

OS/390

Performance Miracles via DASD IO Activity Tuning

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Abstract

The OS/390 environment IO activity tuning opportunities can produce results that seem like miracles. Productive capacity of a complex can be greatly increased because IO activity tuning will also improve processor, main storage and virtual storage utilization. This presentation will demonstrate all that is needed for an effective IO activity tuning project along with the benefits achieved by such activities.

Bullet Points

- Anatomy of IOs
- Where, What, How of Measurement Data
- Obtaining Information from Measurements
- Tuning Alternatives
- Sample Results



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Presentation Outline

1. Anatomy of IOs
 - Life of a Read
 - Life of a Write
2. Where, What, How of Measurement Data
 - RMF, SMF, Others
 - Collection Issues
3. Obtaining Information from Measurements
 - 80/20 Analysis
 - Quantifying Potential Benefits
4. Tuning Alternatives
 - Workload Management
 - Disk Subsystems
 - Applications
5. Sample Results

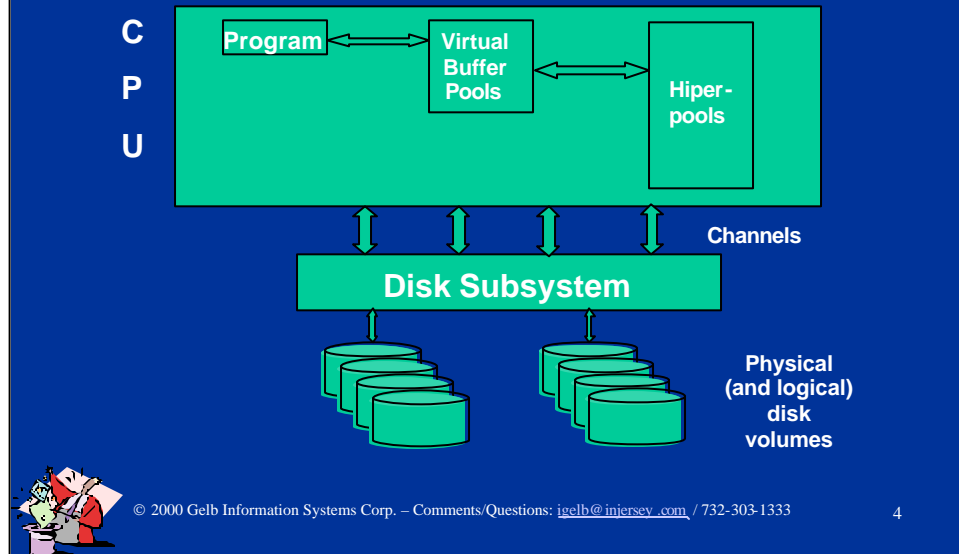
Anatomy of IOs

- Life of DB2 Data
- Anatomy of a Read
- Anatomy of a Write



Next is the discussion of the travels of a record within a typical OS/390 complex.

Life of DB2 Data



This is an illustration of the data locations in a S/390 system.

Life of data begins and ends on a disk volume (except for some rare data in memory applications).

The focus of this presentation will be on the analysis of disk I/O activity and the miraculous results such performance tuning efforts can yield.

When data has to be placed on or retrieved from a disk volume, it takes many orders of magnitude longer than any other component of the total service time. Typically, I/O time is 60 - 90% of the total time.

Anatomy of IOs - READ

- Application issues a read request for a record:
- 1. Virtual buffer pools (VP) are searched. Record could be found in storage, paged out, in hiperpools or not found.
- 2. If used, and made found in hiperpool, record is moved into VP and request is completed.
- 3. Request is sent to disk subsystem.
Performance factors: IOS queuing, channel utilization.
- 4. Cache is searched.
Performance factors: Amount of cache, other good or bad cache users, channel utilization, I/O pend request handling by CPU.
- 5. If not found, read is sent to disk drive.
Performance factors: device utilization, intra-file contention, inter-file contention, channel utilization, path utilization, I/O pend request handling by CPU.



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Typical read I/O request service times:

- Nano- seconds if found in main or expanded storage
- < 5 milliseconds average if found in cache
- > 15 milliseconds average if found on drive

Read performance is affected by the factors enumerated on this slide.

Anatomy of IOs - WRITE

- A threshold value, commit request, or checkpoint causes a write request:
- 1. Request is sent to disk subsystem.
Performance factors: IOS queuing, channel utilization.
- 2. If fast write enabled, data is written to non-volatile storage and end of I/O is signaled to CPU while the physical write will be asynchronous.
Performance factors: Amount of NVS cache, contention with other writers.
- 3. Write is sent to disk drive.
Performance factors: device utilization, intra-file contention, inter-file contention, channel utilization, path utilization, I/O pend request handling by CPU.



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Typical write I/O request service times:

- < 5 milliseconds average if fast write is used

- > 15 milliseconds average if a synchronous physical write

Write performance is affected by the factors enumerated on this slide.

Where, What, How of Measurement Data

- Measurements Collection Issues
- RMF, SMF, & Other Measurements



Next we will review the issues related to performance data collection.

Measurements Collection Issues

- Monthly
- Weekly
- Daily
- Hourly, 30 minutes, 15 minutes,...
- Choose intervals with care

GUIDING THOUGHT: Collect during the period(s) when your life and/or your company's business success depends on the performance of the system.



“Tricks” of data collection:

1. Collect enough data to be sure that it is representative.
2. Insure that critical periods of differing profiles are represented.
3. Keep checking that the periods you select are the important ones.
4. Multiple periods can increase the complexity of the analysis.
5. Keep collection and periodic analysis going even if things are OK!
6. Make sure that you have focused on all “politically” important times.

RMF, SMF, & Other Measurements

- RMF CPU, Disk, and Workload activity records
- SMF records:
 - Type 30 -2, -3, -4, -5
 - Type 42 if you look at just one!
 - Various dataset activity record
- Accounting records and product specific traces for really gory details



RMF records are the best single place to find out very specific information about your workloads and the utilization of all resources. Attention must be paid to collection intervals and the records collected.

SMF records are best to discover details about your workloads. Again, collection intervals are a must to be able to focus on critical periods of activity. Watching averages only can be very hazardous to your career.

Product specific (such as CICS, DB2) performance records provide insights into the activity within the particular subsystem.

RMF Type 74 Sample

Volser	LCU	Rate	Util%	Resp	IOSQ	Pend	Conn	Disc
SMDOG2	06E	2.7	86.5	393.3	0.1	0.1	277.4	115.7
DBVIP2	08D	9.4	84.5	89.9	66.0	0.2	9.3	14.4
DBVIP6	06B	14.8	76.6	52.0	0.0	0.1	1.0	51.0
DBDOG3	08E	5.2	72.1	138.7	108.8	0.2	21.4	8.2
DBVIP5	06C	1.8	1.6	116.3	99.4	0.1	2.4	14.3



This data is real and it is found in the RMF 74 records. Only the names and addressees were changed to protect the guilty.

Following are the field descriptions:

- Rate - I/O activity rate/second
- Util% - volume utilization
- Resp - response time/request in milliseconds
- IOSQ - IOS queue time/request in milliseconds
- Pend - volume pend time/request in milliseconds
- Conn - volume connect time/request in milliseconds <= “THE GOOD”
- Disc - volume disconnect time/request in milliseconds

SMF Type 30 Sample

JOB=VIPCICS1				
STARTTIME	ENDTIME	ELAPSED	CPUTIME	DISKIOS
13FEB2000:23:25	14FEB2000:20:00	20:35:00	1:10:00	1169947
15FEB2000:05:31	15FEB2000:20:02	14:30:42	1:08:34	892672
16FEB2000:05:41	16FEB2000:20:00	14:19:38	1:07:00	620659
17FEB2000:05:23	17FEB2000:20:00	14:36:09	1:09:38	805563
18FEB2000:05:19	18FEB2000:18:01	12:42:01	1:09:52	716565



SMF 30-2 and 3, interval accounting records, are the input to this sample. These records should be collected for all long running address spaces. The collection interval can be adjusted to your activity patterns. You should focus on the shortest possible interval during which your life, or something equally important, depend on the service levels provided.

These records are an excellent way to monitor the overall cycles of a system. The collection period durations can be easily changed by operator commands. Remember that the shorter you make the interval, the more data will be collected.

This sample is a summary, but the same report can be produced for any size interval. It is not a good practice to try to “create” small interval numbers from large data collection intervals no mater what rule-of-thumb you apply. However, the opposite is a safe practice.

SMF Type 42 Details - 1

Volume	IO Intensity	IO Cyls	IO Resp	IO Com	IO Pend	IO Disc	IO Queue	IO Count	Cache Card	Cache Hts	IO/Sec	Cache Ratio	Write Card	Write Hts	Write Ratio
DAS137	1.7062	84	28	4	0	13	11	240889	175485	154498	38.2363	88	1185	1110	95
DAS247	0.3747	98	11	3	0	6	2	214629	214127	210581	34.6810	98	738	728	99
DAS143	0.8266	94	21	4	0	11	6	212560	194434	179316	39.3511	96	141	134	95
DAS134	0.7370	92	25	4	0	15	6	185712	179808	171261	28.4781	95	992	966	97
DAS112	0.7701	51	30	3	0	14	13	161711	156353	62467	25.6684	52	89	79	95
DAS117	0.4516	85	16	3	0	8	5	152424	136737	129899	28.2267	94	1737	1730	99
DAS393	0.3790	80	16	3	0	7	5	127505	109375	102143	23.6861	92	848	828	98
DAS108	0.7114	44	36	5	0	11	20	124498	64014	54794	19.7616	85	2937	2934	99
DAS118	0.9528	51	28	6	0	12	10	124380	92395	63461	19.7429	88	489	453	90
DAS29F	0.4038	74	21	3	0	10	8	120843	105381	89830	19.1814	84	4084	3915	95
DAS138	4.2508	87	33	6	0	18	9	109775	96728	55862	121.9722	98	22	20	90
DAS152	0.3421	69	20	3	0	10	7	107770	88877	74073	17.1063	85	2747	2673	97
DAS385	0.8023	95	7	2	0	2	3	103149	99546	98015	114.6100	98	1998	1539	95
DAS390	0.1277	90	9	2	0	2	4	100566	93702	60885	15.9629	96	1957	1477	94
DAS39P	0.1716	88	8	2	0	3	3	96524	88288	85913	21.4498	97	2748	2648	96
DAS144	0.2932	90	20	3	0	12	5	92364	85214	82965	14.6610	96	581	575	98
DAS33N	0.1169	94	9	3	0	3	2	92075	90156	77517	14.6152	96	2619	2491	95



IO activity by disk volume can reveal high level problems. I prefer viewing this report for about a 2 hour interval in various sort sequences:

- this sample is sorted descending by IO COUNT
- other descending sort sequences useful in tuning physical IO activity include IO INTENSITY, IO RESP, IO QUEUE, and IO DISC. These are the measures you can most affect with your tuning activities.

SMF Type 42 Details - 2

Datasets on volume DAS137:

Database	Object	File	Partition	IO Intensity	IO Chit%	IO Resp	IO Conn	IO Pend	IO Disc	IO Queue	IO Count	Cache Cand	Cache Hits	IO/Sec	Cache Ratio	Write Cand	Write Hits	Write Ratio
DPOLBQMO	SPURCHS	I0001	A001	0.6052	50	27	8	0	7	12	141223	83180	70355	22.4163	84	929	878	94
DRCLBQMO	SRECDIS	I0001	A014	0.0114	55	26	7	0	8	11	2774	1967	1528	0.4403	77	125	123	98
DCRLBQMO	SCKACTV	I0001	A016	0.0022	51	28	1	0	16	11	485	483	245	0.0770	50	85	84	98
DAPLBQMO	SPREQIT	I0001	A027	0.0007	35	36	1	0	20	15	123	122	43	0.0195	35	22	21	95
DBSTPROD	SSKST	I0001	A007	0.2547	86	18	2	0	5	11	89162	83252	76556	14.1527	91	3	3	100
DRCLBQMO	SRECITM	I0001	A006	0.0010	49	31	5	0	21	5	203	166	99	0.0322	59	1	1	100
DAPLBQMO	SVNDINV	I0001	A009	0.0000	0	43	1	0	33	9	1	1	0	0.0011	0	0	0	0
DEPLBQMO	ITEPITMH	I0001	A002	0.0008	16	39	17	0	17	5	19	5	3	0.0211	60	0	0	0
DMLLBQMO	SWKSCLS	I0001	A039	0.0517	82	27	6	0	4	17	6899	6309	5669	1.9164	89	0	0	0



A view of the I/O activity for 2 hours on a volume by datasets can help you see some interesting facts:

- demonstrate that intra-volume contention creates some poor performing files
- Database DBSTPROD performs better than some less active files
- Most of the degradation is introduced by disconnect elongation of the lower activity files or they are worst cache candidates
- Most files seem to “enjoy” a significant percentage of their service in IO queue time. A sign of contention among multiple applications.

SMF Type 42 Details - 3

DASD/Xpert

File Help

Analysis Database by Volume Database by Volume Cache Database Partitions Tuning Summary

Volume	ID Intensity	ID Chk%	ID Count	Cache Cand	Cache Hits	Cache Ratio	Cache Cand%
DAS132	3.4028	94	857520	761003	723466	95	99
DAS166	36.2856	92	286465	267136	264212	98	99
DAS137	1.7062	64	240889	175485	154496	88	73
DAS247	0.3747	98	214629	214127	210591	98	100
DAS143	0.6266	94	212550	194434	178316	96	97
DAS134	0.7370	92	186712	179908	171361	95	97
DAS112	0.7701	51	161711	156953	82467	52	97
DAS117	0.4516	95	162424	126737	129999	94	99
DAS350	0.9790	90	127905	108975	102149	92	96
DAS109	0.7114	44	124488	64014	54794	85	51
DAS118	0.5528	51	124380	92955	63461	68	74
DAS33F	0.4028	74	120843	105391	89930	84	99

Database	Object	File	Partition	ID Intensity	ID Chk%	ID Count	Cache Cand	Cache Hits	Cache Ratio	Cache Cand%
DBFLBQNO	UCACT00	0001	A006	0.0059	43	1434	1434	617	85	100.0000
DBFLBQMT	SPNFSMS	0001	A010	0.0021	78	1103	94	80	85	91.0000
DBFLBQNO	SSKSTDD0	0001	A001	0.0485	44	10909	10955	4782	44	100.0000
DBSTPR00	SSK	0001	A001	1.6090	95	944795	749360	717899	95	99.0000
DBSTPR00	SSKSTMTK	0001	A001	0.0013	17	164	148	32	21	90.0000
DBSTPR00	SSKSTWK	0001	A021	0.0007	35	195	112	56	50	72.0000

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This is another sample of the data contained in the SMF type 42 record plus some fields calculated by the DASD/Xpert product. The best improvement you can make to an IO is to eliminate it by insuring that the required data is found in a buffer pool or cache.

IDUG and Computer Measurement Group (CMG) meetings are full of presentations of many buffer pool tuning experiences. However, tuning of cache activity is a more complicated proposal. First, staff from many different areas of responsibility have to cooperate. Second, we lack controls for 100% guaranteed effectiveness. Lastly, it can be difficult, time consuming and labor intensive to move data around to obtain the best results.

SMF Type 42 + RMF Type 74 Details - 1

Total Serv./ IO Intensity (mins)	% of Current Total Service	Cummul. % of Current Service	DATA NAME	VOL SER	Sum of All Activity / CPU / File within the Sysplex								
					VOL RATE	FILE UTL	VOL UTL	ALL UTL	RESP MS	CONN MS	DISC MS	PEND MS	IOSQ MS
13.71	6.68%	6.68%	A	1	77.6	45.7	48.8	48.8	16.1	3.6	2.3	0.3	10
6.81	3.32%	10.00%	B	2	40.3	22.7	23.1	23.1	6.5	3.6	2	0.3	0.6
5.88	2.86%	12.86%	C	3	12.2	19.6	19.8	24.4	23.4	3.5	12.7	1	6.3
4.89	2.38%	15.24%	D	4	36.4	16.3	23	23	6.7	1.2	3.3	0.3	1.9
4.65	2.27%	17.51%	E	5	22.4	15.5	15.8	15.8	11.6	4	2.9	0.6	4.1
4.53	2.21%	19.72%	F	6	29.5	15.1	15.3	15.3	8.6	2.2	2.9	0.3	3.2
4.29	2.09%	21.81%	G	7	28	14.3	14.5	14.5	7.6	2.3	2.8	0.4	2
4.29	2.09%	23.90%	H	8	6.4	14.3	14.7	14.7	26.9	2.8	19.5	0.5	4.1
4.23	2.06%	25.96%	I	9	8.9	14.1	14.2	30.7	24.4	3.8	11.9	3.3	5.4
4.20	2.05%	28.00%	J	10	8.9	14	14.2	31.2	26.5	3.8	11.9	3.7	7
4.11	2.00%	30.01%	K	11	36.8	13.7	15.9	15.9	5.2	1.3	2.4	0.3	1.3

Physical IO Activity Details by Sysplex Member																						
VOL SER	VOL RT2	PCT BY2	RSP TM2	IOQ TM2	CON TM2	DISC TM2	PND TM2	VOL RT4	PCT BY4	RSP TM4	IOQ TM4	CON TM4	DISC TM4	PND TM4	VOL RT5	PCT BY5	RSP TM5	IOQ TM5	CON TM5	DISC TM5	PND TM5	
1	78.7	48.8	16.5	9.9	3.6	2.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.3	23.1	6.3	0.2	3.7	2.1	0.4	0.0
3	0.0	0.0	67.4	0.0	32.7	7.9	26.9	1.0	2.0	26.7	0.5	3.6	15.3	7.3	12.2	19.8	22.0	4.7	3.6	12.7	1.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.5	23.0	5.6	2.1	1.3	1.9	0.4	0.0
5	22.4	15.8	10.9	3.1	4.0	3.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	29.5	15.3	8.3	2.7	2.2	3.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	28.0	14.5	7.4	1.9	2.3	2.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	6.6	14.7	26.6	3.7	3.1	19.2	0.6	0.0	0.0	0.7	0.0	0.4	0.0	0.2	0.0	0.0	0.6	0.0	0.4	0.0	0.3	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	8.4	22.7	2.8	3.8	10.6	5.5	8.9	14.2	23.6	4.4	3.9	12.0	3.4	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	8.6	27.2	5.6	3.9	11.2	6.5	8.9	14.2	24.3	4.6	3.9	12.0	3.7	0.0
11	61.3	15.9	4.0	1.1	1.1	1.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



We have shown the wealth of information in the SMF type 42 records. This last example is a combined report of RMF type 74 and the SMF type 42 records. The need for this combination is created in a Sysplex or any shared disk environment. The data from all the processors sharing a given disk volume has to be combined to produce this report. Due to space limitations on the foil, we are only showing some details segments/CPU in this Sysplex

This type of report can quickly locate cases when "important" work from another processor causes your loved applications service times to head way up North!

In this sample, the 11 files shown (from over 2,000 analyzed) account for 30% of the total IO activity. 3% of the files accounted for over 60% of the IO service.

On volumes 9 and 10, over 50% of the IO activity was NOT generated by our 'loved' files!

SMF Type 42 + RMF Type 74 Details - 2

- How was this done?
 - SMF type 42, file activity records, were collected for durations meaningful for this performance study
 - RMF type 74, disk activity records, were also collected for durations meaningful for this performance study
 - For each file activity record, on each OS/390 instance within the Sysplex, a summary record was produced by adding all the specific volume activity segments
 - The final report was sorted by data name and descending by IO intensity to produce the “80/20” report we were seeking



This example shows how is a combined report of RMF type 74 and the SMF type 42 records. The need for this combination is created in a Sysplex or any shared disk environment. The data from all the processors sharing a given disk volume has to be combined to produce this report.

The purpose of this reprocessing is to end up with a single record that quickly identify all the relevant information we may need for data level disk IO activity within an OS/390 Sysplex.

The four steps of this data analysis are provided on the foil.

Obtaining Information from Measurements

- 80/20 Analysis
- Quantifying Potential Benefits



Next we will present analysis methods and how to effectively present your accomplishment.

80/20 Analysis - 1

- Our experience shows IO activity tuning to be 95/05 rather than an 80/20 proposition
- Most results/benefits achieved within 5% of the selection list candidates
- Examples:
 - Data & Index tables with highest total time in use
 - Volumes at or near practical capacity limits
 - Transaction with highest total IO time/Unit-Of-Work (UOW)



A vast amount of experience at over 100 sites shows that 95% of the problems are found in 5% of the top samples.

Later, 20% of the effort can yield 80% of the benefits. Good news for most of us!

Focus, focus, focus.

80/20 Analysis - 2

Plan Name	Total Elapsed	Total CPU	CPU / Elapsed	Freq.	Total Time	@25% IOs Saved
P09GI0032	120	18	15%	100	12,000	-2,550
P09GI0003	240	44	18%	100	24,000	-4,900
P09GI0009	80	48	60%	1000	80,000	-8,000
P09GI0018	310	53	17%	100	31,000	-6,425

- In what order would you focus your efforts? Why?
- How many votes for the sequence of 9, 18, 3, 32?
- How many votes for the sequence of 32, 3, 9, 18?



This is sample of how to quickly focus on where you should pay attention for the most payback. Note that this is generic tuning that benefits the entire system.

The ratio of CPU / Total Elapsed focuses us on the transactions with the highest IO content if you select the lowest % plans first.

However, for maximum impact, select based on the estimated maximum benefit. “Political importance” may bias your selection sequence.

In this sample, we estimate that we can reduce IO time by 25%. The last column shows the total response time reduction you could achieve.

Please note that in this data the total includes ALL the IO related suspensions. In DB2 measurements this is the sum of synchronous IO suspensions, other read suspension and other write suspensions.

Quantifying Potential Benefits

- Example for technical audience
- Example for all audiences



Examples about how to present results follow.

Example for Technical Audience

- Just be careful when & where you use these
 - Volume DBMS01 - 27 utilization decreased by 10%
 - Average database disk volume service time went from 23 to 20 milliseconds
 - Processor utilization and transaction rate for order entry application increased by 23% (total processor utilization stayed at 100%!)



What do you report and to who are the most critical success factors for such performance improvement projects.

When communicating with business managers, avoid reporting IT resource utilization numbers. These are almost always misunderstood and you do not find this out until it is too late.

The best term for reporting are business activity metrics such as:

-trades / minutes

-sales / hour

-trades / day

-orders / week

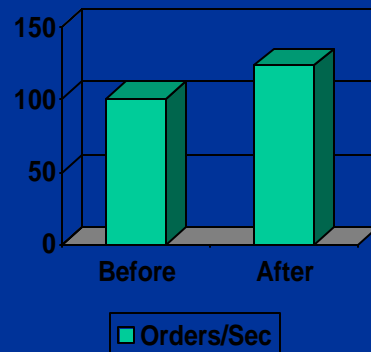
-payees (as in Payroll!) / month

-etc....

Example for All Audiences

- Best: "Capacity of our configuration increased from 100 to 123 orders/second without any increase in spending."
- Good: "The order entry application can handle 23% more volume without any increase in spending."

Project HOAH Results



This is an example of stating the same result in two different ways. The first one is best because it expresses your results in ways that are tangible for business managers.

If you reported that transaction response time was reduced from 100 to 77 milliseconds, while it is the same exact result, it does not quantify the benefit directly for most "normal" people.

Don't force your audience to do any public math to quantify the benefits of your efforts. Most of the time, they will fail to arrive at the conclusion you were hoping for.

Tuning Alternatives

- Methodology Overview
- Workload Management
- Disk Subsystems
- Tuning Recommendations



Next is the discussion of tuning methodology, overall management of the workloads, details relevant to disk subsystems and specific tuning recommendations that are proven effective.

Methodology Overview

1. Collect and review performance statistics and looked for problems based on thresholds and service level objectives.
2. Select data for baseline periods on which to base detailed analysis and further study.
3. Study utilization patterns at different business activity levels to insure that some consistency in behavior is observable.
4. Prepare models with linear forecasting to identify likely I/O activity trouble spots.
5. Prepared analytic queuing models (or similar) to more accurately gauge the impact on specific disk volumes.



These are the 5 key steps in this tuning project. Steps 1 to 4 are sufficient if you do not manage your resources to their upper limits. However, you should include step 5 if you are forced to live on the edge.

With modeling of various types, you can predict service time consequences of your actions before you spend the time to actually implement the change.

Modeling / simulation tools are very effective ways to explore the expected benefits of a change you may plan without having to make the change. This way, you can evaluate multiple alternatives, and decide which result do you prefer before asking for a possibly difficult and time consuming change to you configuration.

Workload Management

- OS/390 Workload Manager (WLM) can favor or hurt selected workloads
- CPU Dispatching Priority of the workload can affect the IO service time (priority passed on after V2.7)
- WLM can be configured to intentionally limit (hurt?) a workload
- WLM can be unintentionally configured to limit (hurt?) a workload



Workload management rules can be hazardous to your loved workload. IPS priorities in compatibility mode or objectives in goal mode can degrade performance unnecessarily.

The setting of these parameters can be used as throttles (dispatching priorities, time slicing, workload velocities) that can prevent a workload from ever taking over in the complex.

The key item here is to insure that IO priority is derived from a workload's dispatching priority. This is implied in goal mode, but it **must** be coded in compatibility mode.

Disk Subsystems

- Physical configuration limits:
 - Channels
 - Controllers
 - Strings
 - Volume sizes
 - Logical to physical volume mapping
- SMS promise... "We will try to fix for tomorrow, or much much later, what we think hurts you today!"
- Most interesting current offering: IBM's Shark (a.k.a. ESS)



Optimizing activities of physical disk configurations are one of the most effective ways to improve performance, but the cost per unit of work can become a factor. If money is no object in your site, ask for a raise quickly!

Seriously, best protection of performance is via various levels of isolation. Following is the list in escalating cost order where the low end cost could be less than \$100, but the high end one could into the many hundreds of thousands.

1. Isolate busy files on volumes.
2. Isolate busy volume on low use physical volumes.
3. Spread out busy volumes across string.
4. Monitor and isolate cache unfriendly volumes.
5. Isolate controllers for the use of your loved workloads

SMS is taking over the disk space management tasks in most installations. Specifications for SMS are one of the most complicated customization tasks in a typical OS/390 environment, and constant monitoring should be employed to avoid unpleasant surprises.

IBM's Shark subsystem and the related concepts of Parallel Access Volumes (PAVs) and Multiple Allegiances can be the "magic" solution for many sites. We expect competitors to show up with similar capability devices.

Disk Subsystems - 2

- **Where is the hardware taking us:**
 - Fewer repetitive tasks for most of us
 - Complexity is increasing with each new device
 - Hardware behavior controlled by performance objectives
 - Performance problems can become harder to attribute
- **Where is the system software taking us:**
 - Fewer repetitive tasks for most of us
 - Complexity is increasing with each new release/product
 - Software behavior controlled by performance objectives
 - Performance problems can become harder to attribute
- **Notice a pattern???**



As the day to day management of the data center becomes easier, our roles as “trouble shooters” will become more involved as we have to understand the innards of more and more complex hardware and software.

We are in a similar position to the car mechanic who has to understand much more today than 20 years ago when cars were simpler to repair, but harder to drive.

Tuning Recommendations - 1

The following six recommendations are provided in order of increasing complexity and effort.

1. Just buy more of WHATEVER if YOU can guarantee cost effective results.

2. Improve file performance via data-in-memory techniques

Included techniques are buffer pools size changes, buffer pool activity allocations, re-balancing buffer pools for handicapping some work in order to favor another, and hiperpool buffers.



1. If it is cheaper to buy rather than fix, do so! Your homework must be done to be able to guarantee that the additional purchase will yield the desired benefit. Discussing how one could do this can be a presentation of its own.

2. The best I/O is no I/O! Go to Computer Measurement Group (CMG), IDUG, and DB2 Conferences. This is the most frequently mentioned topic. Why? Because it works, and can produce miraculous results as well.

Tuning Recommendations - 2

3. Improve performance of the disk I/O subsystems

SMS classification, file placement if non-SMS, logical volume allocations, quantity of available cache, use of hypervolumes or file isolation to dedicated volumes.

4. Add more disk volumes to spread out the file's activity

The method is: (a) divide the forecasted utilization of the volume by the maximum planned utilization level; (b) round up to the next whole number and spread the file over that many volumes.



3. A “tune-up” of your DISK subsystems is necessary periodically. Remember the “95/5” or “80/20” rule. You will always have candidates for tuning. If you do a very effective job, the returns/effort will diminish. This would be a good time to go do something else. Think of these tuning efforts as health checkups!

4. Spread a file/DB2 table over multiple volumes only when: (1) the activity warrants several volumes, (2) you want to increase processing parallelism, and (3) the application requires fastest possible I/O to meet service level requirements.

Tuning Recommendations - 3

% Dev. Busy	Response Time	% Change
0%	10 ms.	0%
30%	14 ms.	+40%
50%	20 ms.	+100%
80%	50 ms.	+400%
99.9%	10,000 ms.	+9900%

- The basic service time doubles at 50% utilization, and it is FIVE times greater at 80%!



Here is a sample of what happens to disk service time as the volume utilization increases so you can choose your preferred level of pain.

Typical objectives are found at 25 to 40% maximum utilization per volume.

Tuning Recommendations - 4

5. Replicate complete files

File replication introduces the possible need for application changes. However, read-only activity segregation could produce major performance improvements.

6. Undertake application I/O performance re-engineering.

Such changes can produce dramatic improvements, but much management support is a critical requirement. Many areas have to work closely together.



5. Since replicating files can become expensive and sometimes difficult to implement and make the required operational changes, it should only be done when it is perhaps the last resort to meet service level objectives. However, if you seek the ability to guarantee service levels, isolation via segregation is very effective.

6. The key to a successful re-engineering project usually hinges as much on our interpersonal skills when presenting the project and working with the programmers as on our technical expertise. There are a number of software tools available from various vendors that can make this task somewhat simpler. The Strobe product is dedicated to identifying such opportunities. Most of the online activity monitors also have features for tracing frequently executed code patterns.

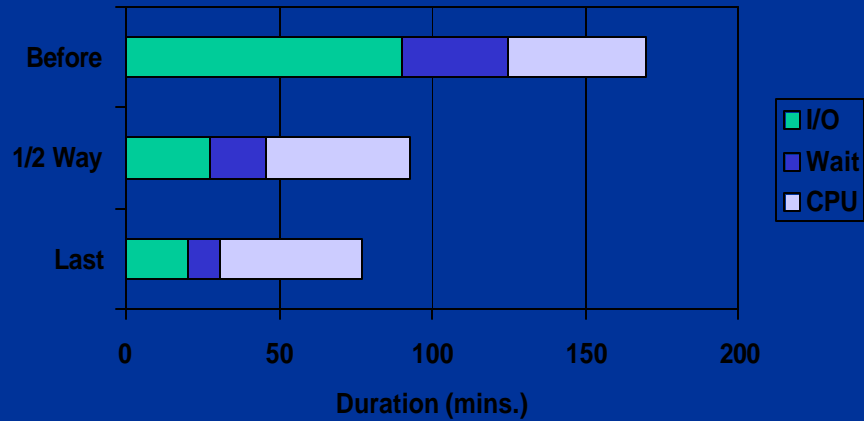
Sample Results

- Batch jobs/Overnight window issue
- Online Systems Performance



Following are two sample results.

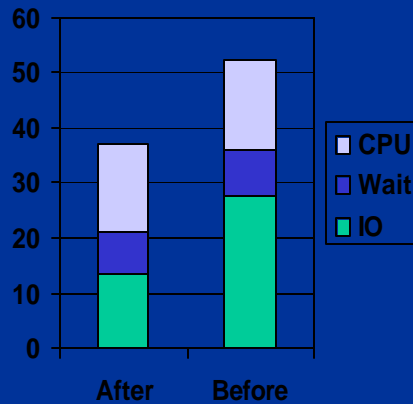
Batch job/Overnight window issue



This is an example of a batch job cycle that was reduced by more than 50% through IO activity tuning.

Notice that the CPU time stayed about the same, but the wait time was also reduced. This is because a shorter job is imposed less wait time upon.

Online Systems Performance



- I/O time reduction of 50%
- Response time reduced by about 30%
- System capacity increased by about 40%
- Practical transaction rate increased from 19 to 26/second



This result was achieved by a simple removal from the controller's cache of a file that was a VERY BAD candidate, and by a split of one volume into two to reduce utilization rate/volume.

The 'practical transaction rate' is the level at which all service level objectives are met.

Information Sources

- Goldstein, Joel, "DB2 Buffer Pool Tuning - Top Down or Bottom Up," IDUG Proceedings, 1998.
- IBM SG24-2213 DB2 for OS/390 Version 5 Performance Topics
- IBM SG24-2244 DB2 for OS/390 Capacity Planning
- IBM SG24-4706 OS/390 MVS Parallel Sysplex Capacity Planning
- Responsive Systems Co., "DASD/Xpert for DB2," 1999



Notes: None

The End

- YOU can perform miracles with I/Os.
- Cooperative staff is most helpful - the opposite just prolongs the process.
- I/O activity optimization will continue to be an area with major benefits.



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If you send me an e-mail message, and it is an urgent matter for you, please also call the above phone number. My e-mail does go unchecked for up to a week periodically.