

High-End Windows Datacenter Ed., SQL Server & Solid State

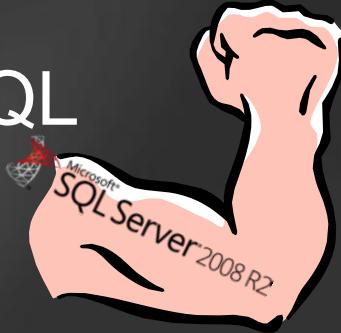
Henk van der Valk
IT Workload optimizer



UNISYS – *European Performance Center*

Agenda

- 10 years Windows Datacenter, Disks & SQL
- High End SQL:
 - 1) ETL World record
 - Loading data: Bottlenecks & Optimizations found
 - SQL 2008 R2 & Solid State on 96 Cores
 - 2) The data is all loaded, what's next?
 - Optimizing an Evil DWH query
 - Speeding up large table scans
- Performance tuning tips & Quick wins
 - Impression of what I'm currently testing



About the speaker



- Co-Founder Unisys
ES7000 Performance Centers (2001)
- Over 5 year history of in depth SSIS / SQL product performance testing with the dev teams
- Performance troubleshooter & Workload optimizer
- 23+ years into computers...
- Deals with the largest & most demanding IT environments (in the world)
- Participates in Dutch + EU SQLPass & Performance SIG

Microsoft & Unisys BI marketing

- The T³ Project – SQL 2000

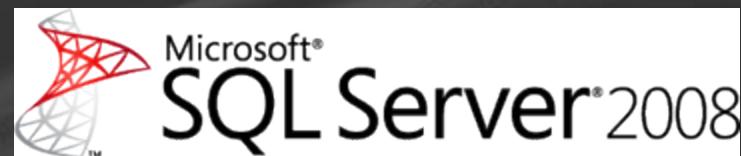
- (terabyte cube, world largest OLAP cube)
 - 1.2TB of data representing 7.7 billion rows;



- Project Real - SQL2005



- ETL World record - SQL2008 launch



- SQL2008 R2: - Global Platinum launch Partner



Long history of TPC-xx records

- TPC- E (OLTP) World Record with SQL2008R2:

Microsoft SQL Server 2008 R2 Windows Server 2008 R2

Support for Largest x64 & IA64 Servers

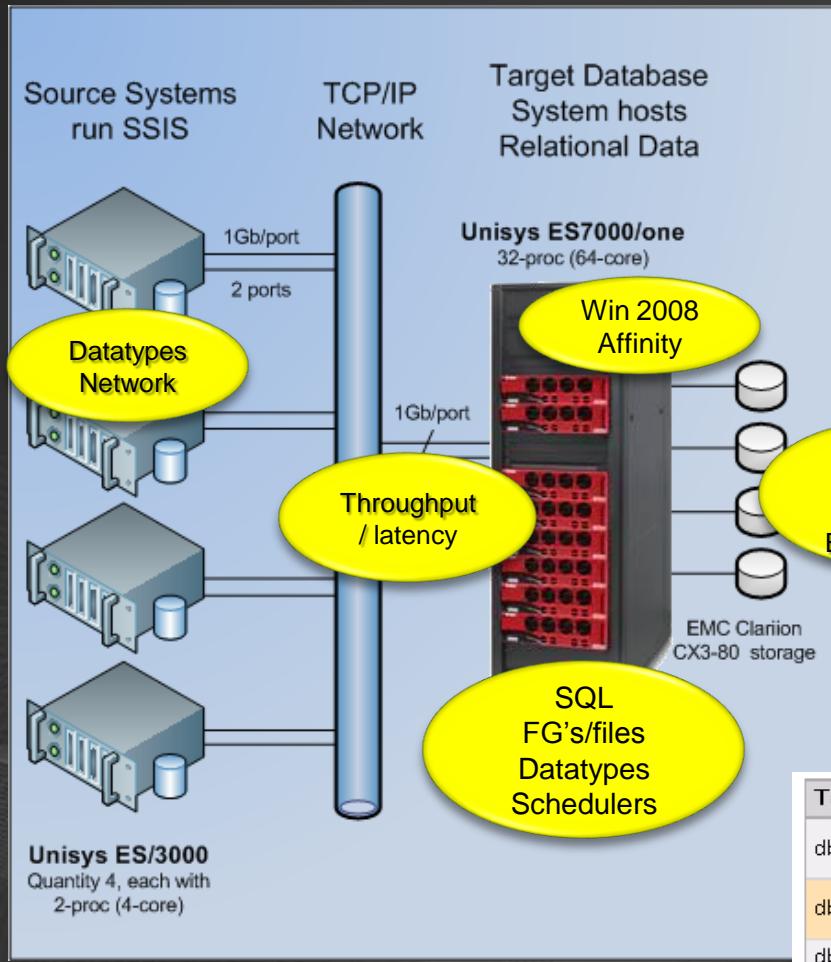
- New *OLTP world-record performance*
TPC-E: 2,012 tpsE
- *Record DW performance on Windows*
TPC-H: 102,778 QphH

UNISYS

- Many Customer Reference cases & prices

SQL Server Integration Services

Record ETL Performance



Microsoft®
SQL Server™ 2008

1.18 TB of data loaded in 29 min 54 sec

- Data model reflects a wholesale supplier data warehouse
- Data is read from text files, sent over network, and stored in a single database image
- 8.5+ Billion records
- SSIS runs on source systems, reflecting a distributed environment
- Built upon
 - SQL Server 2008 Ent. Ed. February CTP
 - Windows Server 2008 Datacenter Ed.

Table Name	# Records	Reserved (KB)	Data (KB)
dbo.LINEITEM	5,999,989,709	679,400,512	679,394,408
dbo.ORDERS	1,500,000,000	182,977,472	182,972,144
dbo.PARTSUPP	800,000,000	125,819,072	125,813,888
dbo.PART	200,000,000	29,367,808	29,361,840
dbo.CUSTOMER	150,000,000	26,157,248	26,152,152
dbo.SUPPLIER	10,000,000	1,598,336	1,592,608

Unisys Into SQL Server since early days:

Partner Award winning solution on SQL2000/ 32bit

- Unisys digital Interactive Archive System (DIAS)
 - 22+ billion records
 - 30TB SQL Data + 30 TB images
 - Redundant / Geo locations



Database Size – All Environments – Data Warehousing								
Company/ Organization	DB Size (GB)	Platform	DBMS	Architecture	DBMS Vendor	System Vendor	Storage Vendor	
Yahoo!	100,386	Unix	Oracle	Centralized/SMP	Oracle	Fujitsu Siemens	EMC	W
AT&T	93,876	Unix	Daytona	Federated/SMP	AT&T	HP	HP	I
KT.I.T.Group	49,397	Unix	DB2	Centralized/Cluster	IBM	IBM	Hitachi	N
AT&T	26,713	Unix	Daytona	Federated/SMP	AT&T	Sun	Sun	T
LGR–Cingular Wireless	25,203	Unix	Oracle	Centralized/SMP	Oracle	HP	HP	E
Amazon.com	24,773	Linux	Oracle RAC	Centralized/Cluster	Oracle	HP	HP	R
Anonymous	19,654	Unix	DB2	Centralized/MPP	IBM	IBM	EMC	C
UPSS	19,467	Windows	SQL Server	Centralized/SMP	Microsoft	Unisys	EMC	O
Amazon.com	18,558	Linux	Oracle RAC	Centralized/Cluster	Oracle	HP	HP	R
Nielsen Media Research	17,685	Unix	Sybase IQ	Centralized/SMP	Sybase	Sun	EMC	P

- My first harddisk

- Seagate ST-225 - 20 MB
 - Seek time / track 65.0/20.0 msec
 - 0.625 Mbyte /Sec MFM interface



- Micropolis 1325

- 72 MB – 13 msec
- Seek time / track 28.0/ 6.0 ms

- Impression of 6millisec seek timings:

<http://www.tubeoli.com/video/Gb1cUbC1VHM/watch.html>



- 1992: Maxtor XT8760S

- 5.25", 3600 RPM
- 760 MB
- 40 MB/sec SCSI
- Seek <3 milliSeconds



- Today's disk drives: 1 or 2 Terabyte

- Speed 7,200 RPM (double)
- Average latency 4.16ms
- Random read seek time <8.5ms
- Random write seek time <10.0ms
- http://www.seagate.com/www/en-us/products/desktops/barracuda_hard_drives/#tTabContentSpecifications

SQLPass 2009 summit keynote

- Picture shamelessly copied from David DeWitt's keynote ;-)

A little closer look at 30 year disk trends

Capacities: 80 MB → 800 GB - **10,000X**
Transfer rates: 1.2 MB/sec → 80 MB/sec - **65X**
Avg. seek times: 30 ms → 3 ms - **10X**
(30 I/Os/sec → 300 I/Os/sec)



The significant differences in these trends (10,000X vs. 65X vs. 10X) have had a huge impact on both OLTP and data warehouse workloads (as we will see)

1999 - How it all started with Unisys & High End SQLServer...the ES7000

- 32way / 64 GB RAM support
- CPU: 32bit PIII - 550 MHz
- @ 64bit Itanium 800 MHz
 - SQL Server (64-bit) released in April 2002.

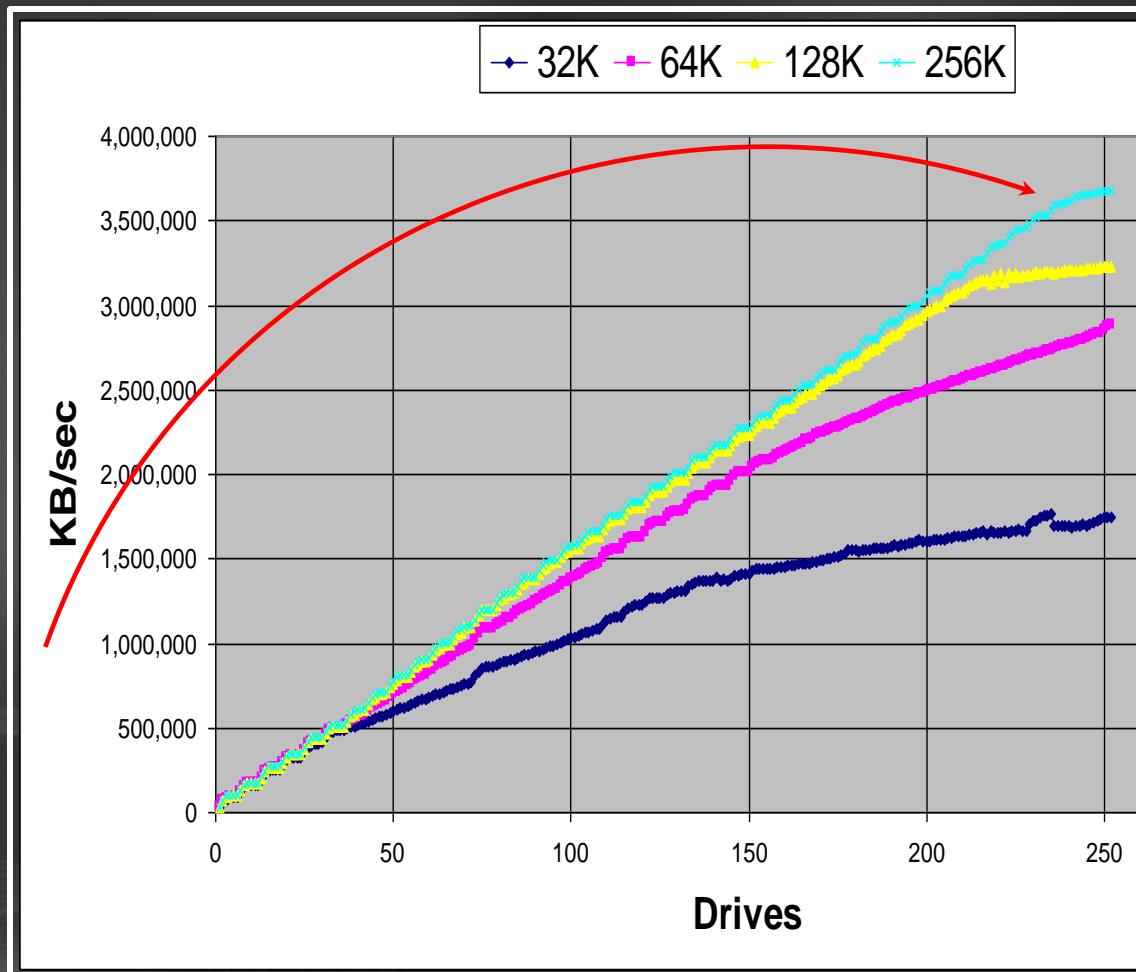


Unisys ES7000 ... Big Windows / Wintel Mainframe Architecture

- >Up to 32 CPU's
- >64/128 GB RAM
- >96 PCI slots

Example : Seq. read

- >ES7000/100
- >1 x OS: Windows 2000 Datacenter
- >42 x 1Gbit HBA's
- >EMC Clariion's with 250 physical drives



ES7000 Evolution

Mainframe Architecture – Performance – Reliability – Modularity – Lower TCO – Agility

1999 —————→ 2008

**Intel® Pentium® III
Xeon® processor
(550Mhz)**



**ES7000/100 & 200
32cpu's /32GB**

**Intel® Xeon®
processor MP**



**ES7000/500
3.4Ghz/64GB**

**Intel Xeon
processor MP**



**ES7000/one
64 cores /256GB
(128 with HT)**

**Intel Xeon
processor EX**



**ES7000
Model 7600R
96 cores
1TB RAM**

Windows Media Player

Now Playing Library Rip Burn Sync Media Guide

Looking at Disk Improvements

- Incredibly inexpensive drives (& processors) have made it possible to collect, store, and analyze huge quantities of data

Over the last 30 years

But, consider the metric **transfer bandwidth/byte**

- 1980: $1.2 \text{ MB/sec} / 80 \text{ MB} = 0.015$
- 2009: $80 \text{ MB/sec} / 800,000 \text{ MB} = .0001$

When relative capacities are factored in, drives are 150X slower today!!!

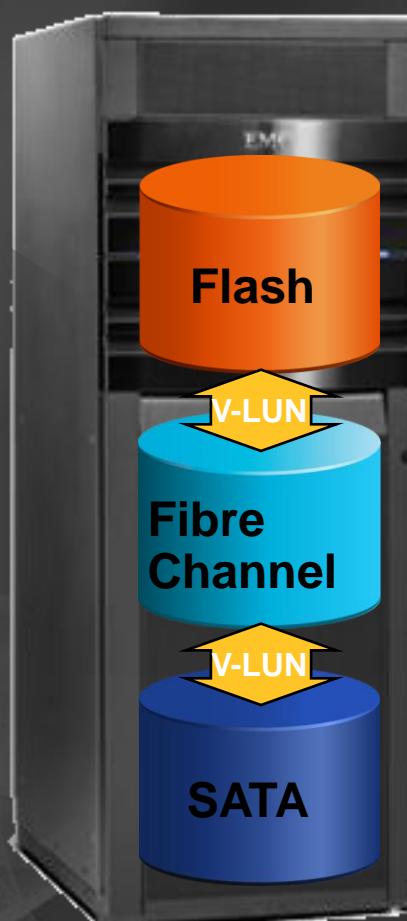
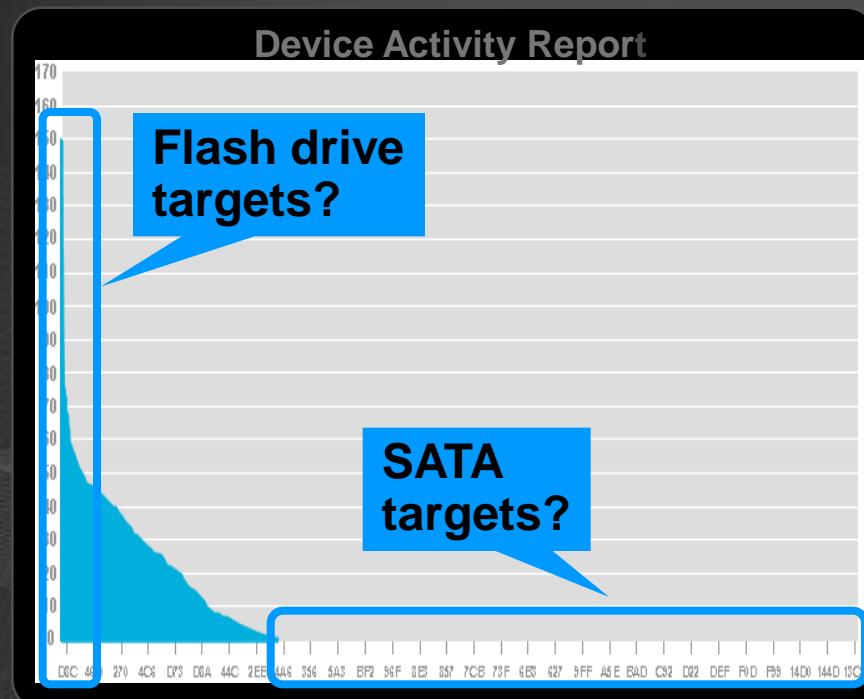
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High End SAN / SSD Market trends

Fully Automated Storage Tiering (FAST)

Storage Tiering Today: Manual

Get the right data
to the right place

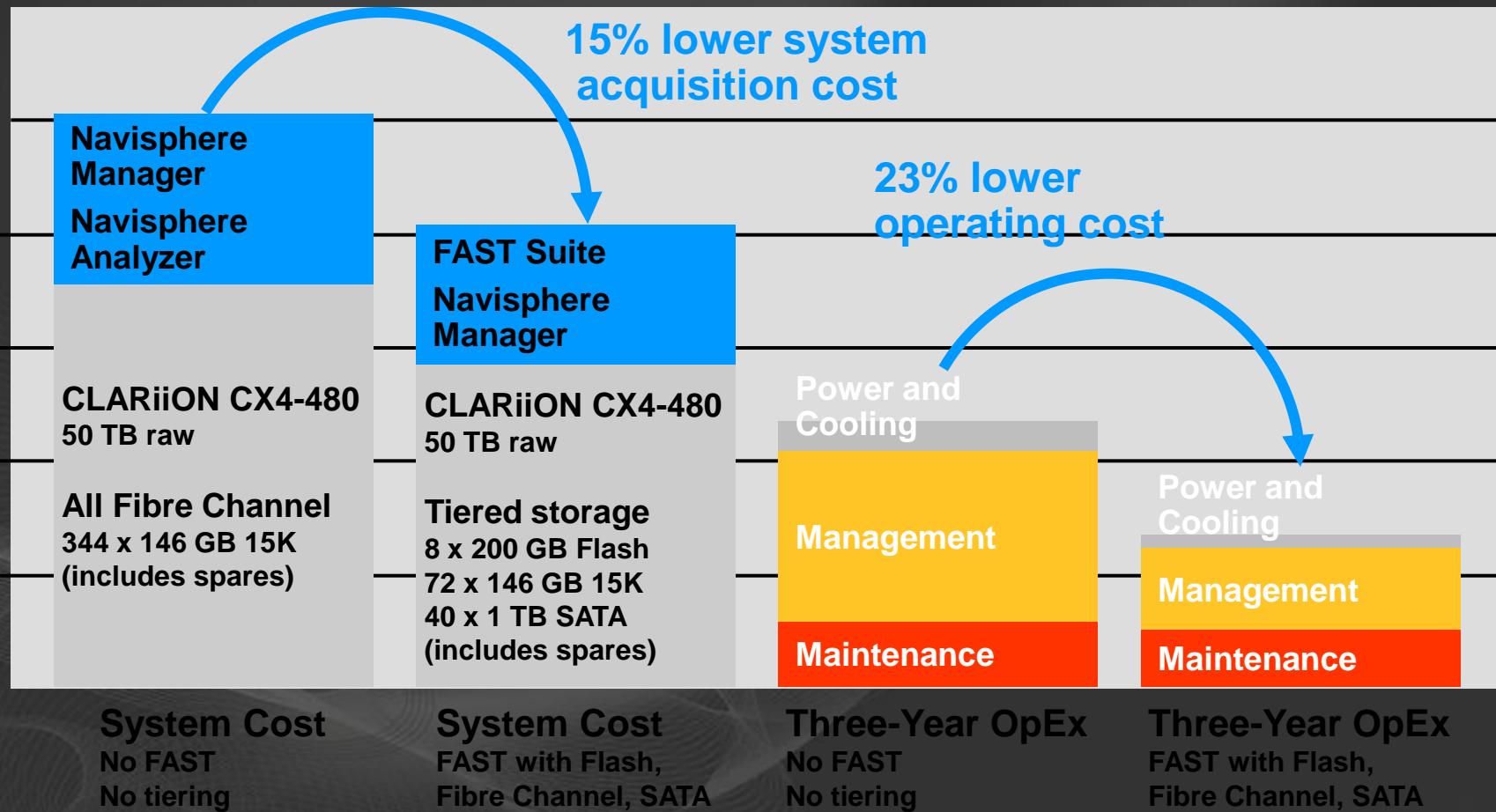


Faster
application performance

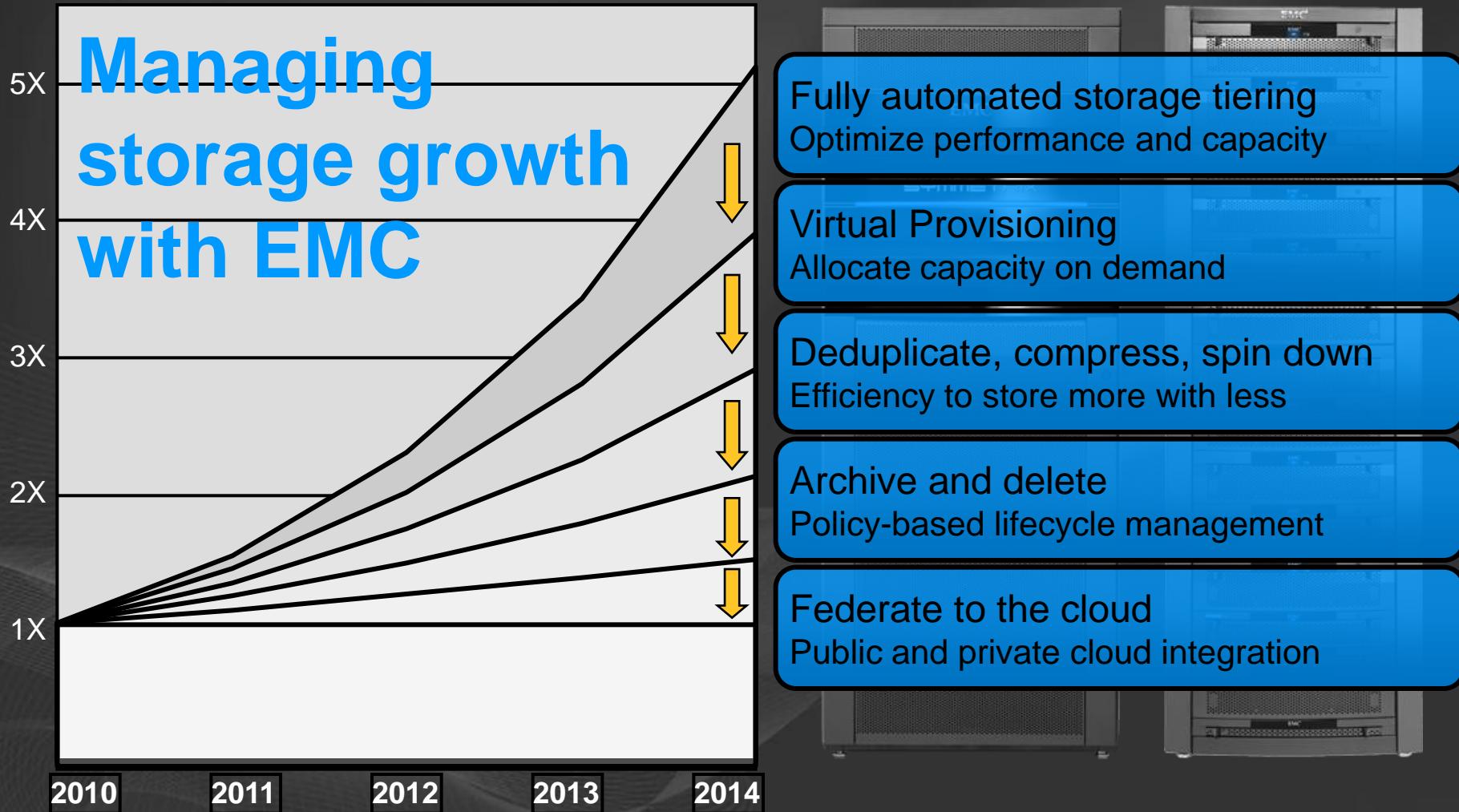
Lower
storage costs and less energy

CLARiiON CX4 Lowering Costs with Tiering and FAST

20% lower three-year total cost of ownership



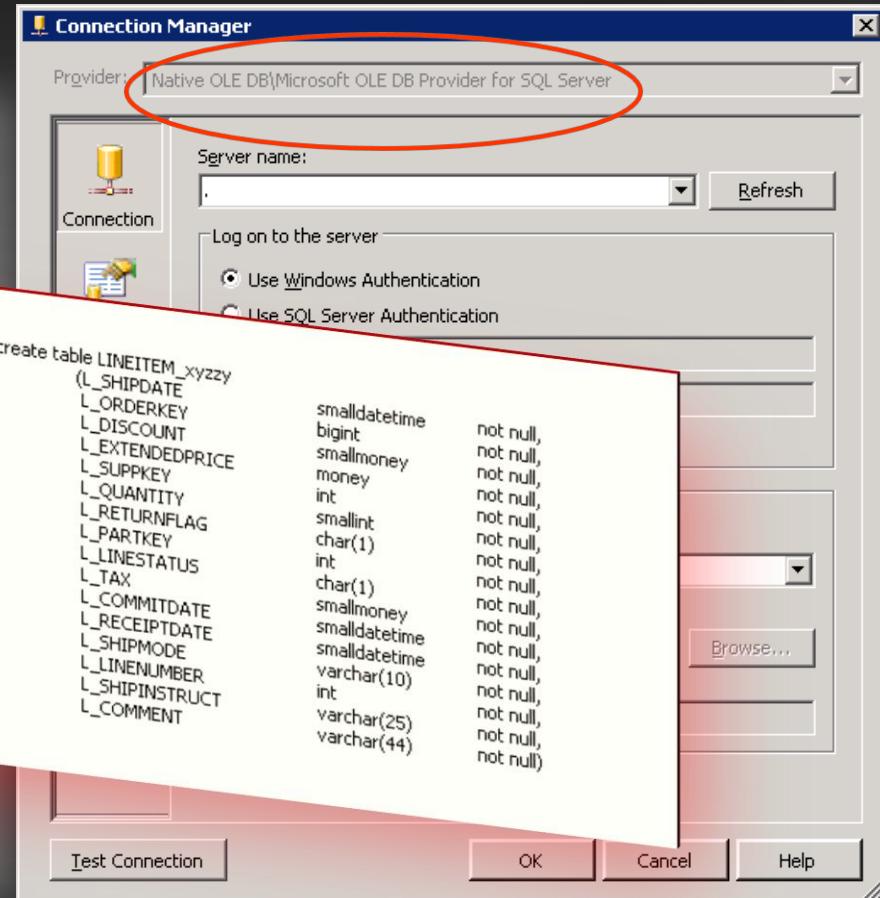
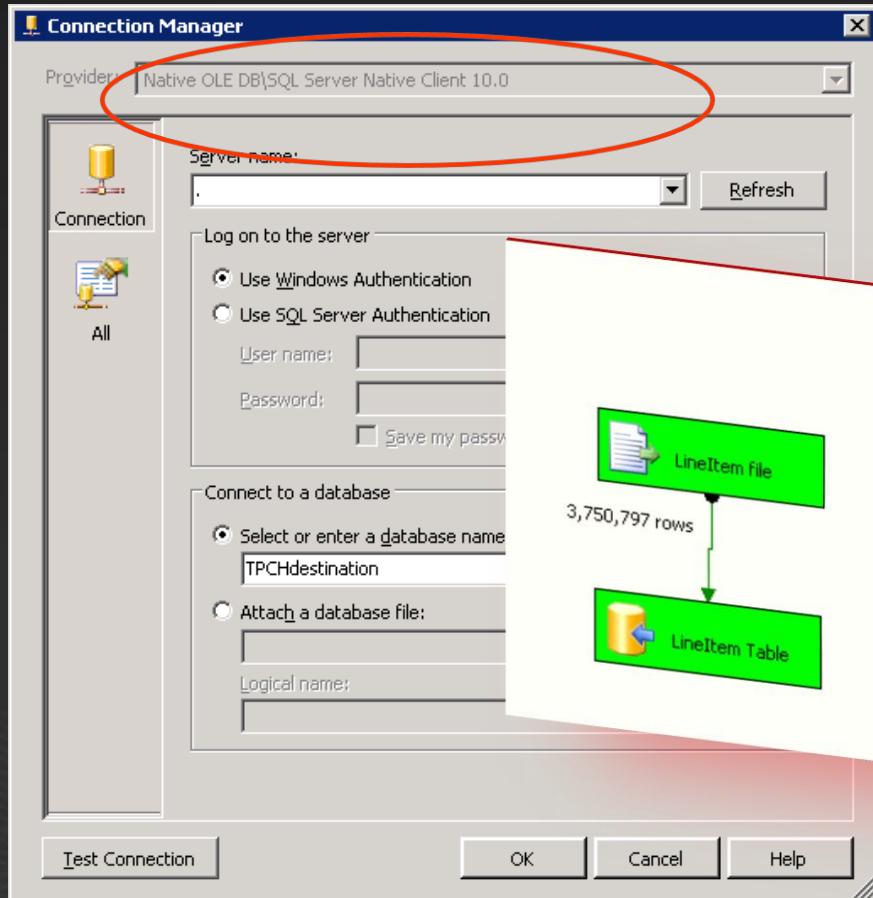
Efficient Management of Information Growth



Question:

- If we have to load data from a flat file as *fast as possible* into SQLServer:
- What methods are there for Bulk load?
- Which will be fastest?
 - BCP
 - BULK INSERT
 - SSIS - Data Destinations
 - Other ?
- Multiple systems for SSIS and SQL?

Functionality	Integration Services		BULK INSERT	BCP	INSERT ... SELECT
	SQL Dest.	OLE DB Dest			
Protocol	Shared Memory	TCP/IP	In Memory	TCP/IP	In Memory
		Named Pipes		Shared Memory	
				Named Pipes	
Speed	Faster / Fastest(4)	Fast / Fastest (1)	Fastest	Fast	Slow / Fastest (2)
Data Source	Any	Any	Data File Only	Data File Only	Any OLE DB
Bulk API Support	Not Native	Not ORDER	All	All	No Hints Allowed
		Not Native			
Lock taken with TABLOCK hint on heap	BU	BU	BU	BU	X
Can transform in transit	Yes	Yes	No	No	Yes
I/O Read block Size	128 KB for text files	Depends(3)	64 KB	64 KB	Up to 512 KB
SQL Server Version	2005 and 2008	2005 and 2008	7.0, 2000, 2005, and 2008	6.0, 7.0, 2000, 2005, and 2008	2008
Invoked from	DTEXEC / BIDS	DTEXEC / BIDS	Transact-SQL	Command Line	Transact-SQL



3750797 rows
463 MB

BULK INSERT dbo.LINEITEM_1 FROM
'C:\Readers\R0\lineitem.tbl.1'
WITH (FIELDTERMINATOR = '|',
ROWTERMINATOR = '\n',
TABLOCK)

Tip: Sharpen data type

Money type (10-20% improvement) (Still Applies to SQL2005)

- Use Money type instead of decimal columns

- Storing as money (a 8-byte integer with implied 4 decimal digits). TDS (Tabular Data Stream) is the format SQL Server uses for transfer of data over the wire
- Money, because it is fixed length, is alignment efficient for the CPU.

Column Name	Data Type	Allow Nulls
ProductID	int	<input type="checkbox"/>
RecCnt	smallint	<input type="checkbox"/>
Gross	decimal(11, 2)	<input type="checkbox"/>
Quantity	decimal(9, 3)	<input type="checkbox"/>
IsPledge	bit	<input type="checkbox"/>
StornoType	tinyint	<input type="checkbox"/>
AuditID	smallint	<input type="checkbox"/>
BonNumber	int	<input type="checkbox"/>
ReceiptDateID	int	<input type="checkbox"/>
Total	decimal(11, 2)	<input type="checkbox"/>
OrgID	int	<input checked="" type="checkbox"/>
ReceiptTimeID	smallint	<input type="checkbox"/>
BonPosID	tinyint	<input type="checkbox"/>



Column Name	Data Type	Allow Nulls
OrgID	int	<input checked="" type="checkbox"/>
BonNumber	int	<input type="checkbox"/>
RecCnt	smallint	<input type="checkbox"/>
ProductID	int	<input type="checkbox"/>
ReceiptDateID	int	<input type="checkbox"/>
ReceiptTimeID	smallint	<input type="checkbox"/>
Gross	money	<input type="checkbox"/>
Quantity	money	<input type="checkbox"/>
Total	money	<input type="checkbox"/>
BonPosID	tinyint	<input type="checkbox"/>
IsPledge	bit	<input type="checkbox"/>
StornoType	tinyint	<input type="checkbox"/>
AuditID	smallint	<input type="checkbox"/>

Single flat file bulk insert results

- 463 MB / 3750797 rows

Method	Connection manager	Provider	Avg. Bulk copy rows/sec	CPU	Reads	Writes	Duration (millisec)
T-SQL Bulk Insert			150000	33446	165603	52763	50432
Native OLEDB \msft OLEDB provider for sql server (TCP)	localhost.TPCHDest 4 KB	SQLOLEDB.1	143000	29780	167120	53237	38444
Native OLEDB \msft OLEDB provider for sql server (TCP)	localhost.TPCHDest 32 KB	SQLOLEDB.1	160000	31684	167120	53235	37460
Native OLEDB \SQL Server Native client 10.0 (in memory)	DestinationDB - 0	SQLNCLI10.1	159000	30997	167259	53237	37951
Native OLEDB \SQL Server Native client 10.0 (in memory)	DestinationDB 32 KB	SQLNCLI10.1	176000	30825	167197	53233	33914

17% faster

The fastest method: SSIS with In memory connection (SQL Server Native Client + 32 KB packet Size)

WRproject (Running) - Microsoft Visual Studio (Administrator)

File Edit View Project Build Debug Data Format SSIS Tools Window Help

LineItemSOLED...dtsx [Design] * LineItemSOLED...dtsx [Design]

Control Flow Data Flow Event Handlers Package Explorer Progress

Data Flow Task: LineItem

create table LINEITEM_xyzy
(
L_SHIPDATE smalldatetime not null,
L_ORDERKEY bigint not null,
L_DISCOUNT smallmoney not null,
L_EXTENDEDPRICE money not null,
L_SUPKEY int not null,
L_QUANTITY smallint not null,
L_RETURNFLAG char(1) not null,
L_PARTKEY int not null,
L_LINESTATUS char(1) not null,
L_TAX smallmoney not null,
L_COMMITDATE smalldatetime not null,
L_RECEIPTDATE smalldatetime not null,
L_SHIPMODE varchar(10) not null,
L_LINENUMBER int not null,
L_SHIPINSTRUCT varchar(25) not null,
L_COMMENT varchar(44) not null)

LineItem file

3,750,797 rows

LineItem Table

▶ Progress: Cleanup - 0 percent complete
▶ Progress: Cleanup - 50 percent complete
▶ Progress: Cleanup - 100 percent complete
◀ Finished, 11:37:57 PM, Elapsed time: 00:00:33.914

Connection Manager

Provider: Native OLE DB\SQL Server Native Client 10.0

Connection

All

Auto Translate: True

Connection Plan

Current Language

Data Type Compatibility: 0

Failover Partner

Failover Partner SPN

Initial File Name

MARS Connection: False

Network Address

Network Library

Old Password

Packet Size: 32767

Replication server name connect opti

Server SPN

Tag with column collation when possi: False

Trust Server Certificate: False

Use Encryption for Data: False

Use Procedure for Prepare: 1

Workstation ID: UNISYS-ES7000

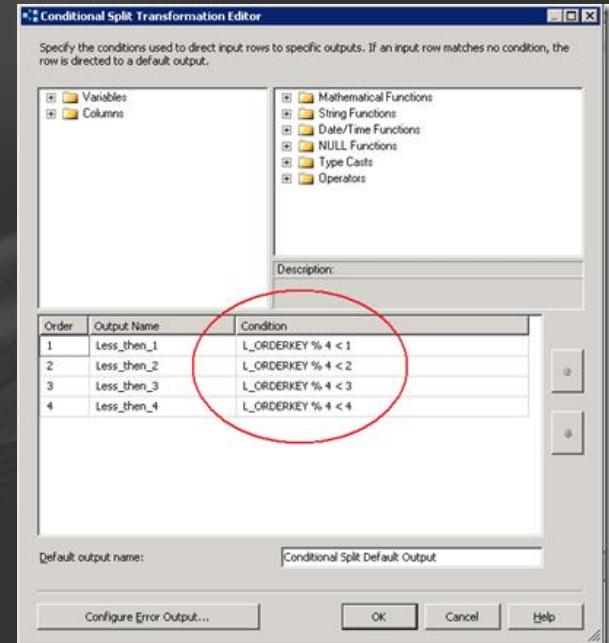
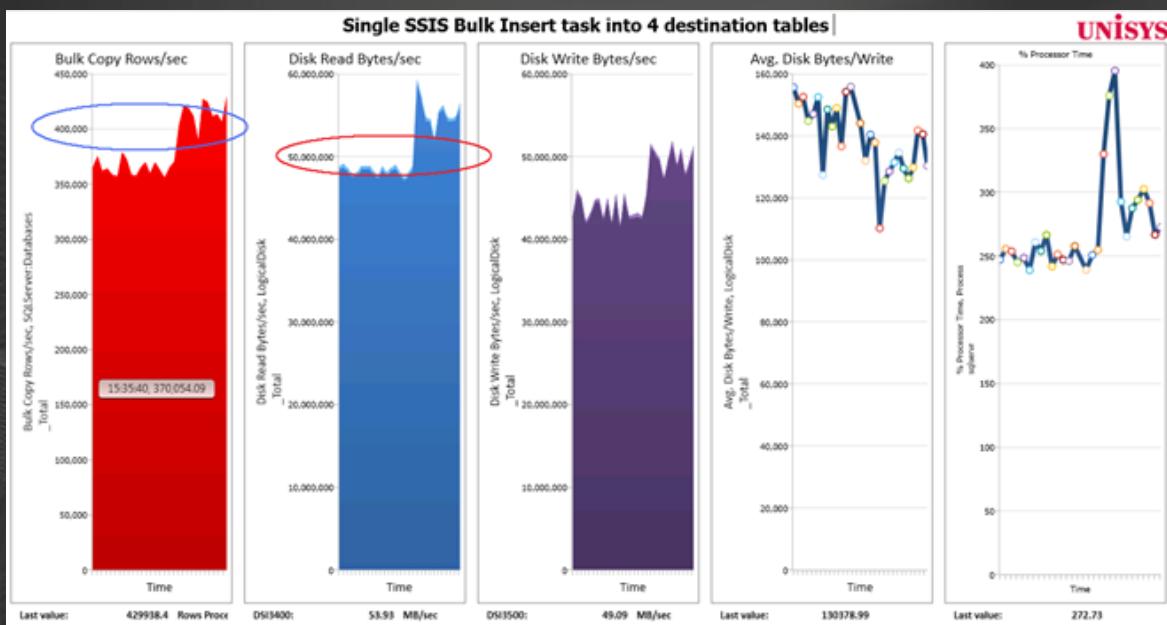
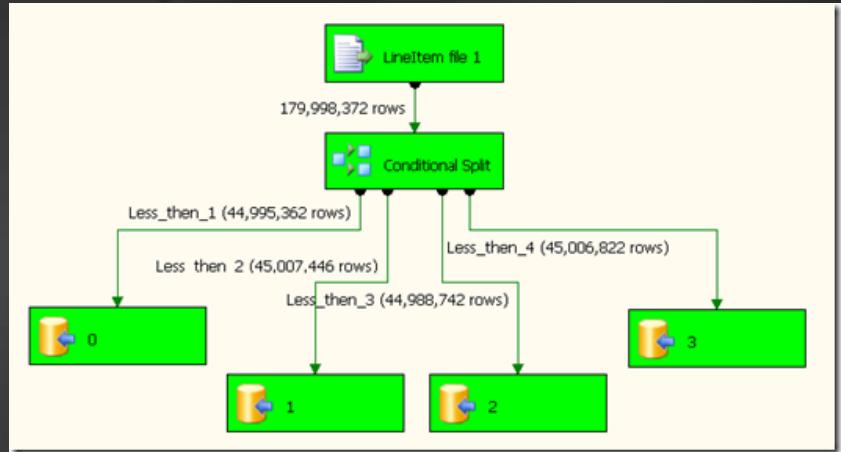
Provider

The name of the OLE DB Provider to use when connecting to the Data Source.

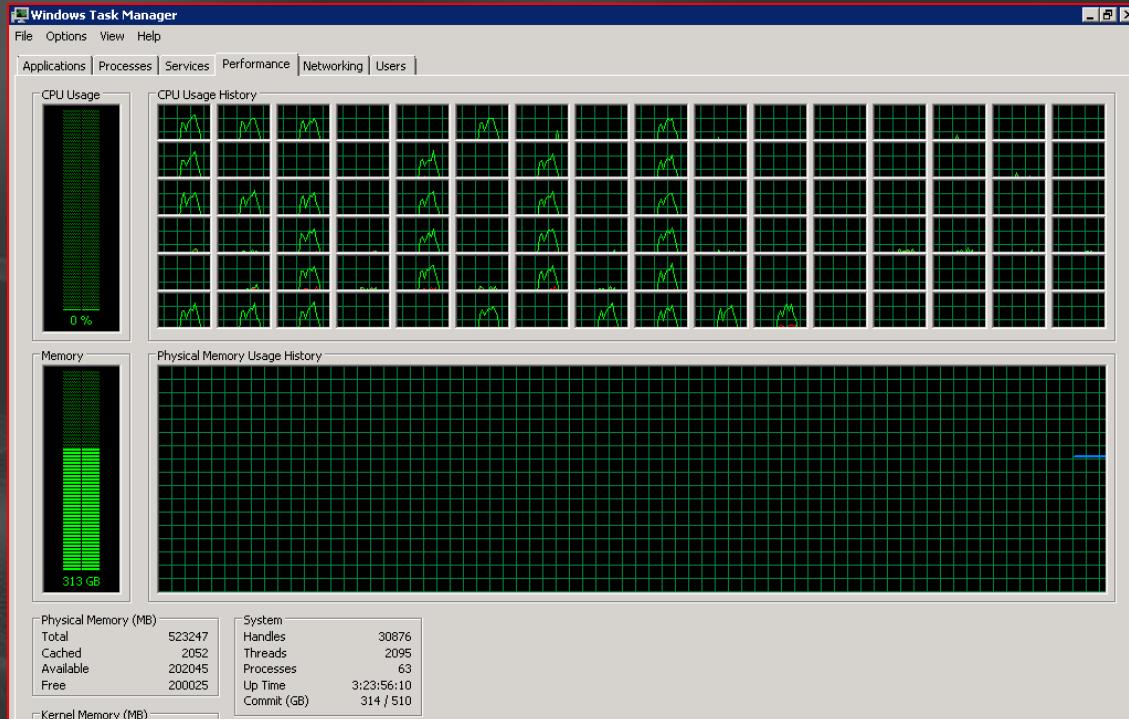
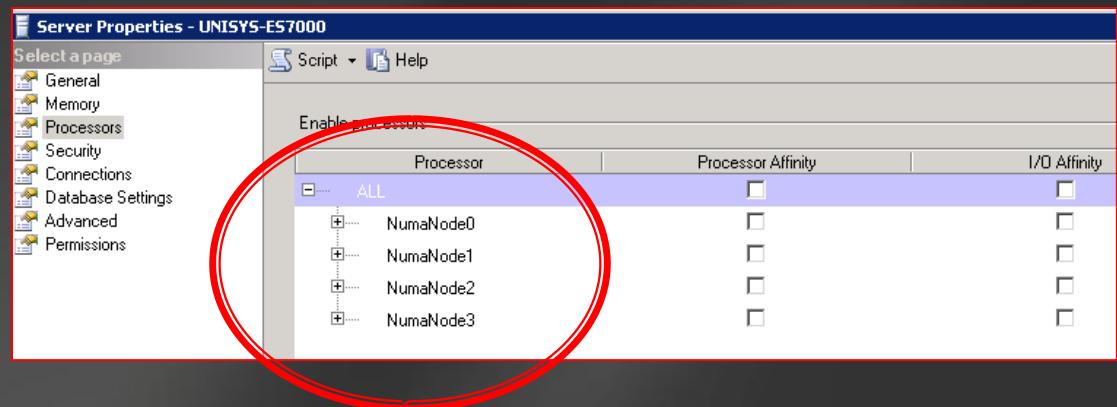
Test Connection OK Cancel Help

Or...use a conditional split + modulo

- From 160K rows/sec to 350+ K row/sec
- 5 Cores loaded



How about SQL 2008 R2 CTP2 on a 96 core Unisys ES7000 server with DSI SSD?



+ Enterprise - High Speed DSI Solid State Storage

DSI3020

Solid State Disk
PCIe Flash Storage Expansion Card



Quick Specs

450 GB Flash Memory
700 MB/sec Read Bandwidth

RAID Protection
500 MB/sec Write Bandwidth

DSI3400

Solid State Disk System
Enterprise High Speed Disk



Quick Specs

Up to 512 GB Capacity
4.5 GB/sec Bandwidth
600,000 I/Os per second

Data Mirroring
Multiple Hot Swap Flash Drives
Up to 8 - 4Gb Fibre Channel Ports



8 Fibers each

DSI3500

Solid State Disk System
Enterprise High Speed Disk



Quick Specs

RAID3 Protection
Up to 2TB Flash Storage
100,000 I/Os per second

Up to 8 - 4Gb Fibre Channel Ports
Hot Swap Architecture
Chipkill Technology

DSI3600

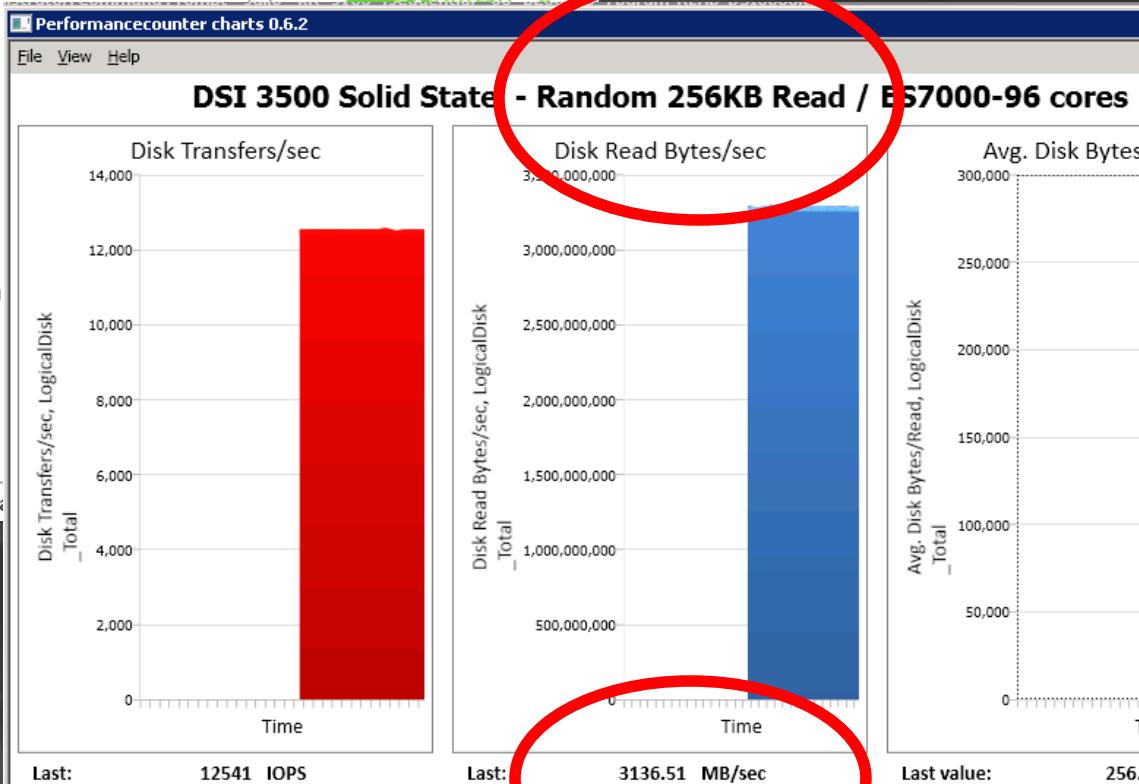
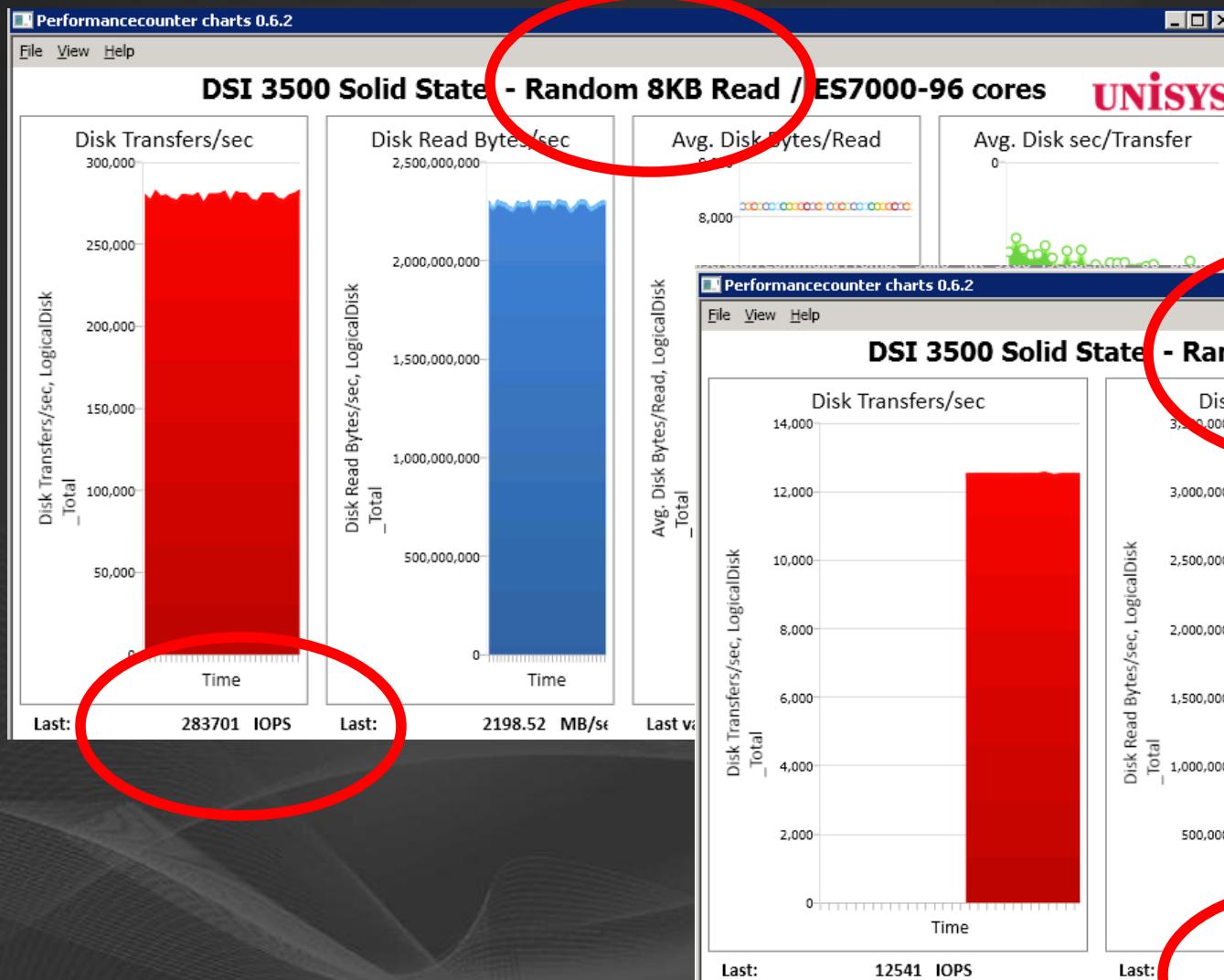
Solid State Disk System
Enterprise High Speed Disk



Quick Specs

Board Level RAID
Up to 5TB Flash Storage
250,000 I/Os per second

Up to 8 - 4Gb Fibre Channel Ports
Hot Swap Architecture
3 GB/sec of bandwidth



SQL2008 R2 96 Parallel Bulk Inserts

- 96 Core ES7000 with DSI Solid State disks
- Bulk Insert rate increases from
4 Million rows/sec -> 14+ Million rows/sec!



- Typically we see a 30% reduction in duration / batch window when using SSD storage

Sometimes SSD doesn't help...

- POC Bulk inserting from flatfiles with SSD cards (non Unisys gear ;-))
- Expect 20 MB/sec for each SQL Server Scheduler/ Core...
 - 32 core SSIS server
 - 32 core DB server
 - 10Gbit network



Typical SQL Wait types while bulk loading

Wait type	Typical cause	Investigate / resolve
LCK_<X>	One process blocking another	Are you using non overlapping input streams? Correct TABLOCK used? Find the top blocker.
PAGEIOLATCH_<X>	Disk system too slow	Add more disk or tune I/O. See "Optimizing I/O and File Layout".
IMPROV_IO	Text file data drive too slow	Optimize I/O on drive used for input files.
PAGELATCH_UP	Contention on PFS Pages	Make sure disk system is fast enough. See "PFS Contention" Run with -E flag.
ASYNC_NETWORK_IO	Network cannot keep up	See "Performance Counters Optimizing Network".
WRITELOG	Transaction log cannot keep up	Verify that you are using minimally logged operations. Make sure the transaction log is on fast disk.
OLEDB	Input data too slow	Optimize speed of input data source.
SOS_SCHEDULER_YIELD	Scheduler contention	See "Scheduler Contention".
ALLOC_FREESPACE_CACHE	Heap allocation contention (only found in sys.dm_os_latch_stats)	Too many threads are inserting into a heap at the same time. Consider partitioning table to get more heaps as insert targets.
PREEMPTIVE_COM_<X>	Nothing	These waits are normal and expected. Ignore them.

SQL Server : How to find out...

4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1843 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev14.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1833 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev19.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1833 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev20.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1846 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev17.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1837 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev16.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1840 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev18.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1844 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev12.mdf] in database [tempdb] (2). The C
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1846 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev13.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1853 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev12_1.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1850 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev15.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1854 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev10.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1853 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev11.ndf] in database [tempdb] (2). The
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1856 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev8.ndf] in database [tempdb] (2). The O
4/15/2009 10:44:52 AM	spid10s	SQL Server has encountered 1855 occurrence(s) of I/O requests taking longer than 15 seconds to complete on file [C:\Writers\W0\tempdev6.mdf] in database [tempdb] (2). The O:

- How many disk IO's are being processed by your SQL Servers at this very moment?
- How many of them are pending, waiting to be serviced?
- Which databases are the top IO consumers
- Which queries are actually creating the majority of the IO load?

Display the Pending Ios...

```
/* V1.0 - 18 dec. 2009 Henk van der Valk
```

Based on query from the Troubleshooting Perf. Probl.in SQL Server 2008:

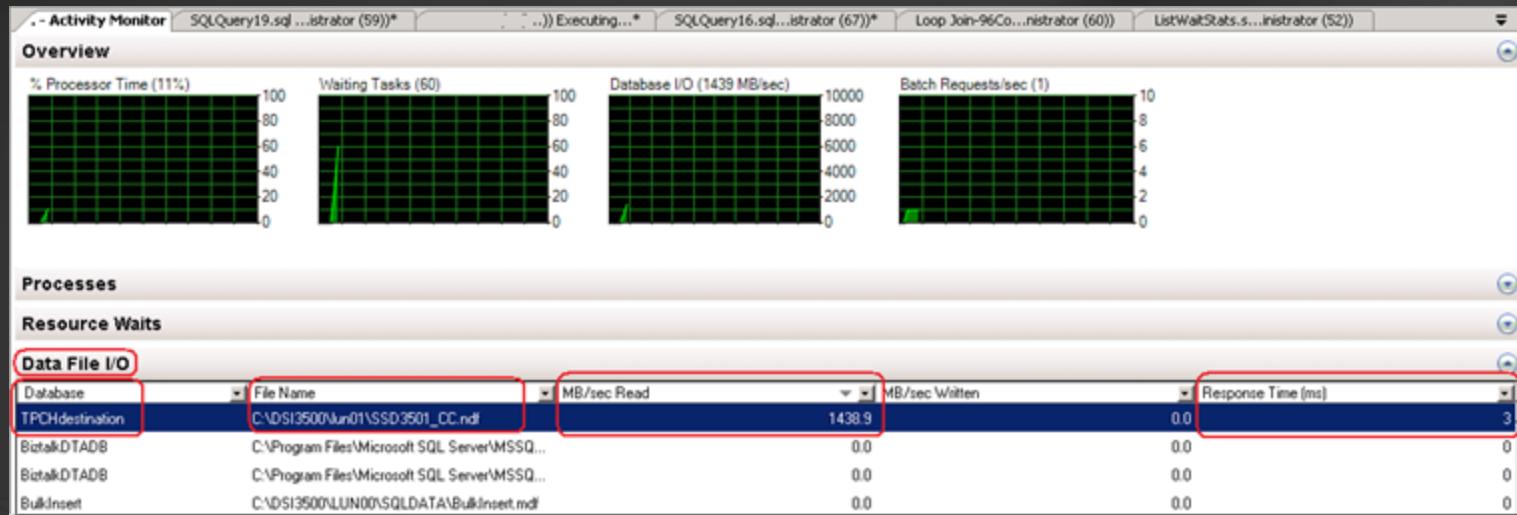
<http://download.microsoft.com/download/D/B/D/DBDE7972-1EB9-470A-BA18-58849DB3EB3B/TShootPerfProbs2008.docx>

*/

```
SELECT db.name AS database_name  
 , mf.name AS file_name  
 , mf.physical_name  
 , vfs.io_stall  
 , t2.io_pending_ms_ticks as IO_pending_millisecond_ticks  
 , t2.scheduler_address  
 , sched.scheduler_id  
  
FROM sys.dm_io_virtual_file_stats(NULL, NULL)vfs  
JOIN sys.dm_io_pending_io_requests as t2  
    ON vfs.file_handle = t2.io_handle  
JOIN sys.databases db  
    ON vfs.database_id = db.database_id  
JOIN sys.master_files mf  
    ON vfs.database_id = mf.database_id  
    AND vfs.file_id = mf.file_id  
JOIN sys.dm_osSchedulers sched  
on t2.scheduler_address = sched.scheduler_address  
  
ORDER BY io_pending_ms_ticks DESC
```

	database_name	file_name	physical_name	io_stall	num_of_bytes_read	io_pending_ms_ticks
1	TPCH_1TB	All_Lun6_1	C:\CX3-80\LUN06\All_Lun6_1.ndf	12160398	24220360704	697
2	TPCH_1TB	All_Lun6_1	C:\CX3-80\LUN06\All_Lun6_1.ndf	12160398	24220360704	681
3	TPCH_1TB	All_Lun6_1	C:\CX3-80\LUN06\All_Lun6_1.ndf	12160398	24220360704	665
4	TPCH_1TB	All_Lun6_0	C:\CX3-80\LUN06\All_Lun6_0.ndf	11439912	24310210560	630
5	TPCH_1TB	All_Lun6_1	C:\CX3-80\LUN06\All_Lun6_1.ndf	12160398	24220360704	619
6	TPCH_1TB	All_Lun6_1	C:\CX3-80\LUN06\All_Lun6_1.ndf	12160398	24220360704	609

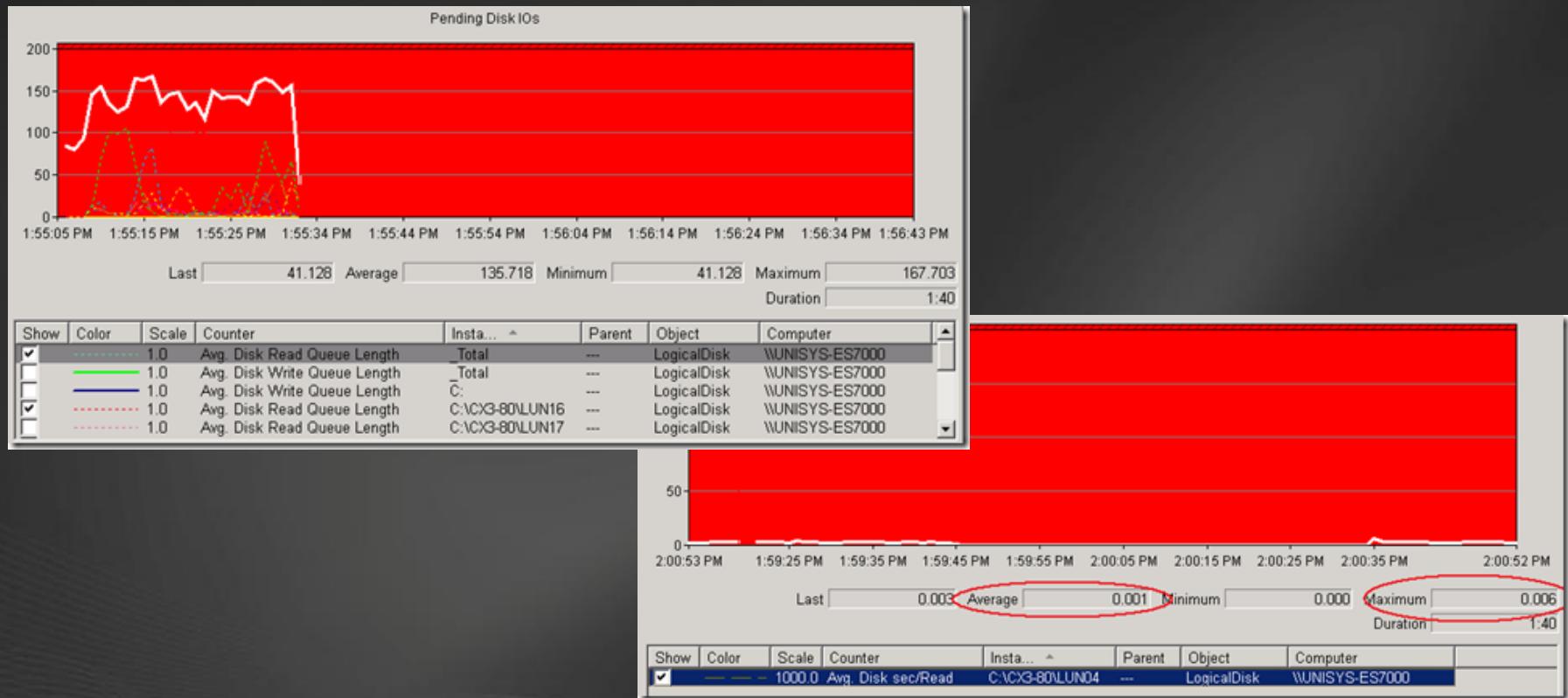
SSMS Activity Monitor



Recent Expensive Queries									
Query	Executions/min	CPU (ms/sec)	Physical Reads/sec	Logical Writes/sec	Logical Reads/sec	Average Duration (ms)	Plan Count	Database Name	
SELECT count (*) from LINEITEM_Hash96Key...	3	3318	2393	0	14	121080	5133	1 TPCHdestination	
INSERT INTO #am_fingerprint_stats_snapshot...	3	1	0	215	128	1	tempdb		

Physical Reads/sec: direct related to the Windows Perfmon Logical Disk counter : Disk Reads/Sec.
Logical Writes+Reads/sec: multiplied by 8192 , this values represents the effective MBytes/sec processed.

The Windows OS view:



- Average disk Read Queue length of around 150 queued IOs
- Average response time of about 1 millisecond each,
- == pending IO values could be as high as 150 milliseconds on a SQL database file level.

Additional Readings

- The Data Loading Performance Guide
 - <http://msdn.microsoft.com/en-us/library/dd425070.aspx>
- ETL World record
 - <http://msdn.microsoft.com/en-us/library/dd537533.aspx>
- Dynamic Solutions SSD Storage Solutions
 - DDR: <http://www.dynamicsolutions.com/main-menu/dsi3400>
 - FLASH: <http://www.dynamicsolutions.com/main-menu/dsi3500>
- Unisys ES7000 Enterprise Servers
 - http://www.unisys.com/products/enterprise_servers/high_end_servers/models/index.htm
- Blog: Henkvandervalk.com



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"Unisys is acting as a true partner in our business. The knowledge and understanding they have is of significant value and makes them to be our solution provider of choice for Enterprise infrastructure." – Ian O'Casey, Director of International IT, GameStop



performance

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- Benchmarks: large-scale testing with state-of-the-art tools
- Workshops
- Evaluation of state-of-the-art E57000 technology
- Reduce risk and create more certainty towards the future
- Right sizing your future environment
- Confirmation of your growth path
- Quicker implementation of your solution
- Knowledge transfer: working with our experts you will learn how to implement best practices
- Best practices/lessons learned: you can learn from the in-depth experience of Unisys with previous projects

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