastructures. ACA Infrastructure for .NET was used in Avanade's Microsoft CRM scalability testing to configure the following infrastructure components:

- ⇒ Network design including security and hardware and software load balancing
- ⇒ Infrastructure identity and access management through Microsoft Active Directory®
- ⇒ Platform design and deployment including scaling and availability for presentation, application, data tiers, storage design, and security

² This index replaced the stock CRM index "ndx_ContactCover."

Test Results

This table provides a summary of the test results for the six test runs:

Test Parameters						
Concurrent Users	1,000	1,000	2,000	2,000	3,000	3,000
Ramp-up Time (mins)	5	5	10	10	20	20
Delay between Transactions (mins)	6	6	6	6	8	8
Transactions/user/hour	10	10	10	10	7.5	7.5
Test Time	1:25:00	1:25:00	1:25:00	1:25:00	1:35:00	1:35:00
Transaction Statistics (Full Run)						
CRM Business Transactions	12,926	12,978	25,648	25,669	31,551	31,531
Avg CRM Transaction Time (secs)	2.17	1.89	4.65	4.80	4.69	3.97
HTTP Requests	141,335	141,658	280,956	281,658	346,087	346,977
Avg Response Time (ms)	195	172	422	435	425	359
Transaction Statistics (Peak Hour)						
CRM Business Transactions	9,927	9,932	19,687	19,654	22,292	22,260
Avg CRM Transaction Time (secs)	2.17	1.93	4.43	4.23	3.62	3.93
HTTP Requests	108,950	108,052	215,895	215,658	244,561	245,247
Avg Response Time (ms)	194	176	402	383	327	355
Error Detail (Full Run)						
HTTP Errors	34	2	5	11	429	21
CRM Errors	10	-	1	-	5	1
Authentication Errors	-	-	-	-	7	-
Error Detail (Peak Hour)						
HTTP Errors	34	2	4	11	8	16
CRM Errors	10	-	1	-	2	1
Authentication Errors	-	-	-	-	2	-
Average Server CPU Utilization (Full Run)						
Web Server 1	6.21	6.53	13.81	13.98	18.14	17.24
Web Server 2	6.83	6.53	13.53	13.60	17.16	17.04
Web Server 3	6.08	5.87	12.90	13.30	16.37	15.80
Database Server	23.11	19.75	72.73	72.90	63.39	63.82
Average Server CPU Utilization (Peak Hour)						
Web Server 1	6.01	6.56	12.99	13.11	15.94	16.84
Web Server 2	6.65	6.50	12.70	12.81	16.64	16.72
Web Server 3	5.86	5.73	12.09	12.36	16.23	15.30
Database Server	22.10	19.81	74.01	73.62	66.31	66.77

This table provides a summary of the test cases executed during the peak hour for the 3,000 user tests:

Test	Completed Tests			Test Execution Time (seconds)					
				Average			Percentile 90 ³		
	Run 1	Run 2	Total	Run 1	Run 2	Total	Run 1	Run 2	Total
AccountActivityRollup	215	208	423	3.59	4.24	3.91	5.30	6.45	6.23
AccountOppRollup	207	218	425	3.83	4.06	3.95	6.08	6.77	6.23
AddActivityToAccount	429	428	857	3.53	4.13	3.83	5.27	6.38	5.75
AddActivityToLead	427	442	869	3.07	3.59	3.34	4.61	5.44	4.97
AdvancedFindAccount	538	564	1,102	3.63	3.84	3.74	4.86	4.86	4.86
AdvancedFindAccountNotes	123	110	233	3.73	4.03	3.87	4.75	4.83	4.75
AdvancedFindContact	884	902	1,786	4.08	4.50	4.29	5.44	5.77	5.55
AssignOpportunity	127	95	222	3.34	3.51	3.41	5.52	4.44	5.42
ConvertLeadToOppWithAccount	105	114	219	4.41	4.48	4.45	6.23	6.44	6.44
CreateAppointment	195	219	414	6.97	6.73	6.84	9.78	9.08	9.52
CreateEmail	1,303	1,313	2,616	3.17	3.64	3.41	5.09	5.69	5.36
CreateFax	105	106	211	3.37	3.54	3.45	5.66	5.05	5.64
CreateLetter	95	116	211	3.18	3.55	3.38	5.05	5.67	5.19
CreateNewAccount	109	113	222	14.70	14.83	14.77	22.28	25.08	23.78
CreateNewContact	194	215	409	2.96	3.10	3.04	6.53	6.33	6.42
CreateNewLead	467	468	935	1.66	1.96	1.81	2.91	3.30	3.11
CreateNewNoteForAccount	120	110	230	2.97	3.80	3.37	4.50	6.27	5.22
CreateNewNoteForContact	115	83	198	3.14	3.23	3.18	5.27	4.70	5.09
CreateNewNoteForLead	111	113	224	2.36	3.01	2.68	3.81	4.80	4.48
CreateNewNoteForOpp	113	96	209	1.98	2.23	2.09	3.52	3.03	3.19
CreateNewOpportunity	58	48	106	1.70	1.91	1.80	2.58	3.61	2.75
CreatePhonecall	868	865	1,733	3.23	3.59	3.41	5.17	5.88	5.48
DeleteAccount	21	26	47	6.42	6.87	6.67	8.95	9.27	9.27
DeleteContact	46	55	101	6.83	8.68	7.83	11.92	15.49	12.74
DeleteLead	101	117	218	4.61	5.74	5.22	7.19	9.50	8.28
DeleteNoteOnAccount	31	28	59	5.05	5.63	5.32	7.13	7.86	7.86
DeleteNoteOnContact	29	25	54	5.33	5.54	5.42	9.72	7.55	8.22
DeleteNoteOnLead	32	23	55	4.10	3.84	3.99	5.89	5.75	5.84
DeleteNoteOnOpportunity	45	22	67	3.47	5.20	4.04	5.17	11.72	6.50
DeleteNoteOnTask	20	32	52	3.49	4.00	3.80	5.30	6.22	5.42
DeleteOpportunity	22	27	49	3.56	4.79	4.24	5.45	8.38	6.64
DeleteTask	103	104	207	4.08	4.92	4.50	6.41	7.45	6.91
OpenAppointment	195	213	408	6.78	6.12	6.44	7.67	8.28	8.02
OpenEmail	42	67	109	2.97	2.64	2.76	4.55	3.72	4.08
OpenFax	26	32	58	3.25	3.43	3.35	5.30	5.19	5.30
OpenLetter	34	18	52	3.26	3.35	3.29	4.89	5.27	4.89
OpenPhonecall	467	443	910	4.61	4.94	4.77	7.34	7.91	7.66
OpenTask	416	431	847	3.19	3.41	3.30	5.19	4.84	5.05
RetrieveAccount	1,420	1,415	2,835	2.79	2.97	2.88	4.44	4.75	4.56
RetrieveContact	1,738	1,705	3,443	2.77	3.00	2.88	4.36	4.84	4.58
RetrieveLead	1,843	1,813	3,656	2.13	2.26	2.19	3.67	3.55	3.59
RetrieveOpportunity	818	834	1,652	1.70	1.97	1.83	3.00	3.39	3.13
UpdateAccount	2,000	1,976	3,976	4.62	4.93	4.78	6.94	7.42	7.11

³ Percentile 90 indicates that 90% of the test cases completed in this number of seconds.

UpdateAppointment	51	49	100	6.69	7.76	7.21	8.89	10.08	10.08
UpdateContact	2,154	2,154	4,308	5.76	6.03	5.90	9.02	9.78	9.38
UpdateEmail	12	15	27	3.31	3.31	3.31	4.92	4.50	4.92
UpdateFax	11	11	22	4.61	4.73	4.67	6.27	6.47	6.47
UpdateLead	1,875	1,778	3,653	3.36	3.67	3.51	5.25	5.73	5.41
UpdateLetter	14	14	28	4.79	5.32	5.06	6.16	7.34	7.34
UpdateOpportunity	987	970	1,957	2.35	2.68	2.52	3.81	4.44	4.00
UpdatePhonecall	428	430	858	6.98	7.60	7.29	10.23	11.38	10.81
UpdateTask	403	487	890	2.93	3.15	3.05	4.48	4.75	4.61
Total	22,292	22,260	44,552	3.62	3.93	3.78	6.14	6.88	6.45

Conclusions

The Avanade test results demonstrate the capability of Microsoft CRM to scale under a medium to heavy sales force automation transaction load. Response times averaged less than 0.5 seconds during all of the test runs Avanade performed.

Proper planning, monitoring and tuning are critical to successful CRM project deployments. Actual user workload as opposed to an absolute number of users is the significant factor when considering Microsoft CRM scalability; varying database volumes, workload profiles, indexing, and hardware specifications will generally yield different results. Avanade has recently conducted a similar benchmark for a large European financial institution based on their specific data load and projected transaction rates which illustrates Microsoft CRM's ability to support large datasets, high transaction loads and 5,000 users with a single installed instance of Microsoft CRM.

For large, complex Microsoft CRM deployments that will need to support a large number of users and/or a persistently high transaction count, Avanade recommends conducting a tailored scalability test based on an organization's specific requirements. In addition to tailored testing, for large-scale organizations that have business requirements that are not well-addressed by a single CRM instance, Avanade recommends leveraging a federated architecture approach. The Avanade Federated Architecture Solution for Microsoft CRM allows customers to easily deploy and manage multiple instances of Microsoft CRM across their organizations to suit the specific needs of each individual department, product brand, or customer channel while sharing the data that they need across territories, brands and/or customer contact channels.

About the Authors

Matt Parks, Avanade Global CRM Solution Architect, is responsible for the development of the Avanade reusable tools that streamline the implementation of Microsoft Dynamics CRM for enterprise customers. Matt has been actively involved with Microsoft CRM since the beta for v1.0 and is a Microsoft CRM MVP. Matt has over 17 years of experience in developing custom applications for clients across a variety of technology platforms.

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