WHITE PAPER

Performance on Sybase® Devices Using Direct I/O, Dsync and Raw Partition

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TABLE OF CONTENTS

1.0 INTRODUCTION

Sybase Adaptive Server® Enterprise 15.0 substantially enhances a database platform already known for its superior performance, reliability, and low total cost of ownership (TCO). Prior to ASE 15, it was recommended that the dsync setting be turned on for devices initialized on UNIX operating system files. The dsync flag ensures that writes to the device file occur directly on the physical storage media, and Adaptive Server can recover data on the device in the event of a system failure. This functionality, however, yields much slower performance during write operations, when compared to using raw partitions.

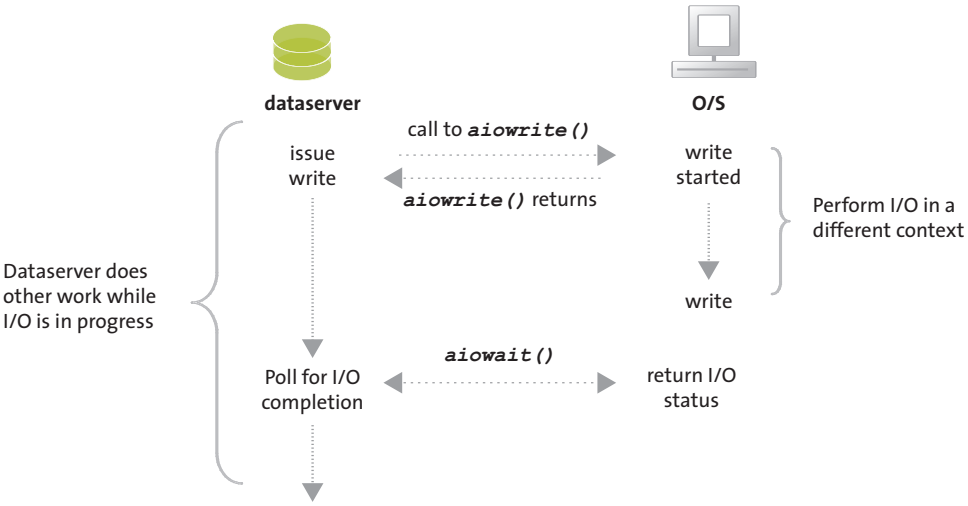
In ASE 15, the directio parameter allows you to configure Adaptive Server to transfer data directly to disk, bypassing the operating system buffer cache. directio performs IO in the same manner as raw devices and provides the same performance benefit as raw devices (significantly better than dsync), but has the ease of use and manageability of file system devices.

Note: The directio and dsync parameters are mutually exclusive. If a device has dsync set to "true," you cannot set directio to "true" for this device. To enable directio for a device, you must first reset dsync to "false."

Following few sections explains Asynchronous, and Synchronous system calls, as well as direct I/O and write with Dsync option.

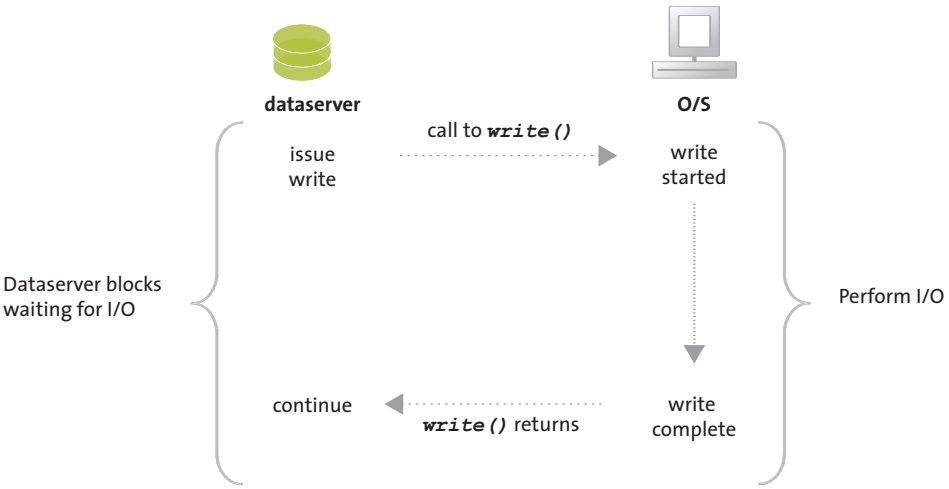
2.0 ASYNCHRONOUS I/O

Asynchronous I/O allows the process issuing the I/O to continue executing while OS completes the request. Dataserver process does not block on this request till its completion. Following figure shows how Adaptive server works with asynchronous I/O.



3.0 SYNCHRONOUS I/O

Synchronous I/O blocks the I/O issuing process from continuing executing while OS completes the request. The process is blocked till the request is completed. This generally results in poor throughput. Following figure shows how Adaptive Server works with synchronous I/O.



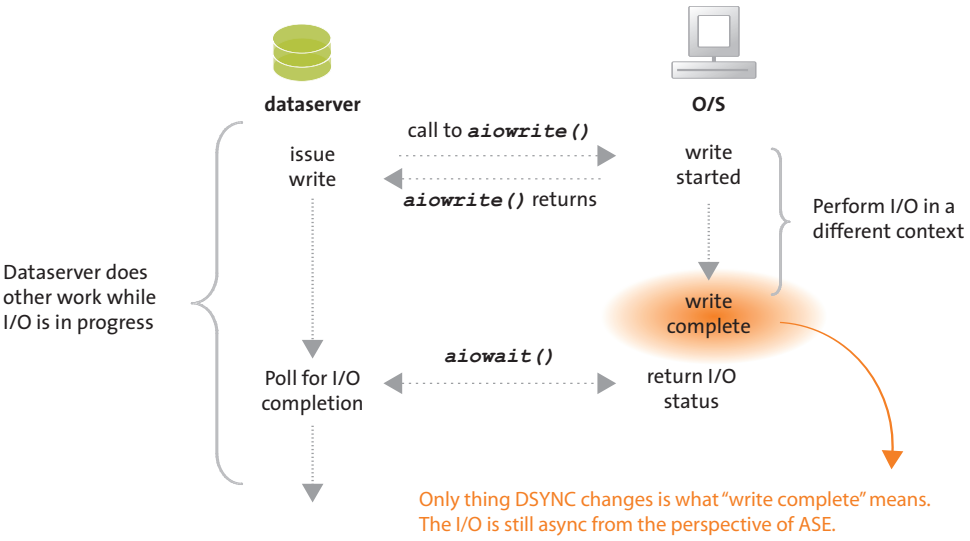
4.0 DSYNC WRITES

For devices initialized on UNIX operating system files, the dsync setting controls whether or not writes to those files are buffered. When the dsync setting is on, Adaptive Server opens a database device file using the UNIX dsync flag. The dsync flag ensures that writes to the device file occur directly on the physical storage media, and Adaptive Server can recover data on the device in the event of a system failure.

Use of dsync option with database device files incurs the following performance trade-offs:

- If database device files on these platforms use the dsync option, the Adaptive Server engine writing to the device file blocks until the write operation completes. This can cause poor performance during update operations
- Response time for read operations is generally better for devices stored on UNIX operating system files as compared to devices stored on raw partitions. Data from device files can benefit from the UNIX file system cache as well as the Adaptive Server cache, and more reads may take place without requiring physical disk access.

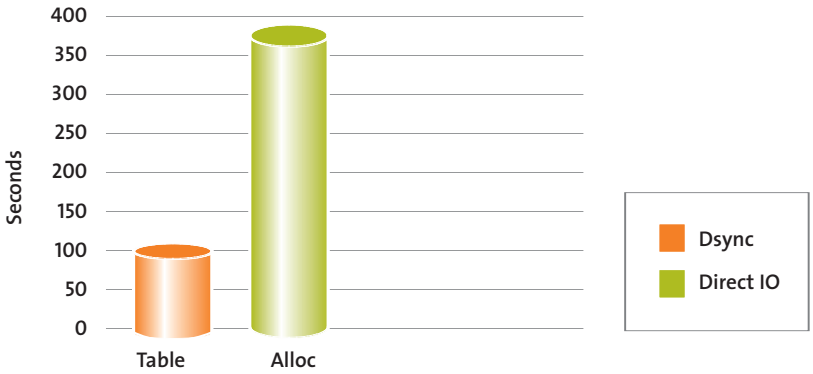
Following figure shows how Adaptive server works when dsync setting is turned on.



Note: Dsync option is useful in Intel 32bit platforms where system can support up to 64G memory but only 4G can be address by ASE. In such scenario, customers can use file system to cache the data in the remaining memory not used by ASE. But with DIRECTIO and Extended cache we can circumvent the problem and use the memory given to the FS by ASE. This is not applicable to 64bit platform hence Direct I/O is always the preferred way.

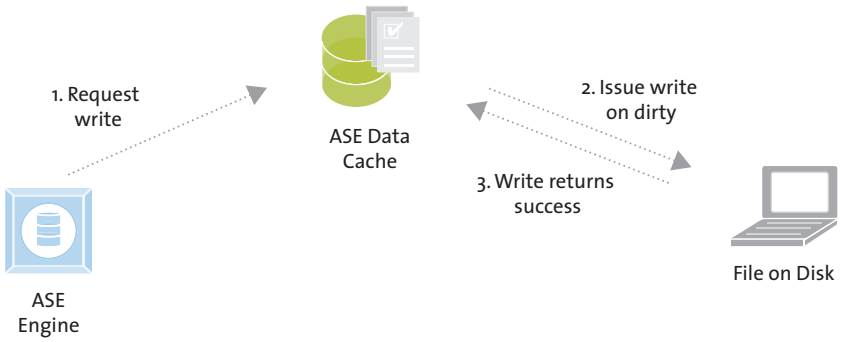
DBCC Tablealloc test

Following chart shows advantage of using dsync option on file system devices for read operation. In this test, Dbcc tablealloc command is executed against Sybase file system devices with direct IO, and devices with dsync options enabled. Dbcc Tablealloc reads and checks the pages from specified table or data partition to see that all the pages are correctly allocated and that no page that is allocated is not used. With dsync option enabled, response time is 96 seconds, while with direct IO option, response time is 386 seconds.



5.0 DIRECT I/O

Direct I/O is the feature of the file system in which writes directly goes to the storage device, bypassing the operating system buffer cache. Direct I/O is invoked by opening a file with O_DIRECT flag. On Solaris™ platform, directio() system call is used after the normal open() call to open file system device. The direct I/O parameter is used with disk init, disk reinit, and sp_deviceattr commands. Direct I/O performs IO in the same manner as raw devices and provides the same performance benefit as raw devices.



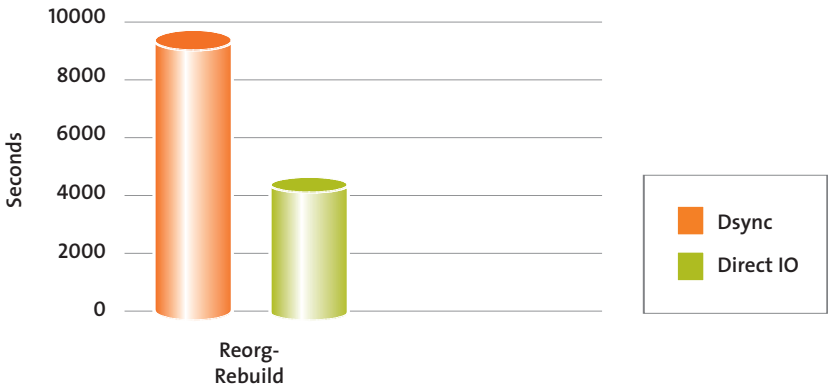
1. ASE requires dirty page in ASE data cache be written written written.
2. ASE issues a write on that page. Write goes directly to disk, bypassing the FS cache
3. Write returns when data hits the disk.

Note: Direct IO, as well as dsync options should not be used for tempdb devices, as recovery is not important for tempdb.

Following few charts shows performance improvement of various commands using Direct IO over Dsync option. Summary of all the results are shown in section 9.0.

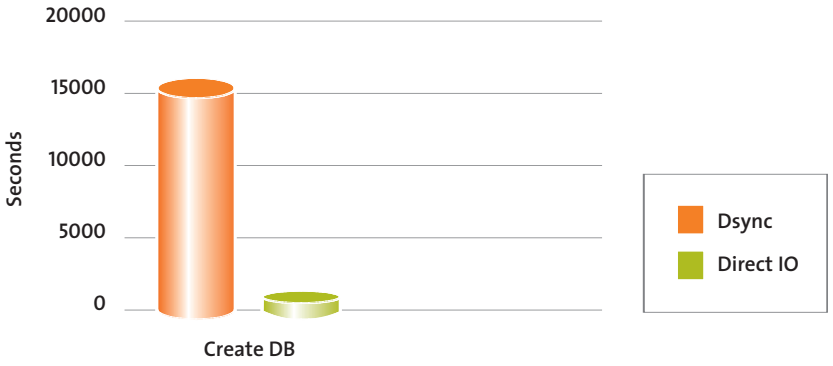
Reorg Rebuild test

Following chart shows the performance of Reorg-Rebuild test on devices with Direct IO option, and Dsync option enabled. Rebuilding the index to compact the index space and improve the clustering ratio is a typical operation in any database environment. Direct IO provides 90% performance improvement when executing the reorg-rebuild on a table of 24 million rows with clustered index and a non-clustered index. This performance improvement is attributable to write operations bypassing the operating system buffer cache.



Create Database Test

Create Database operation initializes 256 pages of writes at a time, which amounts to 512k for page size 2k and up to 4 MB for page size of 16K. This allows for full use of the I/O bandwidth of the underlying devices. With Direct IO option, create database command for a 25 GB of database takes 7 minutes compare to 4.5 hours with Dsync option.



Summary of IO Operations

	Feature/Major benefits	Version
Asynchronous I/O	Allows OS control/no database interfering	ASE 12.5, ASE15.0
Synchronous I/O	IO issuing process is blocked while OS is executing the IO	ASE 12.5, ASE 15.0
Dsync writes	Writes to the device occur directly to media storage. Recovery is ensured in case of failure	ASE 12.5, ASE 15.0/UNIX only
Direct I/O	Bypasses the OS buffer cache. Provides better write performance	ASE 15.0

6.0 SUPPORTED PLATFORMS

Following chart shows supported platforms for Direct IO.

	Direct I/O	Dsync	Raw Partition
Solaris SPARC 2-bit/64 bit	yes	yes	yes
IBM® AIX 64 bit	yes	yes	yes
Windows® x86	yes	yes	yes
Linux® x86	yes	yes	yes
HP-UX PA-RISC 64 bit	No	yes	yes

7.0 PERFORMANCE

To analyze the I/O performance on various Sybase devices, TPCH benchmark suite with dbscale of 15 has been used to populate the database. Total database size is 24 GB. Most of the commands used in this benchmark test are I/O oriented.

8.0 CONFIGURATION

8.1 System Configuration

Server Machine	Sun-Fire-V490
Total Memory	16 GB
# of CPUS	8 X 1050 MHz
Server Software	ASE 15.0

8.2 ASE 15.0 configuration

ASE 15.0 server is built with 4k page size. In all three tests, ASE 15.0 server configuration is kept identical. Most of the configuration parameters are kept to default value except shown in the table.

Configuration Parameter Name	Value
Max memory	4 GB
Cache size	3 GB
2k Buffer Pool	1.5 GB
16k Buffer Pool	1.5 GB
Disk I/O Structures	2048
Max network packet size	4096
Default network packet size	4096
Max async i/os per engine	2048
Max async i/os per server	2048
Max online engines	4
Procedure cache size	30000
Number of pre-allocated extents	31
Number of sort buffers	2000

9.0 RESULTS

All the results are measured in seconds. All the commands used in this benchmark are shown in Appendix A.

9.1 Performance comparison between Direct I/O and devices with dsync on

Results are categorized in three sections. In first section, results of the read only commands are shown. In second section, results of the commands that perform read and write operations are shown. And in the third section, results of the commands that perform write operations are illustrated.

9.1.1 Read operations Results

Performance for read operation is better when devices are opened with dsync option. Reads benefit from the UNIX file system cache as well as the Adaptive Server cache, and more reads may take place without requiring physical disk access.

Commands	Dsync	Direct IO	Percentage Gain	Comment
Dbcc Tablealloc	96 Seconds	381 Seconds	-296%	24 million rows table
Update Statistics	249 Seconds	323 Seconds	-29.72%	24 million rows table

Note: Response time for dbcc tablealloc command was 373 seconds, when executed after clearing file system cache. Data from file system cache was cleared by rebooting the machine.

9.1.2 Read Write operations Results

Commands	Dsync	Direct IO	Percentage Gain	Comment
Alter Table	10635 Seconds	3969 Seconds	167.95%	24 million rows table with cl index, and nl index
Create Clustered index	16233 Seconds	3103 Seconds	423.14%	24 million rows, 4.3 GB table size
Create Non Clustered index	4928 Seconds	2296 Seconds	114.63%	24 million rows table, 4.3 GB of size
Reorg Rebuild	9686 Seconds	5102 Seconds	89.85%	Same as above

9.1.3 Write operations results

Results clearly demonstrates that commands performing only write operations to the storage device shows significant performance gain with direct IO, as it bypasses operating system buffer cache.

Commands	Dsync	Direct IO	Percentage Gain	Comment
Create Database	16343 Seconds	440 Seconds	3614.32%	Database size is 25 GB
BCP In	1073 Seconds	334 Seconds	221.26%	6 million rows
Insert	88.3 Seconds	18.8 Seconds	369.68%	100000 rows
Update	11 Seconds	10.4 Seconds	5.77%	10000 rows

9.2 Performance comparison between Direct I/O and Raw partition

Commands	Direct I/O	Raw Partitions	% difference	Comments
Create Database	440 Seconds	457 Seconds	3.86%	Database size is 25 GB
Update Statistics	323 Seconds	343 Seconds	6.19%	24 million rows table
Alter Table	3969 Seconds	3699 Seconds	7.3%	24 million rows table with cl index, and nl index
Reorg Rebuild	5102 Seconds	5181 Seconds	1.55%	Same as above
Bcp In	334 Seconds	338 Seconds	1.2%	6 million rows
Insert	18.8 Seconds	19.2 Seconds	2.13%	100000 rows
Update	10.4 Seconds	9.2 Seconds	13.04%	
Create clustered index	3103 Seconds	2799 Seconds	-10.86%	24 million rows table
Create Non Clustered index	2296 Seconds	2224 Seconds	-3.24%	24 million rows table, 4.3 GB of size

10.0 CONCLUSION

Direct I/O is one of the many features in ASE 15.0 that improves the performance significantly. Above results shows that direct I/O provides same performance benefit as raw devices, but has the ease of use and manageability of the file system devices. On Solaris platform, direct IO provides excellent performance gain over dsync option. The performance gain provided by direct IO varies from platform to platform.

APPENDIX A

1) **Create database command**
   Create database tpcd on tpcd_dev1 = 10000, tpcd_dev2 = 10000 log on tpcd_log1 = 5000
2) **Update Statistics command**
   Update statistics lineitem
3) **Alter table command**
   Alter table lineitem lock datarows
4) **Reorg command**
   Reorg rebuild lineitem
5) **Create clustered index command**
   Create unique clustered index cl on lineitem(l_orderkey, l_linenumber)
6) **Create non clustered index command**
   Create non clustered index nl on lineitem(l_suppkey, l_orderkey,l_extendedprice, l_discount,l_shipdate)
7) **Update command**
   set rowcount 100000

   update lineitem set l_comment = "xxxxxxxxxxxxxxxxxxxxxxxxxx"
8) **BCP IN command**
   Bcp tpcd..line in line.out –Usa –P –b 20000 –c –A4096
9) **Checkalloc command**
   Dbcc checkalloc("tpcd")
10) **Tablealloc command**
   Dbcc tablealloc("lineitem")

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