IMS Database Buffer Handlers (A Performance & Tuning Point of View)

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Introduction & Agenda

Discussion is limited to

- OSAM and VSAM full function buffer handlers
- A performance and tuning perspective

Agenda

- A high-level view of the execution environment
- Selected bufferhandler functions related to performance
- Use of the IMS Monitor for analysis and tuning

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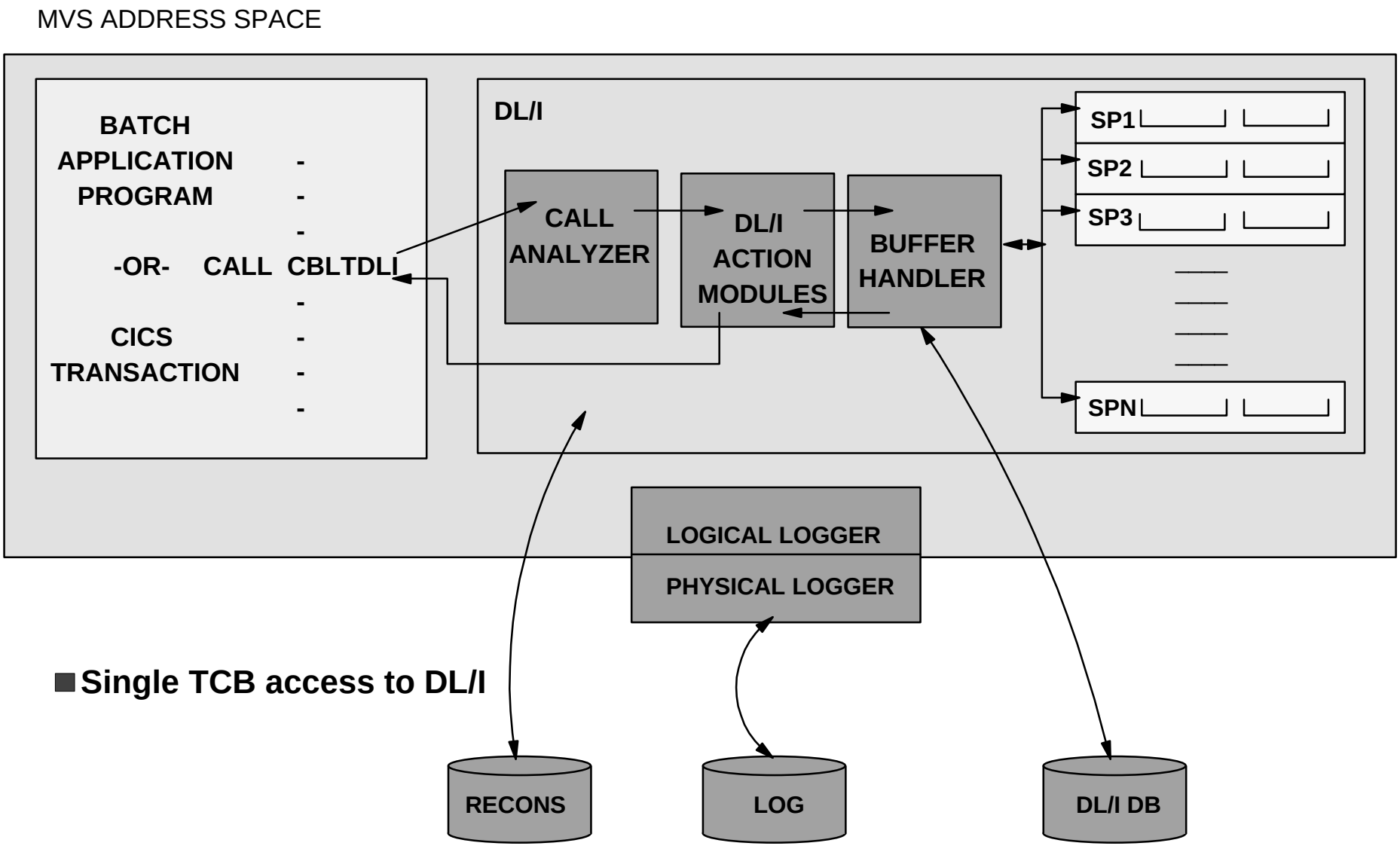
The Execution Environment

Standalone Batch & CICS with Local DL/I



- Single TCB access to DL/I

Standalone Batch and CICS with Local DL/I

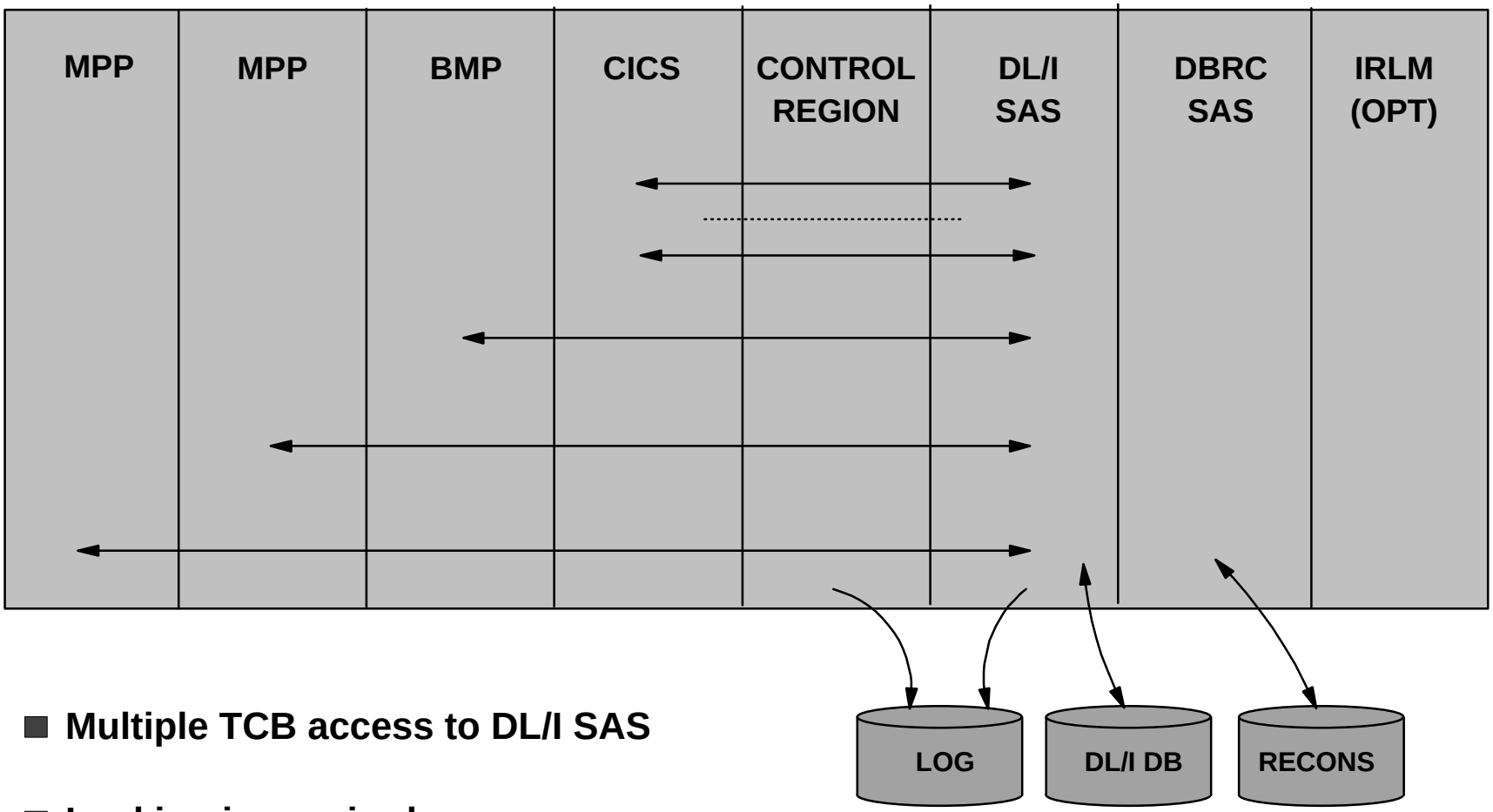
Buffer handler activities

- Satisfy requests from the action modules for data or services
- Responsible for all data base reads and writes

Standalone Batch and CICS with Local DL/I

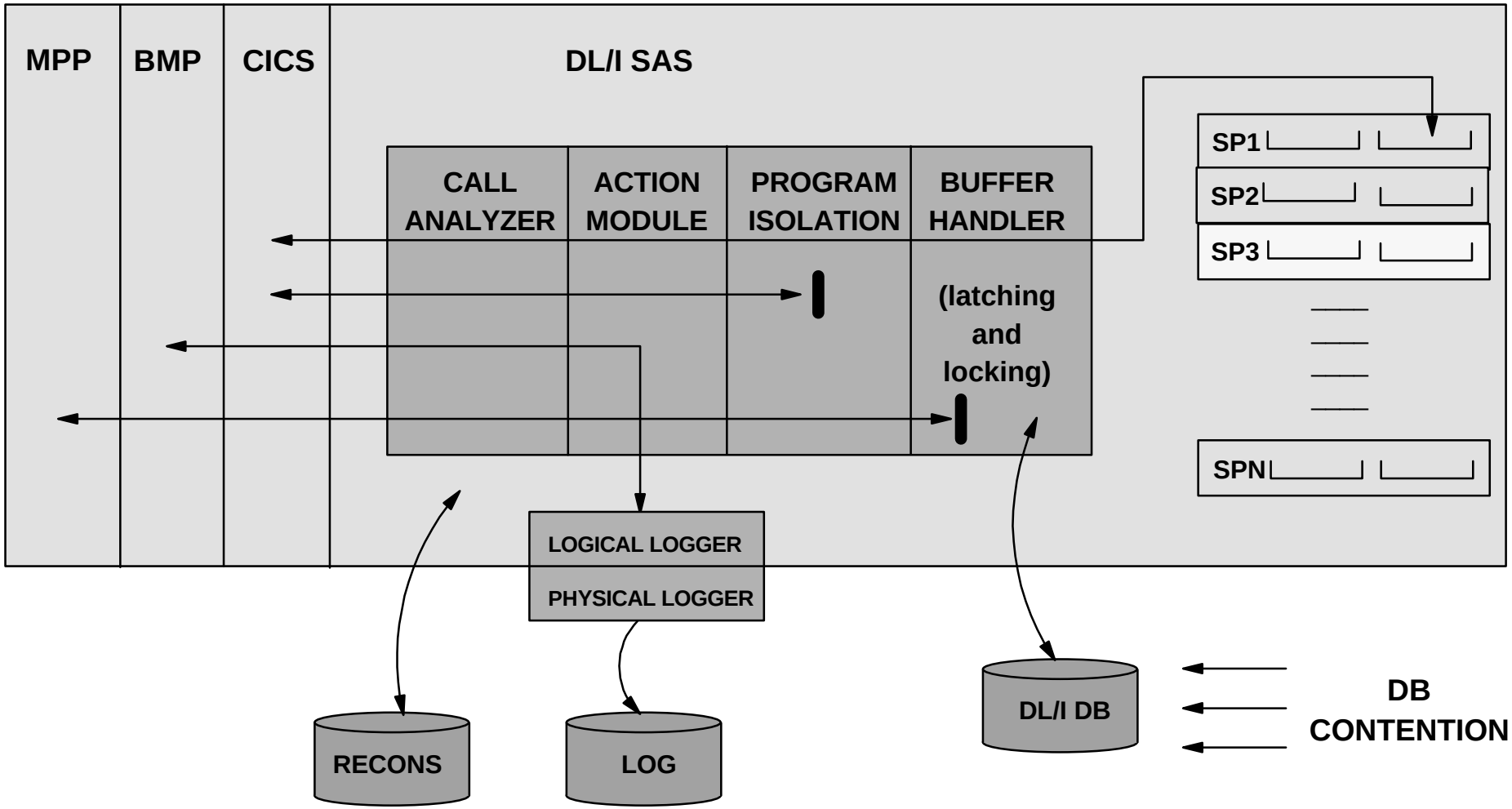
- **Buffer handler contention: Standalone batch**
  - OSAM SB overlapped read caught in progress
  - VSAM background write with other VSAM read/write activity
- **Buffer handler contention: CICS local DL/I**
  - Same as for standalone batch
  - Plus, activity initiated by other 'concurrent' transactions

IMS TM and DB Control



- Multiple TCB access to DL/I SAS
- Locking is required

Online Contention



Online Contention

Buffer handler activities

- Satisfy requests from the action modules for data or services
- Responsible for all data base reads and writes

Contention

- Locking of DB resources
- Logging
- Access to buffer pool resources or services
  - Same as for CICS local DL/I
  - Plus, multiple TCB access to buffer handler resources

IMS Monitor reporting of buffer pool contention

- OSAM: NOT IWAIT time
- VSAM: DB IWAIT time

Buffer Pool Management

- **Each buffer in a subpool has a prefix**
  - IBPRF (OSAM)
  - IDABUGC (VSAM)

- **Prefix contents includes**
  - Buffer ID
  - LRU chain pointer
  - MRU chain pointer
  - Relative block number of buffer contents
  - Waiting PST anchor
  - Buffer attributes
  - and more ...

Buffer Attributes

- **Owned**
  - For example, set when position established in a buffer
    - Released when call completed or move to another buffer
      (Batch exception (standalone and BLDS))
    - A dependent region can only own one buffer at a time in a subpool
    - Multiple dependent regions can own the same buffer
- **Busy (OSAM), Locked (VSAM)**
  - For example, set when read or write in progress into or from a buffer
- **Locked (OSAM and VSAM)**
  - For example, write error and no storage for write error buffer

Buffer Attributes

- **Altered**
  - Set by action module when update call changes the contents of a buffer
- **New ID pending (OSAM only)**
  - Buffer prefix to be replaced because new block is being read in
- **Empty**
  - For example, buffer invalidated (data sharing)

Action Module Requests of the Buffer Handlers

- **Requests of the OSAM buffer handler**
  - Search pool for block in range
  - Release ownership of a buffer
  - Locate a single block by RBN
  - Locate byte
  - Create new block
  - Write blocks altered by PST (purge BQEL chain)
  - Mark buffer altered
  - Byte locate and mark altered
  - Mark buffer empty
  - Purge the pool because of application checkpoint
  - Purge the pool due to ABEND
  - Buffer forced write

Action Module Requests of the Buffer Handlers

- **Requests of the VSAM buffer handler**
  - Locate a logical record by block RBA
  - Locate a logical record by byte RBA
  - Purge all buffers of the current PST if an I/O error occurs
  - Search a subpool for an RBA within a certain range
  - Mark buffer altered
  - Background write
  - Locate a logical record and mark buffer altered
  - Purge all buffers at request of ABEND STAE routine
  - Purge subpools when CHKP or sync point occurs
  - Locate a logical record whose key is EQ to or GT a given key
  - Locate the first logical record of a data base
  - Erase a logical record
  - Insert a logical record within a KSDS
  - Add a logical record to an ESDS

Action Module Requests of the Buffer Handlers

- **Requests of the VSAM buffer handler ...**
  - Get the next logical record in a data base
  - Release PST ownership of a buffer
  - Mark all buffers invalid
  - Locate the given logical record for image copy
  - Get the next logical record for image copy

Managing Contention

- **OSAM buffer handler**
  - Subpool latch
  - Buffer attributes
  - Compare and swap

- **VSAM buffer handler**
  - Compare and swap
  - Buffer attributes
  - Latching

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Selected Buffer Handler Functions

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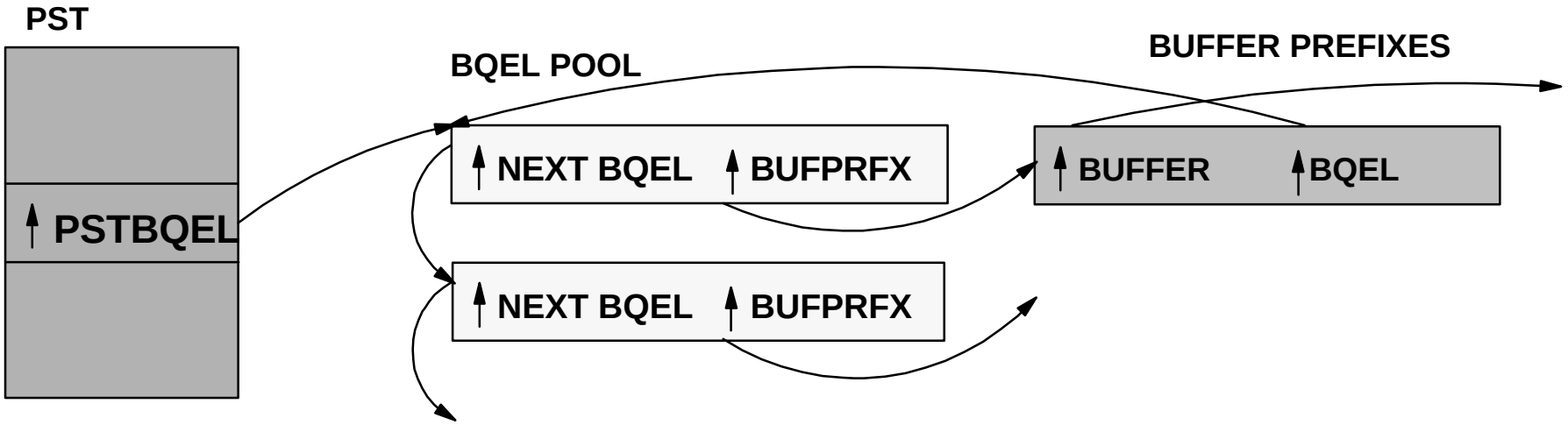
Buffer Pool Purge

- **Buffer pool purge writes all buffers altered by a dependent region to the appropriate data base data sets**
  - Purge is caused by transaction sync point or BMP CHKP/SYNC call
  - Buffers to be written are chained together (BQEL chain)
  - Chain is anchored to the PST

- **BQEL chains are an efficient way to find all buffers to be written**



Buffer Pool Purge ...

- **Write to log required for all changes not yet physically logged**
- **Altered OSAM DB buffers written to DBDSs using BQEL chain**
  - In RBA sequence by volume
  - Buffers on same track chained together
  - Multiple blocks per SIO
  - Overlap writes by volume and subpool
- **VSAM subpools also purged using BQEL chain**
  - Overlapped with OSAM purge
  - Single CI per SIO in BQEL chain sequence
- **Blocks/CIs still available in subpool(s)**

Buffer Pool Purge ...

Tuning Comments

- **Large blocksize best for sequential readers and updaters**
- **Maintain data base record locality of reference**
  - Tailor blocksize to data base record size
  - Set SCAN=0 and provide freespace (consider use of FBFF)
  - Timely DB reorganization
- **OSAM users should checkpoint for performance**
- **Purge is automatic with IMS V6 and standalone batch**
- **Background write most effective for writing VSAM CIs**

Buffer Pool Purge ...

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VSAM Background Write

Background write attempts to overlap read & write activity

- Specified on OPTIONS statement (DFSVSAMP DD or DFSVSMxx member)

```
OPTIONS    BGRT=YES | NO | (YES,n)
```

Do not set background write percentage too high

- Background write steals altered buffers and may cause LWA
- If too high, may cause rewrites of the same CIs which may otherwise be avoided`

Buffer Stealing: OSAM

OWNED	PSTLR	BUSY	ALTERED	USE LEVEL
BUFFER MARKED EMPTY				0
NO	EQ OR 0	NO	NO	0
NO	NE	NO	NO	1
NO	EQ	YES	-	2
NO	NE	YES	-	3
NO	EQ	NO	YES	4
NO	NE	NO	YES	5
YES	-	-	NO	6
YES	-	-	YES	7
CURRENTLY READING DATA				8
BUFFER HAS NID PENDING SITUATION				9
BUFFER IS LOCKED DUE TO A WRITE ERROR				10

WHERE: PSTLR = DEPENDENT REGION LAST REFERENCING THIS BUFFER

USE LEVEL = DETERMINES STEAL PRIORITY

'-' = NOT CHECKED
'NE' = NOT EQUAL
'EQ' = EQUAL

- **The steal routine searches a subpool in LRU sequence**
- **The subpool latch is held unless CICS or batch**

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YES	-	-	NO	6
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Buffer Stealing: OSAM ...

The subpool is searched in three increments

- For any increment, a use level 0 buffer ends the search immediately
  - **1st increment**: Buffers with use level 0 to 5 are eligible.

    1. If batch or CICS local DL/I, the increment is two.

    2. For online and DBCTL,

       A) If less than 15 dependent regions, then 2 X no. of scheduled regions = 1st increment

          else, 30 = 1st increment

       B) If 1st increment greater than the no. of buffers in subpool, then half the no. of buffers = 1st increment

  - **2nd increment:** Buffers with use level of 0 to 5 are eligible.

    No. buffers = (no. buffers/1st increment) - 1st increment

  - **3rd increment**: Buffers with use level of 8 or lower are eligible.

    The 3rd increment is the remaining buffers.

EXAMPLE 1:

60 BUFFERS, 15 DEPENDENT REGIONS

1ST INCREMENT = 30 BUFFERS
2ND INCREMENT = 28 BUFFERS
3RD INCREMENT = 2 BUFFERS

EXAMPLE 2:

500 BUFFERS, 40 DEP. REGIONS

1ST INCREMENT = 30 BUFFERS
2ND INCREMENT = 454 BUFFERS
3RD INCREMENT = 16 BUFFERS

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Buffer Stealing: OSAM ...

Tuning Comments

- **Use multiple subpools to minimize latch contention**
- **If altered buffer steals are occurring and system is transaction driven**
  - Increase the size of the subpool until eliminated
- **If altered buffer steals are occurring and batch or NMD BMP**
  - Ensure subpool is large enough to eliminate LWA
    - Reported as NOT IWAIT time by IMS Monitor
  - Replace all altered buffer steals with OSAM Queued Write
    - Ensure SYNC or CHKP frequency is adequate
- **IMS V6 should eliminate all altered buffer steals for standalone batch (OSAM Background Write)**

Buffer Stealing: OSAM ...

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Buffer Stealing: VSAM

- **Steal a buffer for a CI to be read into a buffer**
- **Steal algorithm consists of two increments**
- **1st Increment: Search 40% of buffers in subpool**
  - Search criteria
    - Not owned
    - Not altered
    - Not busy reading or writing
    - Not locked
  - First buffer to meet criteria ends the search
- **2nd Increment: Entire subpool searched for eligible buffer**
  - Search criteria
    - First buffer found that is not owned or locked ends the search

Buffer Stealing: VSAM ...

Tuning Comments

- **Transaction driven systems**
  - Ensure subpool is large enough to avoid altered buffer steals
- **Batch or NMD BMP**
  - Ensure subpool is large enough to avoid
    - Altered buffer steals
    - Buffer rewrites
  - Use background write to eliminate altered buffer steals

Locate Block/CI Within Range

- **Action module request to satisfy HD request for space**

- **OSAM and VSAM pools may be scanned to satisfy the HD Space Search Algorithm**

  1. Most desirable block
  2. Second most desirable block (effective with FBFF=)
  3. Block/CI in the buffer pool on same cylinder (scan)
  4. Block/CI on same track per bit map
  5. Block/CI on same cylinder per bit map
  6. Block/CI in buffer pool within SCAN= cylinders (scan forward then backward)
  7. Block/CI within SCAN= per bit map
  8. Any block/CI in buffer pool at end of data set (scan forward then backward)
  9. Any block/CI at end of data set per bit map
  10. Any block/CI in data set per bit map

Locate Block/CI Within Range ...

- **Scan processing is reflected in NOT IWAIT time**
  - Invoked for ISRTs and some variable length REPLs
  - Scan pathlength can be severe. Largely dependent upon number of unsuccessful 'hits' (space not found)

- **Tuning actions to consider**
  - Use freespace (FSPF and/or FBFF)
  - Only virtual storage buffers are searched
    - Good reason to use HIPERSPACE
    - Good reason to use multiple smaller subpools
  - Reorganize to reset freespace (best solution)

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Relationship to IMS Monitor

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Call Summary - PSB3 (BMP)

IMS MONITOR ****CALL SUMMARY**** TRACE START 122 14:22:06 TRACE STOP 122 14:26:14

PSB NAME	PCB NAME	CALL FUNC	LEV NO.SEGMENT	STAT CODE	CALLS	IWAITS	IWAITS/ CALL	..ELAPSED TIME. MEAN	MAXIMUM	NOT IWAIT TIME MEAN	MAXIMUM
PSB3	I/O PCB	CHKP	( )		31	189	6.09	26377	61297	12712	42903
		LOG	( )		310	0	0.00	742	75482	742	75482
		I/O PCB SUBTOTAL			341	189	0.55	3073		1830	
	PSB3DB2	ISRT	(02)TRANRTE		3027	56	0.01	1941	200579	1831	200579
		ISRT	(01)TRANROOT		36	9	0.25	4358	29540	2364	7094
		GU	(00)	GE	36	12	0.33	8225	57002	3166	57002
		REPL	(01)TRANROOT		35	0	0.00	822	3512	822	3512
		GU	(01)TRANROOT		35	0	0.00	1054	11196	1054	11196
		DL/I PCB SUBTOTAL			3169	77	0.02	2018		1832	
	PSB3DB1	GU	(01)SCRCHPAD		3026	4946	1.63	23933	578509	3278	520010
		GU	(00)	GE	1	2	2.00	22173	22173	1282	1282
		DL/I PCB SUBTOTAL			3027	4948	1.63	23933		3277	
	PSB3DB3	GU	(01)DB3ROOT		37	12007	324.51	1529514	56406152	107264	3863552
		GN	(00)	GB	1	1142	1142.00	4087572	4087572	351127	351127
		GN	(01)DB3ROOT		823	819	0.99	3099	22523	1115	18879
		DL/I PCB SUBTOTAL			861	13968	16.22	73438		6083	
		PSB TOTAL			7398	19182	2.59	19345		2918	

7398 CALLS X 19.4 MS/CALL = 143.5 SECS TOTAL PSB CALL ELAPSED

7398 CALLS X 2.9 MS/CALL = 21.6 SECS TOTAL PSB NOT IWAIT ELAPSED

(ADDITIONAL CALCULATIONS AND NOTES ARE CONTINUED ON THE NEXT FOIL.)

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GU (01) SCRCHPAD 3026 CALLS X 23.933 MS/CALL = 72 SECS

GU (01) DB3ROOT 37 CALLS X 1,529.514 MS/CALL = 57 SECS

GN (00) GB 1 CALL X 4,087.572 MS/CALL = 4 SECS

Program I/O

```
IMS MONITOR   ****PROGRAM I/O*** TRACE START  122 14:22:06   TRACE STOP  122  14:26:14  PAGE 0104

                                        .........IWAIT TIME.........
 PSBNAME  PCB NAME      IWAITS       TOTAL        MEAN     MAXIMUM   DDN/FUNC  MODULE

PSB3      PSB3DB1         2865    47733904       16661      129201   DB1DB      VBH
                          2083    14790495        7100       91334   DB1IX      VBH
          PCB TOTAL       4948    62524399       12636

           I/O PCB         166      350945        2114        5269   DB2DB      VBH
                            23       72652        3158       20337   DB2IX      VBH
          PCB TOTAL        189      423597        2241

           PSB3DB2           71      525609        7402       38252   DB2DB      VBH
                              6       62877       10479       34396   DB2IX      VBH
          PCB TOTAL          77      588486        7642

           PSB3DB3           19      105500        5552       27646   DB3IX      VBH
                          13949    57887258        4149      127107   DB3DB      VBH
          PCB TOTAL       13968    57992758        4151

          PSB TOTAL       19182    121529240       6335
```

PCB NAME	TOTAL IWAIT TIME	DDNAME
PSB3DB1	47.7 SECS	DB1DB
	14.8	DB1IX
PSB3DB3	57.9	DB3DB
TOTAL	120.4 SECS	

- **Selected DDNAMES are**
  - 99% of total IWAIT time
  - Identify which DB buffer pools to tune
  - Identify portion of DASD subsystem to analyze

VSAM Buffer Pool

```
V S A M   B U F F E R   P O O L
```

FIX INDEX/BLOCK/DATA	Y/Y/Y
SHARED RESOURCE POOL ID	XXXX
SHARED RESOURCE POOL TYPE	D
SUBPOOL ID	3
SUBPOOL BUFFER SIZE	4096
NUMBER HIPERSPACE BUFFERS	0
TOTAL BUFFERS IN SUBPOOL	2000

	DIFFERENCE
NUMBER OF RETRIEVE BY RBA CALLS RECEIVED BY BUF HNDLR	456018
NUMBER OF RETRIEVE BY KEY CALLS	6515
NUMBER OF LOGICAL RECORDS INSERTED INTO ESDS	1
NUMBERR OF LOGICAL RECORDS INSERTED INTO ESDS	479
NUMBER OF LOGICAL RECORDS ALTERED IN THIS SUBPOOL	39311
NUMBER OF TIMES BACKGROUND WRITE FUNCTION INVOKED	0
NUMBER OF SYNCHRONIZATION CALLS RECEIVED	2208
NUMBER OF WRITE ERROR BUFFERS CURRENTLY IN THE SUBPOOL	0
LARGEST NUMBER OF WRITE ERRORS IN THE SUBPOOL	0
NUMBER OF VSAM GET CALLS ISSUED	220356
NUMBER OF VSAM SCHBFR CALLS ISSUED	10046
NUMBER OF TIMES CTRL INTERVAL REQUESTED ALREADY IN POOL	195738
NUMBER OF CTRL INTERVALS READ FROM EXTERNAL STORAGE	37572
NUMBER OF VSAM WRITES INITIATED BY IMS/ESA	5241
NUMBER OF VSAM WRITES TO MAKE SPACE IN THE POOL	0
NUMBER OF VSAM READS FROM HIPERSPACE BUFFERS	0
NUMBER OF VSAM WRITES TO HIPERSPACE BUFFERS	0
NUMBER OF FAILED VSAM READS FROM HIPERSPACE BUFFERS	0
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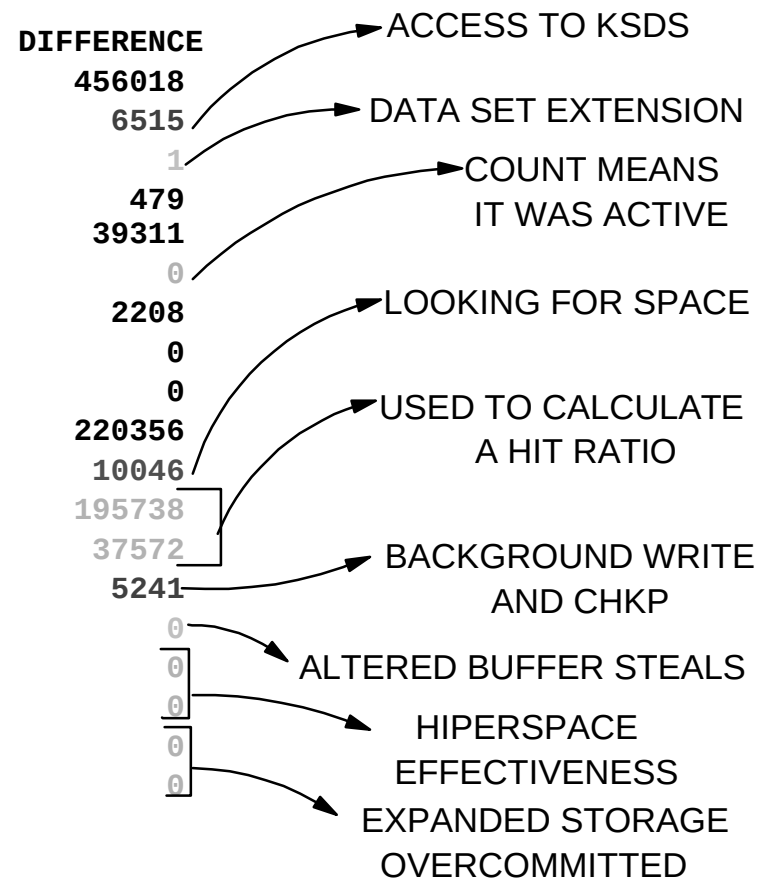

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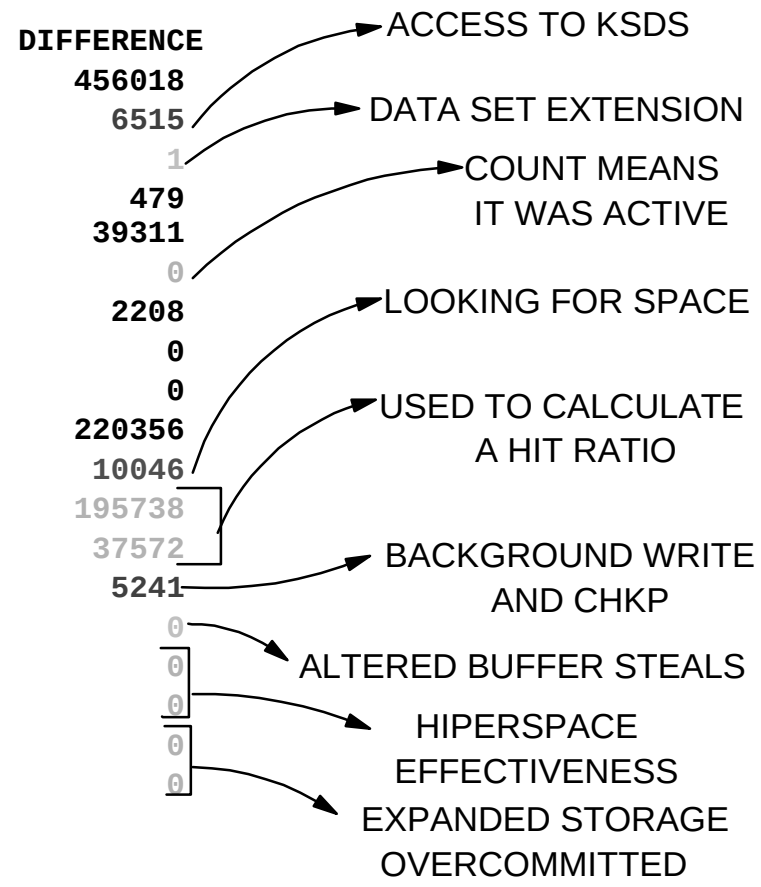

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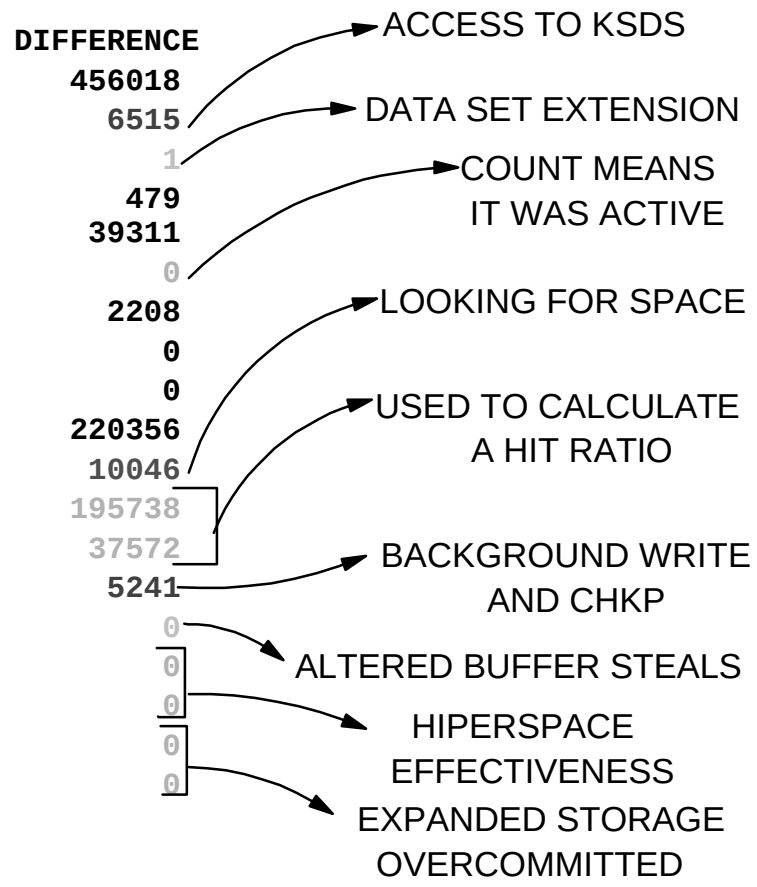
NUMBER OF WRITE ERROR BUFFERS CURRENTLY IN THE SUBPOOL	0
LARGEST NUMBER OF WRITE ERRORS IN THE SUBPOOL	0
NUMBER OF VSAM GET CALLS ISSUED	220356
NUMBER OF VSAM SCHBFR CALLS ISSUED	10046
NUMBER OF TIMES CTRL INTERVAL REQUESTED ALREADY IN POOL	195738
NUMBER OF CTRL INTERVALS READ FROM EXTERNAL STORAGE	37572
NUMBER OF VSAM WRITES INITIATED BY IMS/ESA	5241
NUMBER OF VSAM WRITES TO MAKE SPACE IN THE POOL	0
NUMBER OF VSAM READS FROM HIPERSPACE BUFFERS	0
NUMBER OF VSAM WRITES TO HIPERSPACE BUFFERS	0
NUMBER OF FAILED VSAM READS FROM HIPERSPACE BUFFERS	0
NUMBER OF FAILED VSAM WRITES TO HIPERSPACE BUFFERS	0



VSAM Buffer Pool ...

```
V S A M   B U F F E R   P O O L
```

FIX INDEX/BLOCK/DATA	Y/Y/Y
SHARED RESOURCE POOL ID	XXXX
SHARED RESOURCE POOL TYPE	D
SUBPOOL ID	3
SUBPOOL BUFFER SIZE	4096
NUMBER HIPERSPACE BUFFERS	0
TOTAL BUFFERS IN SUBPOOL	2000

	DIFFERENCE
NUMBER OF RETRIEVE BY RBA CALLS RECEIVED BY BUF HNDLR	456018
NUMBER OF RETRIEVE BY KEY CALLS	6515
NUMBER OF LOGICAL RECORDS INSERTED INTO ESDS	1
NUMBERR OF LOGICAL RECORDS INSERTED INTO ESDS	479
NUMBER OF LOGICAL RECORDS ALTERED IN THIS SUBPOOL	39311
NUMBER OF TIMES BACKGROUND WRITE FUNCTION INVOKED	0
NUMBER OF SYNCHRONIZATION CALLS RECEIVED	2208
NUMBER OF WRITE ERROR BUFFERS CURRENTLY IN THE SUBPOOL	0
LARGEST NUMBER OF WRITE ERRORS IN THE SUBPOOL	0
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NUMBER OF VSAM READS FROM HIPERSPACE BUFFERS	0
NUMBER OF VSAM WRITES TO HIPERSPACE BUFFERS	0
NUMBER OF FAILED VSAM READS FROM HIPERSPACE BUFFERS	0
NUMBER OF FAILED VSAM WRITES TO HIPERSPACE BUFFERS	0

ACCESS TO KSDS

DATA SET EXTENSION

COUNT MEANS IT WAS ACTIVE

LOOKING FOR SPACE

USED TO CALCULATE A HIT RATIO

BACKGROUND WRITE AND CHKP

ALTERED BUFFER STEALS

HIPERSPACE EFFECTIVENESS

EXPANDED STORAGE OVERCOMMITTED

VSAM Buffer Pool ...

```
V S A M   B U F F E R   P O O L
```

FIX INDEX/BLOCK/DATA	Y/Y/Y
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SHARED RESOURCE POOL TYPE	D
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Data Base Buffer Pool Report

```
***I M S  M O N I T O R***  BUFFER POOL STATISTICS  TRACE START 135 14:00:03 TRACE STOP 135 14:05:04

                              D A T A   B A S E   B U F F E R   P O O L

                                                          FIX PREFIX/BUFFERS              N/N
                                                          SUBPOOL ID
                                                          SUBPOOL BUFFER SIZE            4096
                                                          TOTAL BUFFERS IN SUBPOOL        250


                                                                    DIFFERENCE
NUMBER OF LOCATE-TYPE CALLS                                             79993
NUMBER OF REQUESTS TO CREATE NEW BLOCKS                                     0
NUMBER OF BUFFER ALTER CALLS                                             3005
NUMBER OF PURGE CALLS                                                     974
NUMBER OF LOCATE-TYPE CALLS, DATA ALREADY IN OSAM POOL                  75091
NUMBER OF BUFFERS SEARCHED BY ALL LOCATE-TYPE CALLS                     93021
NUMBER OF READ I/O REQUESTS                                              4581
NUMBER OF SINGLE BLOCK WRITES BY BUFFER STEAL ROUTINE                       0
NUMBER OF BLOCKS WRITTEN BY PURGE                                        1623
NUMBER OF LOCATE CALLS WAITED DUE TO BUSY ID                                3
NUMBER OF LOCATE CALLS WAITED DUE TO BUFFER BUSY WRT                        0
NUMBER OF LOCATE CALLS WAITED DUE TO BUFFER BUSY READ                       0
NUMBER OF BUFFER STEAL/PURGE WAITED FOR OWNERSHIP RLSE                      0
NUMBER OF BUFFER STEAL REQUESTS WAITED FOR BUFFERS                          0
TOTAL NUMBER OF I/O ERRORS FOR THIS SUBPOOL                                 0
NUMBER OF BUFFERS LOCKED DUE TO WRITE ERRORS                                0

QUOTIENT :  TOTAL NUMBER OF OSAM READS + OSAM WRITES =                   0.00
                      TOTAL NUMBER OF TRANSACTIONS
```

FORMAT LOGICAL CYLINDER

USED TO CALCULATE A HIT RATIO

ALTERED BUFFER STEALS

BLOCKS WRITTEN BY SYNCPT

BUFFER HANDLER CONTENTION

BUFFER POOL TOO SMALL

Data Base Buffer Pool Report ...

```
***I M S  M O N I T O R***  BUFFER POOL STATISTICS  TRACE START 135 14:00:03 TRACE STOP 135 14:05:04

                              D A T A   B A S E   B U F F E R   P O O L

                                                          FIX PREFIX/BUFFERS              N/N
                                                          SUBPOOL ID
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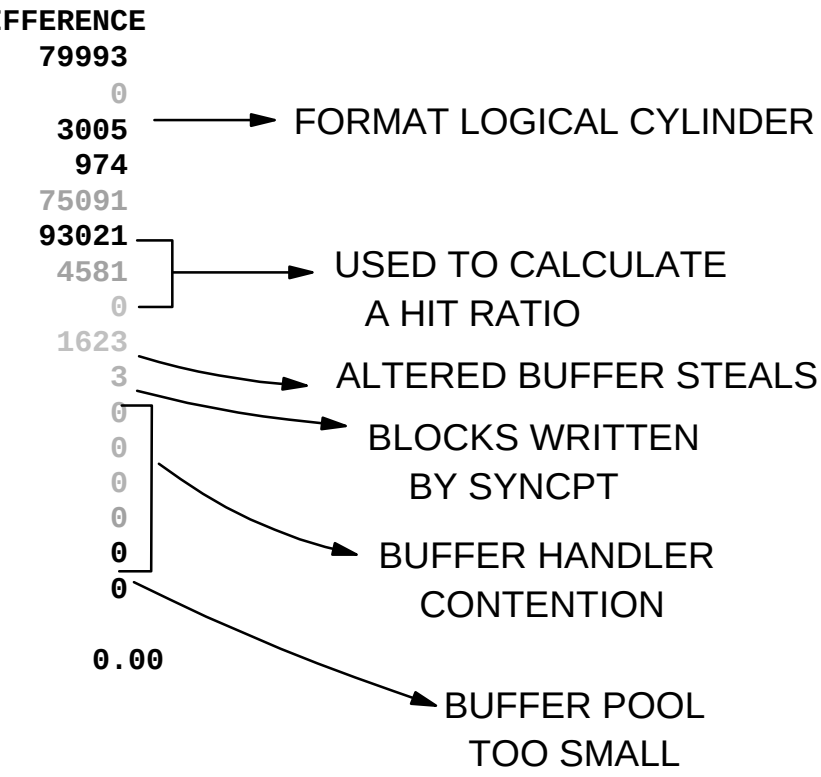

Data Base Buffer Pool Report ...

```
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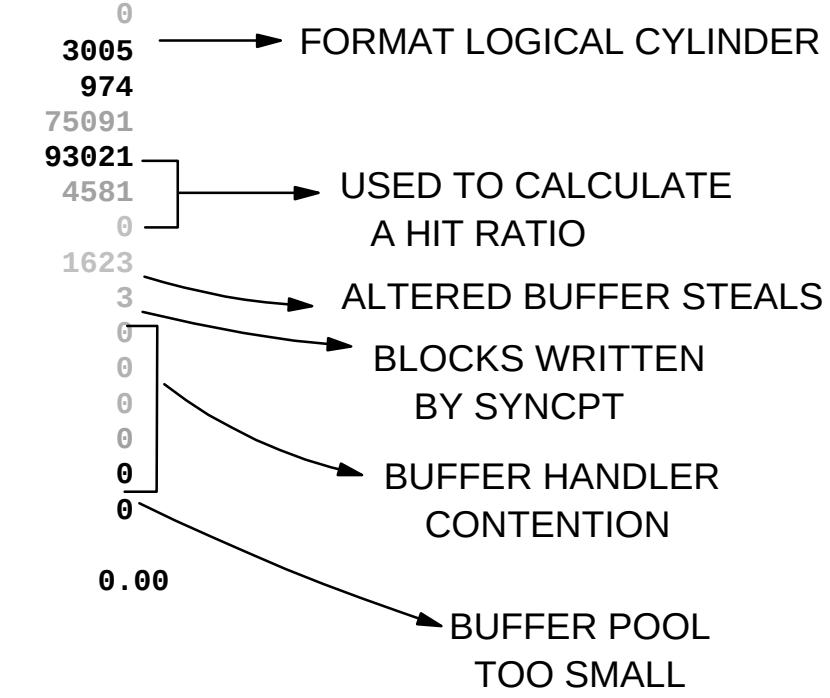

OSAM Statistics (V6)

Improved statistics for OSAM pools

- OSAM caching activity counts
  - Blocks read from CF (read from DASD avoided)
  - Blocks expected but not read (not in CF - read from DASD)
  - Blocks written to CF (total writes to CF)
  - Blocks written to CF (writes of changed data to CF)
  - Blocks not written because storage class full (not used)
  - Blocks invalidated with XI (found in buffer pool - not valid)
  - XI calls issued (may cause buffers on other IMSs to be invalidated)

- Sequential buffering counts
  - Anticipatory reads (read ahead 10 blocks)
  - Immediate (synchronous) reads (block not in SBH buffers - read 10 blocks)

Summary

Summary

- **Discussed the full function buffer handlers to some degree**
  - Selected specific buffer handler functions and activities
- **Discussion was in light of performance and possible tuning options**
- **Related buffer handler activity to the IMS Monitor reports**