Microsoft® SQL Server® 2008 R2

TEMENOS™

Benchmark Results for Temenos T24 with SQL Server 2008 R2 on Intel-based NEC Servers

25 Million Highwater Benchmark Testing Proves Performance and Scalability

Contents:

Abstract

This report describes the TEMENOS T24 (T24) R10 Highwater Benchmark performance test conducted at the Microsoft® Partner Solution Center (MPSC) in Redmond, Washington on the NEC® Express5800/A1080a 8-CPU Server System with the Intel® Xeon® processor 7500 series, from July 14th to August 27th, 2010.

This benchmark test was performed as part of the strategic alliance between Temenos Group AG and Microsoft Corporation that was announced in 2009—an alliance that aims to deliver an optimized T24 core banking solution on Microsoft technology and thus increase operational efficiency at large-scale banks.

The Highwater Benchmark test comprises a mix of standard, real-world banking transactions defined by Temenos. These transactions, online business transactions and those generated in a close-of-business (COB) capitalization, represent typical transactions for a large Tier-1 retail bank with an extensive customer base.

The results of the benchmark testing were impressive. At peak performance, the system processed 3,437 transactions per second (TPS) in online business testing and averaged a record-breaking 5,203 interest accrual and capitalizations per second during COB testing, processing 25 million accounts in less than two hours. The maximum CPU utilization of the NEC database server during the peak hour did not exceed 70%, providing considerable additional capacity.

These benchmark performance results, together with the massive scalability of Microsoft® SQL Server® 2008 R2 data management software running on the NEC Express5800/A1080a with the Intel Xeon processor 7500 series, make the combination of T24 and Microsoft® technologies a viable solution for the largest banks in the world.

A Brief Introduction to TEMENOS T24

Temenos Group AG, founded in 1993, is the market-leading provider of integrated core banking systems, giving banks a single, real-time view of the client across the enterprise. Headquartered in Geneva, Switzerland, Temenos has more than 1,000 customers and 600 implementations in more than 120 countries.

TEMENOS T24 (T24) is a fully integrated, modular core banking solution that covers a broad spectrum of functional requirements for the retail, private, corporate, universal, and Islamic banking and microfinance sectors. T24 consists of a core system for the common operations between the various banking activities and a series of modules that address the operational requirements of different users. T24 is built on an open architecture and uses established standards such as HTTP, XML, and Java 2 Platform Enterprise Edition (J2EE).

T24 is available as a Model Bank implementation, which embodies standard business practices built on the experience of a large number of T24 implementations around the globe. The Model Bank includes thousands of pre-configured solutions for most general banking requirements. Additionally, T24 can be customized on-site to match specific client requirements for unmatched product flexibility.

The T24 solution consists of several layers, as shown in Figure 1, including:

- User access
- Presentation (clients)
- Messaging/connectivity (web servers)
- Application (application servers)
- Database (database servers)

The application layer accepts messages in a Temenos-specific format called Open Financial Services (OFS). All requests, from a web browser or from a non-web client, are translated into the OFS format and then submitted to the application layer. The communication between the messaging/connectivity layer and the application layer depends on the specific deployment and can use various channels, including message queues, web services, and a native direct connection between the two layers.

T24 was originally designed to use jBASE, a multidimensional database that uses records consisting of fields, multi-values (multi-valued lists), and

Figure 1. T24 infrastructure.

sub-values. OFS messages are transformed into the internal record format and processed by the application layer; the records are then stored in a jBASE database. When SQL Server, a supported database system, is used, the jBASE records are transformed into XML format (or in some cases left as BLOBs) and are stored in the database.

T24 is written primarily in BASIC and C programming languages, and T24 uses jBASE Query Language (jQL) internally. The SQL Driver is written in C++ and uses Object Linking and Embedding, Database (OLE DB) to connect to SQL Server.

SQL Server 2008 R2: A Proven Database for T24

Microsoft SQL Server 2008 R2 is enterprise ready and provides an ideal database platform for T24. By choosing SQL Server 2008 R2, T24 customers experience faster funds transfers, higher security-trade volumes, and quicker close-of-business processes; T24 customers can also benefit from open, state-of-the-art technologies to accelerate innovation, greatly increasing the speed and effectiveness with which new products and services are created.

The 64-bit architecture of SQL Server 2008 R2 lets customers take advantage of up to 2 terabytes of RAM in Windows Server® 2008 R2 operating system.

SQL Server 2008 R2 supports up to 256 logical processors. This scalability makes it ideal for data-intensive and mission-critical applications.

SQL Server 2008 R2 can also take advantage of the scalability features of the Intel Xeon processor 7500 series: eight sockets or more, eight cores and 16 threads per socket, and up to two terabytes of RAM in an eight-socket configuration.

NEC Express5800/A1080a: A Scalable Platform for T24

NEC's Express5800/A1080a represents NEC's fifth-generation Enterprise Server architecture, delivering exceptional configuration flexibility, capacity, record-breaking performance, and reliability—exploiting the inherent functionality of the Intel Xeon processor 7500 series.

NEC's Express5800/A1080a series server accommodates up to 2 TB of memory and 128 threads with modular in-box partitioning in an innovative single 7U chassis. Combined with SQL Server 2008 R2 and T24, Temenos customers can benefit from the record-breaking performance of the NEC enterprise scalable server.

Intel Xeon Processor 7500 Series: A Mission-Critical Solution for T24

System downtime leads to costly consequences in the banking industry, and Temenos needs a solution that supports a mission-critical environment. The Intel Xeon processor 7500 series delivers unprecedented reliability and scalability for T24. The Intel Xeon processor 7500 series includes reliability, availability, and serviceability (RAS) features that provide superior data integrity, improved system availability, and enhanced serviceability. These features help protect data by reducing circuit-level errors, detecting errors across the system, and then limiting the impact of errors to keep critical systems operational. Intel Xeon processor 7500 series help boost availability by healing failing connections and recovering from data errors, as well as by supporting redundancy and failover for key system components. Additionally, features of the Intel Xeon processor 7500 series help IT administrators proactively monitor and manage systems.

Paired with NEC Express5800/A1080a series servers, Windows Server 2008 R2, and SQL Server 2008 R2, Temenos customers can gain new levels of performance and maximized operational efficiency.

Better Together: Microsoft and Temenos

Every bank is under pressure to reduce costs—particularly in the area of operations. To become more efficient, banks must take a new look at the processes and technology used to run the bank.

Figure 2 shows the Microsoft/Temenos ecosystem, a result of the Temenos investment in the Microsoft software stack.

Microsoft and Temenos can provide a lower total cost of ownership (TCO), along with optimal performance:

- **Optimized Technology Stack for Lower TCO and High Performance**
  - Industry-standard 32-bit and 64-bit hardware with superior price/performance, the Windows Server operating system, and Microsoft SQL Server 2008 R2
  - "On-premises-to-cloud" platform strategy
  - Microsoft® Mission Critical Program and Microsoft® Services
- **Industry-Standard Architecture**
  - Benefit from the collaboration of two of the founding members of the Banking Industry Architecture Network (BIAN)
  - Service-oriented architecture (SOA) best practices and commitment to interoperability
- **The Banking Industry's Leading Application**
  - Support for a full range of banking verticals and geographies
  - Respond faster to changing market and regulatory demands
  - Protect investments with a modular, scalable, upgradable solution

The T24/SQL Server 2008 R2 Highwater Benchmark

The benchmarking study began with a hypothesis: Combining SQL Server 2008 R2, TEMENOS T24 R10, and Intel processors can result in faster funds transfers, higher security-trades volumes, and quicker close-of-business processes than a typical bank requires, as well as the capacity to scale effectively for future growth.

The objective of the Highwater Benchmark testing was to measure the online business and COB transaction scalability and throughput capacity of a T24 R10 retail Model Bank on Windows Server® 2008 R2 Datacenter and Microsoft SQL Server 2008 R2 Enterprise running on Intel Xeon processor 7500 series-based servers. Test cases and mix percentage were compiled from existing and prospective T24 clients to simulate the real-world banking scenarios.

The benchmark testing looked at two key requirements for the core system of banks: performance and scalability. Performance testing included:

- **Online Business Test.** Capability to process online business transactions to represent activity during business hours—used nine different types of transactions (withdrawals, ATM transactions, and so on).
- **COB Test.** COB capability to run the end-of-day batch processes for 25 million accounts.

Benchmark Testing Targets

Benchmark targets were set by the Temenos Retail Banking Committee:

- **CPU utilization target:**
  Maximum CPU utilization of the database server during the peak hour was not to exceed 75%
- **Scalability target:**
  Close to linear scalability when increasing application agents (or scale out) from 100 to 200, and from 200 to 300

Transaction Mix Used for Online Business Benchmark Test

For an online business transaction load of approximately 22 million transactions per eight-hour day, while accommodating a peak-hour load of 50% of all daily transactions, a T24 business scenario online test must meet a minimum throughput target of approximately 3,000 TPS.

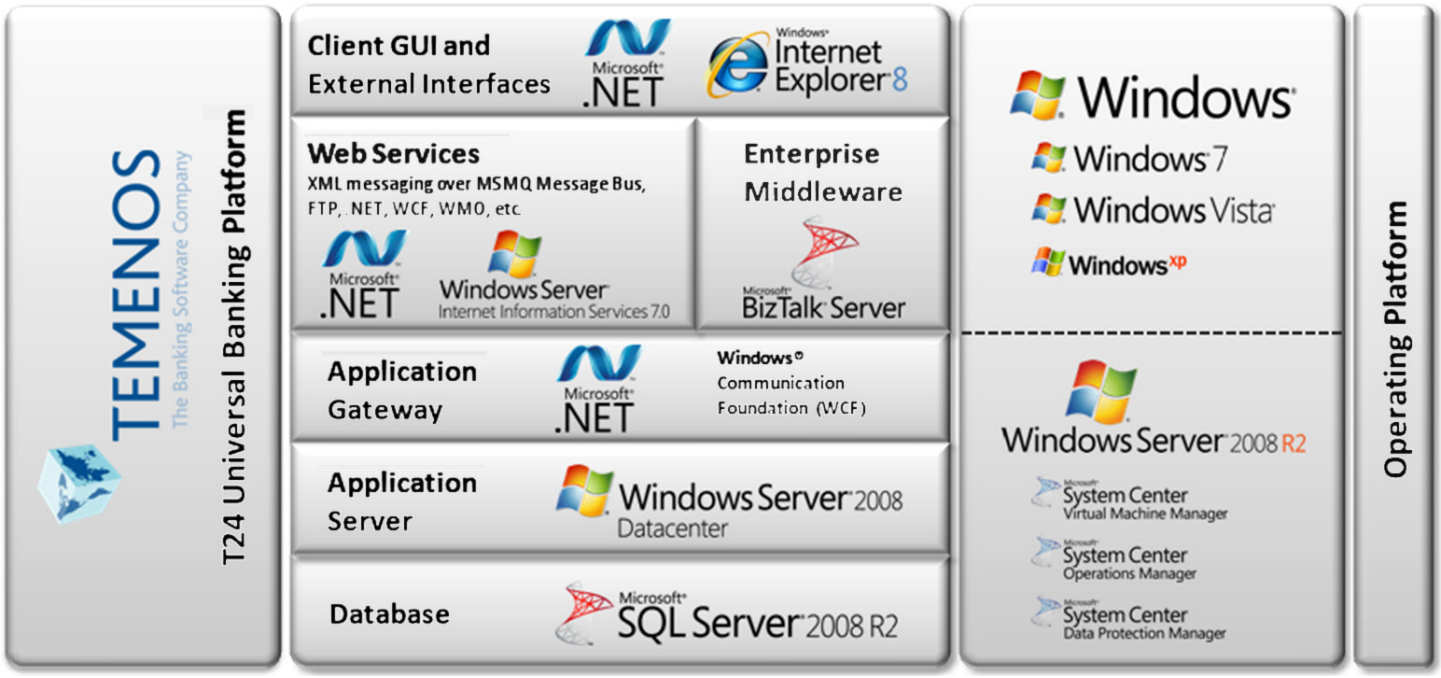

Figure 2. The Microsoft/Temenos ecosystem.

Benchmark Test Environment

The data set used in the benchmarking test reflects real-world banking activity volumes.

Number of accounts	25 million accounts (1 million of these foreign currency accounts)
Number of customers	15 million customers
Number of branches	2,000 branches
Direct channel peak-hour load	4 million accounts
Transaction history	1-month full transaction history
Number of transactions per day	21.5 million transactions/day, half during a single peak hour
Peak online business load	21.5 million transactions/day, half during a single peak hour
Number of application servers	16 application servers running T24

Table 1. Benchmark test environment.

The application servers were connected to a central single instance of Microsoft SQL Server 2008 R2 Enterprise and Windows Server 2008 R2 Datacenter.

Benchmark Test Details

Following are the details of the Highwater Benchmark test setup.

Software Used

Table 2 gives details of the software used.

Name and Version	Use
Temenos T24 R10	The main application performance testing software Used XmlMSSQL drivers
JBoss 4.2.3GA	Web server, based on Apache Tomcat Also used BrowserWeb
Temenos T24 browser R10.000	A web-based UI for the core banking system used to process and send requests to T24 via the web server
IBM MQ Series 7.0.0.1s	A queuing server used to facilitate message passing between the server and web browser
Apache JMeter 2.3.2	Graphical server performance testing tool used to inject and simulate user transactions to T24 via the browser
Temenos MqInjector 1.1/MQ7	Used to inject Open Financial Services (OFS) messages to MQ. Note that OFS is a message syntax proprietary to Temenos
Microsoft SQL Server 2008 R2	Database
TAFC R10 SP4	Application framework (runtime)
TOCF.NETR10 SP4	Temenos Open Connectivity Framework, provides interface connectivity to T24 from the MQ Server
TWS R10 V10.0.0.1	Temenos Web Services
T24 Monitor R10.0.1	T24 application monitor

Table 2. Software used.

Hardware Used

Table 3 shows details of the servers used in the benchmarking tests.

8 - HP BL460G6 Servers				
CPU	Total Cores	Threads	Cache	RAM
2 x 2.53 GHz (E5540)	8 cores	16 threads	8-MB cache	48 GB RAM

8 - HP BL490G6 Servers				
CPU	Total Cores	Threads	Cache	RAM
2 x 2.66 GHz (E5650)	12 cores	24 threads	12-MB cache	48 GB RAM

1 - Dell R910 Application Server				
CPU	Total Cores	Threads	Cache	RAM
4 x 2.27 GHz (x7560)	32 cores	16 threads	24-MB cache	512GB RAM

1 - NEC A1080a-E Database Server				
CPU	Total Cores	Threads	Cache	RAM
8 x 2.27 GHz (x7560)	64 cores	128 threads	24-MB cache	1024 GB RAM

Table 3. Server details.

The following storage was used in the benchmark scenarios:

Storage for Online Business Testing	
Atrato Extreme Velocity 1000	iSCSI host ports, 2 Access Controllers M2 (10-Gbps iSCSI ports), 2 VxSSD Enclosures 24 Drives, 3 TB usable

Storage for COB Testing	
HDS USP-V	480 drives, 300-GB 15K FC drive, 256-GB mirror cache, host ports 16 FC 4 GB

Table 4. Storage details.

Figure 3 shows the hardware configuration for the online business testing.

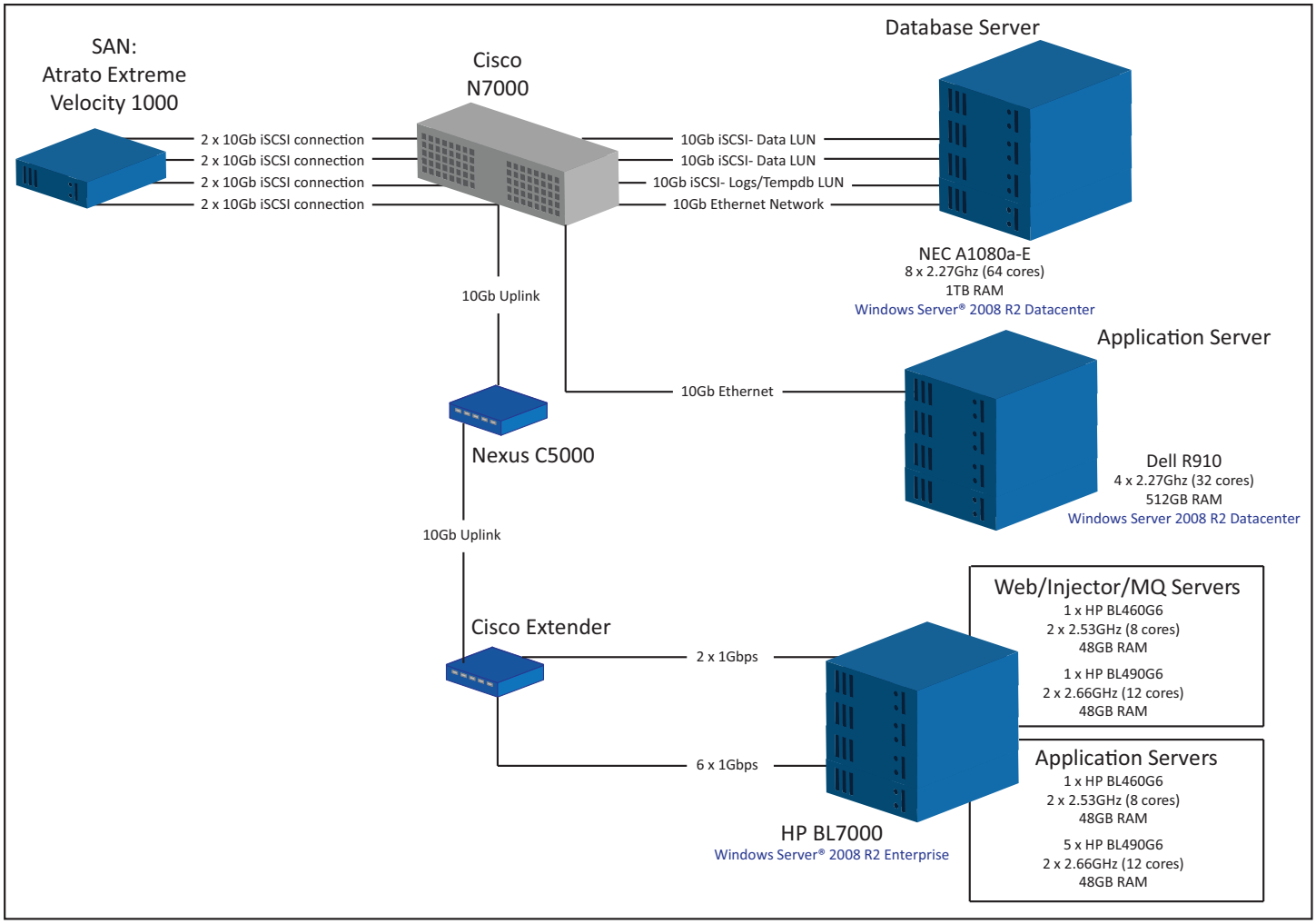

Figure 3. Online business testing configuration.

Figure 4 shows the hardware configuration for the COB testing.

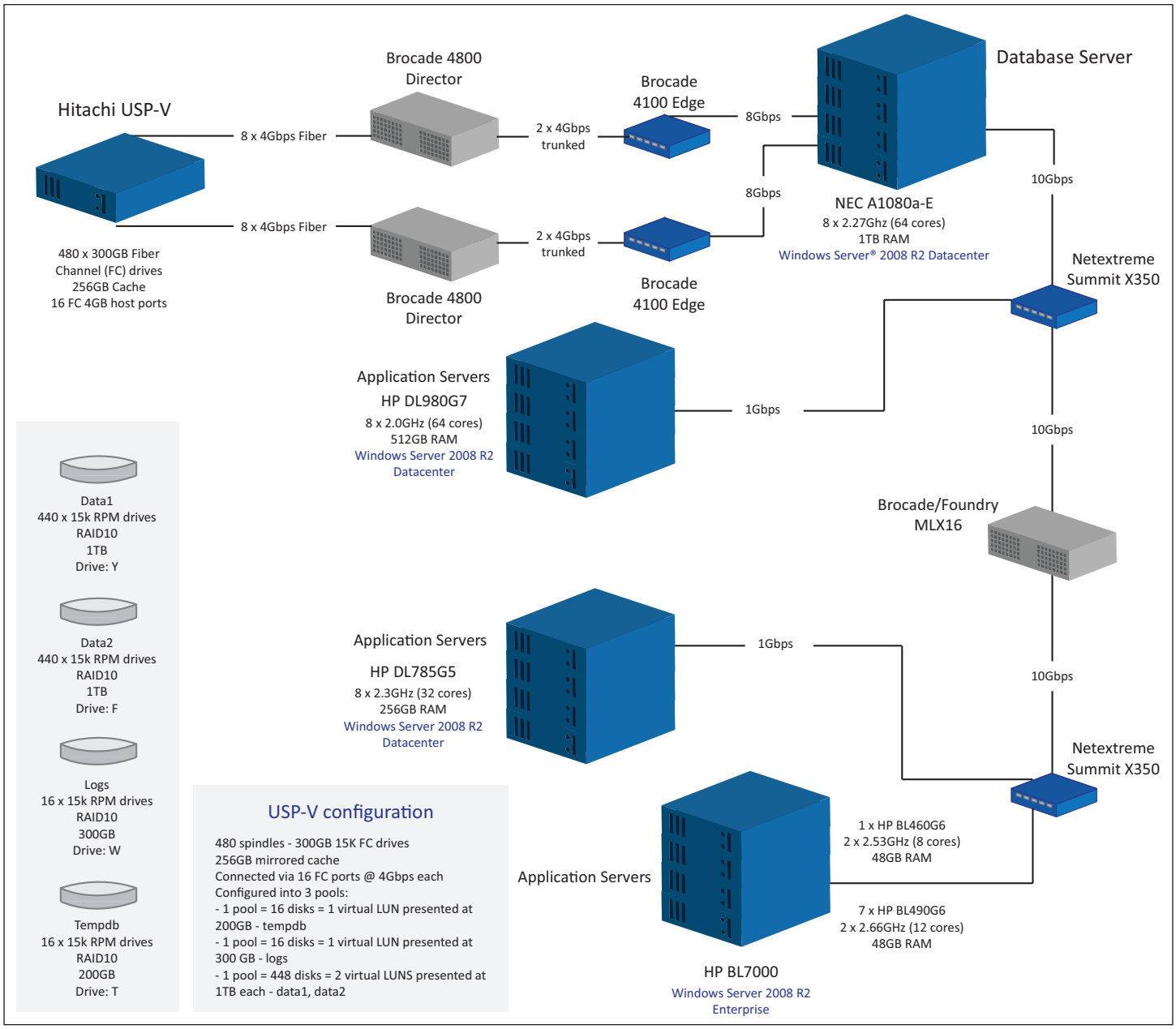

Figure 4. Hardware configuration for COB testing.

Benchmark Test Results: Record-Breaking Performance

The benchmarking test results show that Microsoft SQL Server 2008 R2 and Intel Xeon processor 7500 series-based servers provide record-breaking results for Temenos T24.

- 5,203 TPS from 320 agents in the COB test.
- 25 million COB accounts processed in less than two hours. (IC.COB total time of 1 hour, 20 minutes; COB total time of 3 hours, 57 minutes.)
- 3,437 TPS in the online business test—with an eight-hour processing day and 50% of the day's transactions in the peak hour, this means 24.7 million transactions per day.
- Up to 140,000 SQL batches/sec.
- 78,000 I/O operations/sec.

At the peak levels of transaction throughput, average CPU utilization across the available server capacity remained below 75%, providing considerable additional capacity for further increases in transactions.

Detailed Results of Online Business Test

The online business test was designed to simulate concentrated daily use of T24 by injecting a high volume of online transactions to the T24 application.

The throughput of online business transactions achieved was 3,437 per second, equal to more than 24.7 million transactions in an eight-hour day.

Table 5 gives the detailed results of the online business test.

Size	25 million accounts	
Throughput	3,437 TPS	
Duration	90 minutes	
Application Tier	# cores	100
	CPU utilization	30%
	# cores used if CPU at 100%	30
Database Tier	# cores	64 (Xeon 7560)
	CPU utilization	75%
	# cores used if CPU at 100%	48
	Memory	1 TB
	Mermory used	178 GB
Network	NIC bandwidth	10 Gbps
	# NICs in data-base	1
	Average network I/O	101 MB/sec
	Peak network I/O	123 MB/sec
I/O System	IOPS average	800
	IOPS peak	22,000
	Data IOPS peak	21,000
	Log IOPS peak	788
	Data IOPS average	390
	Log IOPS average	404

Table 5. Online business test detailed results.

Table 6 shows details of the transaction mix used in the online business test and the online business test results.

The online business test was run with the following configuration:

- 7 application servers running T24/TAFC were used, with a total of 100 cores.
- IBM WebSphere MQ V 7 and TOCF.NET were deployed on one 12-core server.
- JBoss, along with JMeter, was run on an independent 12-core server.
- SQL Server 2008 R2 was run on a 64-core NEC EX5800 server.
- A total of 356 Temenos agents were run for the online business test.
- Atrato Extreme Velocity 1000 storage was used.

Channel Type (Mix Percent)	T24 Transaction	Transaction Type interface	Required TPS	TPS Achieved
ATM and POS				
Balance inquiry (5%)	Custom Routine OFS.GET.ACCT.BALANCE	OFS-MQ	150 TPS	175 TPS
Cash withdrawal (25%)	OFS Clearing Manager with transaction request	OFS-MQ	750 TPS	767 TPS
Branch Office Transactions				
Teller cash deposit (2%)	TELLER,MB.DEPOSIT	XML-Browserweb	60 TPS	75 TPS
Collections (0.5%)	FT,MB.OT	OFS-MQ	15 TPS	15 TPS
SB account opening (0.1%)	ACCOUNT,MB.NEW	XML-Browserweb	3 TPS	7 TPS
Internet Banking				
Funds transfer (2%)	FT,MB.ACCT.TO.ACCT	XML-Browserweb	60 TPS	68 TPS
Balance inquiry (21%)	ENQ ACCT.BAL.TODAY	OFS-MQ	630 TPS	729 TPS
Bank statement (1%)	ENQ STMT.ENT.BOOK	OFS-MQ	30 TPS	32 TPS
Financial transaction inquiry (12%)	ENQ STMT.ENT.BOOK	OFS-MQ	360 TPS	402 TPS
IVR and Clearing				
IVR balance inquiry (8%)	Custom Routine OFS.GET.ACCT.BALANCE	OFS-MQ	240 TPS	365 TPS
Clearing transactions (23.4%)	OFS CLEARING MANAGER (BULK)	OFS-MQ	702 TPS	802 TPS

Table 6. Transaction mix for online business testing.

Table 7 shows the CPU utilization of the servers during the online business benchmark testing.

Server Make and Model	Number of Cores	CPU Utilizations
HP BL490G6	12	30%
HP BL460G6	8	20%
HP BL490G6	12	30%
HP BL490G6	12	30%
HP BL490G6	12	29%
HP BL490G6	12	55%
HP BL490G6	12	40%
Dell R910	32	20%
NEC A1080a-E	64	75%

Table 7. CPU utilization in online business test.

Detailed Results of Close-of-Business Test

The COB test was designed to simulate close-of-business batch processing and to measure the speed at which account capitalizations could be processed for a database of 25 million accounts.

The results of the COB capitalization test were impressive: 5,203 TPS, and 25 million accounts processed in 1 hour, 20 minutes, and 34 seconds.

Table 8 gives the detailed results of the COB test.

Size	25 million accounts	
Transactions	Accruals and capitalizations	
COB total time	3 hours, 17 minutes	
IC.COB time	1 hour, 20 minutes	
Application tier	# TAFC agents	320
	# cores	188 (X6550, E5540, E5650, X7560)
	CPU utilization	73%
	# cores used if CPU at 100%	137
Database tier	# cores	64 Xeon 7560
	CPU utilization	70%
	Cores used if CPU at 100%	45
	Memory	1 TB
	Memory used	600 GB
Network	NIC bandwidth	10 Gbps
	# NICs in database	1
	Network I/O average	150 MB/sec
	Network I/O peak	233 MB/sec
I/O system	IOPS average	7,000
	IOPS peak	62,000
	Data IOPS peak	60,000
	Log IOPS peak	1,500
	Data IOPS average	6,000
	Log IOPS average	1,000

Table 8. COB test results.

The COB capitalization test was run with the following configuration:

- 10 application servers were used with a total of 188 cores.
- Database server was running Microsoft SQL Server 2008 R2 with 64 cores.
- jDLS locking was deployed on the database server and was set to accommodate 200,000 locks.
- 320 agents were used for the COB test.

Table 9 shows the CPU utilization of the servers during the COB benchmark testing.

Server Make and Model	Number of Agents	Number of Cores	CPU Utilizations
HP BL460G6	15	8	80%
HP BL490G6	30	12	75%
HP BL490G6	30	12	75%
HP BL490G6	30	12	82%
HP BL490G6	30	12	75%
HP BL490G6	30	12	78%
HP BL490G6	30	12	85%
HP BL490G6	30	12	78%
Dell R910	40	32	85%
HP DL980G7	55	64	60%
NEC A1080a-E		64	70%

Table 9. CPU utilization in COB test.

Scalability

The scalability of TEMENOS T24 was demonstrated during the benchmark testing in several ways. Scalability tests were run with 100 agents, 200 agents, and 300 agents, looking for linear scalability. The results were 95% scalable.

Multiple application servers were used, showing that customers can use existing and new hardware simultaneously to develop a resilient and scalable architecture.

CPU utilization of the servers scaled in a linear fashion as greater numbers of transactions were passed to TEMENOS T24. At the peak levels of transaction throughput, CPU utilization across the available server capacity remained below 70%, providing considerable additional capacity for further increases in transactions.

NEC Corporation of America

NEC.com
6535 N. State Highway 161
Irving, Texas 75039-2402
(214) 262-2000 / (800) 338-9549

Intel.com
2200 Mission College Blvd.
Santa Clara, CA USA
95054-1549

Summary

Temenos and Microsoft are working together to provide banking solutions that address today's industry challenges and demands in the most cost-effective way, while offering the agility to respond to the business and technology opportunities of tomorrow.

The Temenos/Microsoft/NEC/Intel Highwater Benchmark proves that SQL Server 2008 R2 can provide record-breaking performance for T24.

For More Information

The Microsoft/Temenos Alliance site

The "TEMENOS T24 Core Banking Optimized on Microsoft SQL Server Database Platform" white paper

The T24/SQL Server 2008 benchmark press release "Microsoft and Temenos Prove Scale of Support for the Largest Retail Banking Operations"

Microsoft.com
Microsoft Corporation
1 Microsoft Way
Redmond, WA USA
98052-6399

Temenos.com
Temenos Headquarters SA
18 Place des Philosophes
CH – 1205 Geneva
Switzerland