ORACLE 19C AUTOMATIC INDEXING - INSIDE & OUT

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VIRTUAL EVENT

Who Am I

ORACLE ACE

Senior Sales Engineer / DBA

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- Current – 30+ Years in Oracle®, DB2®, ASE, SQL Server®, MySQL®
- DBA and Developer

Specialize in Performance Tuning

Review Database Performance for Customers Common Question – How do I tune it?

Quest

Agenda

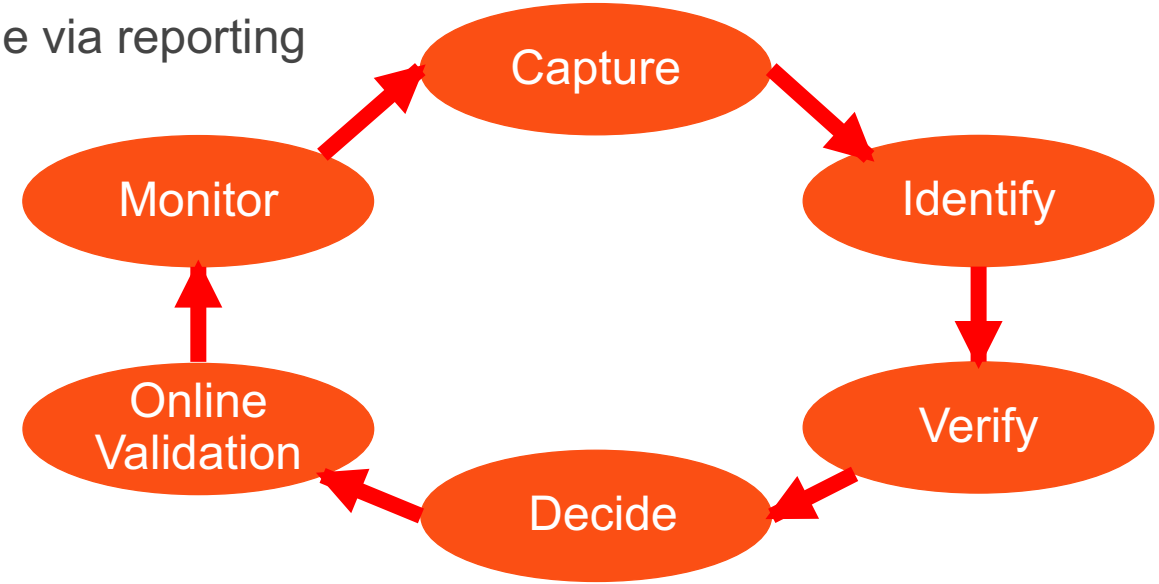
- 19c Automatic Indexing – What is it?
- High Level Steps
  - Capture
  - Verify
  - Decide
  - Monitor
  - Report
- DBMS_AUTO_INDEX Package
- 19c Automatic Indexing – How It Works
  - Several Case Studies
  - How to drop Automatic Indexes

19c Automatic Indexing – What is it?

- Implements indexes based expert index tuning knowledge
  - Identifies ‘candidate indexes’ based on table column usage
  - Without DBA involvement
    - Except for DBA can set preferences
      - > View report of indexes and their impact on the application
- Works incrementally
  - Needs to be iterative and continuous
  - Created as invisible
    - Uses ‘SYS_AI’ as the name prefix
  - Automatic indexes are tested
    - If improved performance – indexes made visible
    - If no improvement – indexes are marked unusable
      - > Later removed

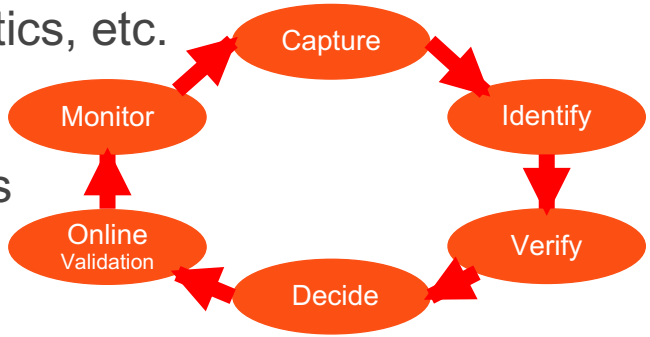
19c Automatic Indexing High Level Steps

- No DBA interaction
- All tuning activities
  - Auditable via reporting



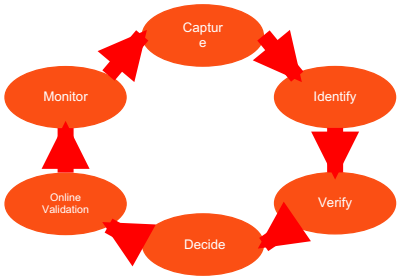
19c Automatic Indexing – How It Works

- Capture
  - Captures the application SQL history into a SQL repository
  - Includes SQL, plans, bind values, execution statistics, etc.
- Identify Candidate Indexes
  - That may help the newly captured SQL statements
  - Creates indexes as unusable invisible indexes
    - Metadata only
  - Drops indexes obsoleted by newly created indexes (logical merge)
- Verify
  - Ask optimizer if index candidates will be used for captured SQL statements
  - Materialize indexes and run SQL to validate that performance improved
  - All verification is done outside application workflow



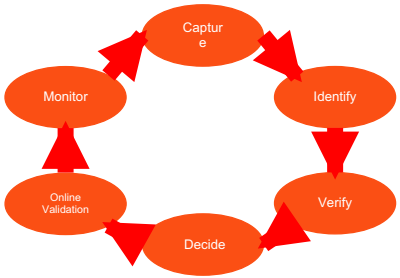
19c Automatic Indexing – How It Works

- Decide
  - If performance is better for all statements, indexes are marked visible
  - If performance worse for all statements, indexes remain invisible
  - If performance worse for some statements
    - Indexes are marked visible except for SQL statements that regressed
- Online Validation
  - Validation of new indexes continues for other statements online
  - Only one of the sessions executing a SQL statement
    - is allowed to use the new indexes
- Monitor
  - Index usage is continuously monitored
  - Automatically created indexes will be dropped if not used in a long time



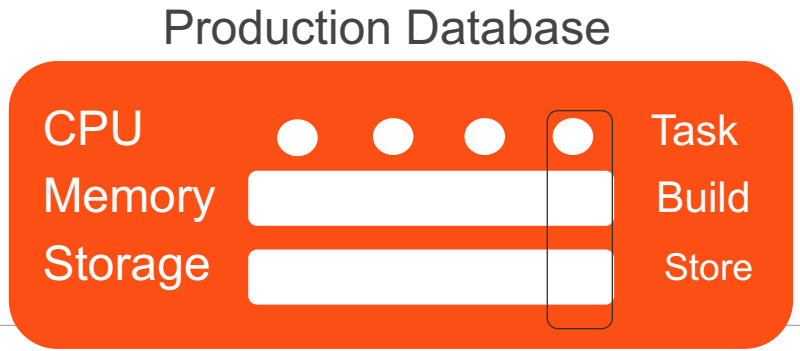
19c Automatic Indexing Benefits

- Great for OLTP, OLAP, mixed workloads but critical for OLTP
- Applies to tuned and un-tuned applications
  - If tuned
    - Existing secondary indexes may be outdated
    - Important indexes are missing
    - Some secondary indexes can be dropped and auto indexes can be added
  - If un-tuned
    - Existing indexes support primary and unique key constraints
- Can be used in all stages of application lifecycle
- Support single and concatenated indexes
  - Function-based indexes
  - Compression advanced low



19c Automatic Indexing

- Automatic indexing defaults to run in same database as application
- Indexing task consumes CPU, memory and storage
  - Resource manager plan limits task to 1 CPU
  - DBA can control
    - Which temp tablespace is used to build indexes
    - Which tablespace and how much space can be used by auto indexing



Automatic Indexing Requirements

- Feature is only available to Enterprise Edition on Engineered Systems
  - Exadata only

Feature / Option / Pack	SE2	EE	EE-ES	DBCS SE	DBCS EE	DBCS EE-HP	DBCS EE-EP	ExaCS	Notes
Automatic Indexing	N	N	Y	N	N	N	N	Y	**EE-ES**: Available on Exadata. Not available on Oracle Database Appliance.

  - Workaround for testing
    - In CDB as sysdba

      Alter system set "_Exadata_feature_on"=true scope=spfile;

      Shutdown immediate;

      Startup
  - Unfortunately this is not supported
    - Don't use on real system

19c DBMS_AUTO_INDEX Controls Auto Indexing

- Automatic indexing procedures
  - CONFIGURE
    - AUTO_INDEX_MODE – Turns on, off or report only
      - IMPLEMENT - Turns on automatic indexing
        - New indexes that improve performance are made visible & used by optimizer
      - REPORT ONLY -Turns on automatic indexing
        - New indexes remain invisible
      - OFF - Turns off automatic indexing
    - AUTO_INDEX_SCHEMA
      - Can include/exclude schemas using ALLOW parameter
        - Is case sensitive & can use wildcards
      - If NULL, all schemas can use auto index

Configure.Auto_Index_Mode Example

```
SQL> SELECT parameter_name, parameter_value
  2  FROM   cdb_auto_index_config
  3* ORDER BY 1, 2;

PARAMETER_NAME                           PARAMETER_VALUE
---------------------------------------- ---------------
AUTO_INDEX_COMPRESSION                   OFF
AUTO_INDEX_DEFAULT_TABLESPACE
AUTO_INDEX_MODE                          OFF
AUTO_INDEX_REPORT_RETENTION              31
AUTO_INDEX_RETENTION_FOR_AUTO            373
AUTO_INDEX_RETENTION_FOR_MANUAL
AUTO_INDEX_SCHEMA
AUTO_INDEX_SPACE_BUDGET                  50

8 rows selected.

SQL>  EXEC DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_MODE','IMPLEMENT');

PARAMETER_NAME                           PARAMETER_VALUE
---------------------------------------- ---------------
AUTO_INDEX_COMPRESSION                   OFF
AUTO_INDEX_DEFAULT_TABLESPACE
AUTO_INDEX_MODE                          IMPLEMENT
AUTO_INDEX_REPORT_RETENTION              31
AUTO_INDEX_RETENTION_FOR_AUTO            373
AUTO_INDEX_RETENTION_FOR_MANUAL
AUTO_INDEX_SCHEMA
AUTO_INDEX_SPACE_BUDGET                  50
```

Configure.Auto_Index_Schema Example

```
SQL> exec dbms_auto_index.configure(parameter_name=>'AUTO_INDEX_SCHEMA', parameter_value=>'TEST',allow=> TRUE);

PL/SQL procedure successfully completed.

SQL> @dba_auto

PARAMETER_NAME                           PARAMETER_VALUE
---------------------------------------- ---------------
AUTO_INDEX_COMPRESSION                   OFF
AUTO_INDEX_DEFAULT_TABLESPACE
AUTO_INDEX_MODE                          IMPLEMENT
AUTO_INDEX_REPORT_RETENTION              31
AUTO_INDEX_RETENTION_FOR_AUTO            373
AUTO_INDEX_RETENTION_FOR_MANUAL
AUTO_INDEX_SCHEMA                        schema IN (TEST)
AUTO_INDEX_SPACE_BUDGET                  50
```

```
COLUMN parameter_name FORMAT A40
COLUMN parameter_value FORMAT A15

SELECT parameter_name, parameter_value
FROM   cdb_auto_index_config
ORDER BY 1, 2;
```

DBMS_AUTO_INDEX.CONFIGURE - Cont.

- CONFIGURE
  - AUTO_INDEX_RETENTION_FOR_AUTO
    - Number of days (default 373) auto indexes retained after last used date
  - AUTO_INDEX_RETENTION_FOR_MANUAL
    - Number of days (default NULL) manual indexes retained after last used date
  - AUTO_INDEX_REPORT_RETENTION
    - Number of days automatic indexing logs are retained before deletion
      - Automatic indexing report is based of the logs (Default is 31 days)
  - AUTO_INDEX_DEFAULT_TABLESPACE
    - Tablespace to use to store auto indexes (Default is NULL)
  - AUTO_INDEX_SPACE_BUDGET
    - Percentage of tablespace size to use for auto indexes
    - Can only be used when using default tablespace is used

DBMS_AUTO_INDEX.CONFIGURE - Cont.

- CONFIGURE additional commands
  - PARAMETER_VALUE is specific to parameter
    - If NULL, setting is assigned a default value
  - AUTO_INDEX_COMPRESSION enables/disables advanced compression
    - ON for Advanced Low Compression
    - OFF for no compression (Default)
  - ALLOW for AUTO_INDEX_SCHEMA parameter
    - TRUE adds the specified schema to the inclusion list
    - FALSE adds the schema to the exclusion list
    - NULL remove the schema from the list that it is currently added

DBMS_AUTO_INDEX.CONFIGURE Examples

```
SQL> exec dbms_auto_index.configure('AUTO_INDEX_REPORT_RETENTION','90');

PL/SQL procedure successfully completed.


SQL> SELECT parameter_name, parameter_value
  2 FROM cdb_auto_index_config
  3 ORDER BY 1, 2;

PARAMETER_NAME                           PARAMETER_VALUE
---------------------------------------- ---------------
AUTO_INDEX_COMPRESSION                   ON
AUTO_INDEX_DEFAULT_TABLESPACE
AUTO_INDEX_MODE                          IMPLEMENT
AUTO_INDEX_REPORT_RETENTION              90
AUTO_INDEX_RETENTION_FOR_AUTO            373
AUTO_INDEX_RETENTION_FOR_MANUAL
AUTO_INDEX_SCHEMA                        schema IN (TEST)
AUTO_INDEX_SPACE_BUDGET                  50

SQL>  create tablespace auto_idx_ts datafile '/home/oracle/db_home/oradata/ORCL/orclpdb/auto_idx_ts.dbf' size 3g autoextend on;

Tablespace created.

SQL>  exec DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_DEFAULT_TABLESPACE','AUTO_IDX_TS');

PL/SQL procedure successfully completed.
```

DBMS_AUTO_INDEX.CONFIGURE Examples

```
SQL> exec DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_SPACE_BUDGET',20);

PL/SQL procedure successfully completed.

SQL> exec  DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_RETENTION_FOR_MANUAL',373);

PL/SQL procedure successfully completed.

SQL> exec DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_RETENTION_FOR_AUTO',15);

PL/SQL procedure successfully completed.

SQL> @dba_auto;

PARAMETER_NAME                           PARAMETER_VALUE
---------------------------------------- ----------------
AUTO_INDEX_COMPRESSION                   ON
AUTO_INDEX_DEFAULT_TABLESPACE            AUTO_IDX_TS
AUTO_INDEX_MODE                          IMPLEMENT
AUTO_INDEX_REPORT_RETENTION              90
AUTO_INDEX_RETENTION_FOR_AUTO            15
AUTO_INDEX_RETENTION_FOR_MANUAL          373
AUTO_INDEX_SCHEMA                        schema IN (TEST)
AUTO_INDEX_SPACE_BUDGET                  20
```

New (CDB/DBA) Views for Auto Indexes

- DBA_AUTO_INDEX_CONFIG *
  - Display the current configuration of the automation index
- DBA_AUTO_INDEX_EXECUTIONS
  - History of Automatic Indexing task executions
- DBA_AUTO_INDEX_IND_ACTIONS
  - Actions performed on automatic indexes (e.g create, rebuild, etc…)
- DBA_AUTO_INDEX_SQL_ACTIONS
  - Actions performed on SQL to verify automatic indexes
- DBA_AUTO_INDEX_STATISTICS
  - Shows statistics related to automatic indexes
- DBA_AUTO_INDEX_VERIFICATIONS
  - Shows statistics about PLAN_HASH_VALUE (original buffer gets, etc…)

Additional Views for Auto Indexes

- DBA_ADVISOR_TASKS – new tasks

```
SQL> select task_name, description, advisor_name, status from dba_advisor_tasks;

TASK_NAME                                DESCRIPTION                    ADVISOR_NAME                   STATUS
---------------------------------------- ------------------------------ ------------------------------ -----------
SYS_AUTO_INDEX_TASK                                                     SQL Access Advisor             EXECUTING
SYS_AI_VERIFY_TASK                                                      SQL Performance Analyzer       COMPLETED
SYS_AI_SPM_EVOLVE_TASK                   Automatic SPM Evolve Task      SPM Evolve Advisor             INITIAL
SYS_AUTO_SPM_EVOLVE_TASK                 Automatic SPM Evolve Task      SPM Evolve Advisor             COMPLETED
AUTO_STATS_ADVISOR_TASK                                                 Statistics Advisor             COMPLETED
SYS_AUTO_SPCADV107000614012020           Auto Space Advisor             Segment Advisor                COMPLETED
INDIVIDUAL_STATS_ADVISOR_TASK                                           Statistics Advisor             INITIAL

8 rows selected.
```

- DBA_INDEXES – new column (AUTO)

```
OWNER      INDEX_NAME                     AUT INDEX_TYPE TABLE_OWNE TABLE_TYPE
---------- ------------------------------ --- ---------- ---------- ----------
TEST       PK_STUDENT                     NO  NORMAL     TEST       TABLE
TEST       PRODUCT_PK                     NO  NORMAL     TEST       TABLE
TEST       SHIPMENTDETAILS_IDX            NO  NORMAL     TEST       TABLE
TEST       SYS_AI_22ty9tc8rvv1x           YES NORMAL     TEST       TABLE
TEST       SYS_AI_76tdrszhyq6sm           YES NORMAL     TEST       TABLE
TEST       SYS_AI_7yqm1agd9ffnn           YES NORMAL     TEST       TABLE
TEST       SYS_AI_8h4g2x5u9jx0v           YES NORMAL     TEST       TABLE
TEST       SYS_AI_9nr176um7dc3x           YES NORMAL     TEST       TABLE
TEST       SYS_AI_b7wfmv59u3nx6           YES NORMAL     TEST       TABLE
TEST       SYS_AI_bbtzahkgk9f9s           YES NORMAL     TEST       TABLE
TEST       SYS_AI_fyjgc63q5mz1d           YES NORMAL     TEST       TABLE
TEST       WAGE_ID_PK                     NO  NORMAL     TEST       TABLE
```

```
SELECT owner,
       index_name,
       auto,
       index_type,
       table_owner,
       table_type
FROM   dba_indexes
WHERE table_owner = 'TEST'
-- WHERE  auto='YES'
ORDER BY owner, index_name;
```

SMB$CONFIG Table

- Shows both documented & undocumented settings for Auto Indexes

```
SQL> desc sys.smb$config
 Name                                                                      Null?    Type
 ------------------------------------------------------------------------- -------- ----------------
 PARAMETER_NAME                                                            NOT NULL VARCHAR2(128)
 PARAMETER_VALUE                                                           NOT NULL NUMBER
 LAST_UPDATED                                                                       TIMESTAMP(6)
 UPDATED_BY                                                                         VARCHAR2(128)
 PARAMETER_DATA                                                                     CLOB

SQL> select PARAMETER_NAME,PARAMETER_VALUE  from sys.smb$config
  2  where parameter_name like '%AUTO_INDEX%' order by 1;

PARAMETER_NAME                                 PARAMETER_VALUE
---------------------------------------------- ---------------
AUTO_INDEX_COMPRESSION                                       0
AUTO_INDEX_DEFAULT_TABLESPACE                                0
AUTO_INDEX_MODE                                              0
AUTO_INDEX_REPORT_RETENTION                                 31
AUTO_INDEX_RETENTION_FOR_AUTO                                0
AUTO_INDEX_RETENTION_FOR_MANUAL                              0
AUTO_INDEX_SCHEMA                                            0
AUTO_INDEX_SPACE_BUDGET                                     50
_AUTO_INDEX_ABSDIFF_THRESHOLD                              100
_AUTO_INDEX_CONCURRENCY                                      1
_AUTO_INDEX_CONTROL                                          0
_AUTO_INDEX_DERIVE_STATISTICS                                0
_AUTO_INDEX_IMPROVEMENT_THRESHOLD                           20
_AUTO_INDEX_REBUILD_COUNT_LIMIT                              5
_AUTO_INDEX_REBUILD_TIME_LIMIT                              30
_AUTO_INDEX_REGRESSION_THRESHOLD                            10
_AUTO_INDEX_REVERIFY_TIME                                   30
_AUTO_INDEX_SPA_CONCURRENCY                                  1
_AUTO_INDEX_STS_CAPTURE_TASK                                 0
_AUTO_INDEX_TASK_INTERVAL                                  900
_AUTO_INDEX_TASK_MAX_RUNTIME                              3600
_AUTO_INDEX_TRACE                                            0
```

Other DBMS_AUTO_INDEX Procedures

- DROP_SECONDARY_INDEXES
  - Deletes all the indexes, except the ones used for constraints
    - From a schema or a table
    - Example - begin dbms_auto_index.drop_secondary_indexes('SH'); end;
- REPORT_ACTIVITY
  - Returns a report of automatic indexing operations
    - Executed during a specific period

```
declare
 report clob :=null;
begin
report :=DBMS_AUTO_INDEX.REPORT_ACTIVITY (
            activity_start => TO_TIMESTAMP('2020-01-01', 'YYYY-MM-DD'),
            activity_end   => TO_TIMESTAMP('2020-01-31', 'YYYY-MM-DD'),
            type           => 'TEXT',
            section        => 'SUMMARY',
            level          => 'BASIC');
dbms_output.put_line(report);
end;
```

```
SELECT DBMS_AUTO_INDEX.report_activity(
    activity_start => SYSTIMESTAMP-1,
    activity_end   => SYSTIMESTAMP,
    type           => 'TEXT',
   section         => 'ALL')
 FROM   dual;
```

- REPORT_LAST_ACTIVITY - Returns a report of the latest operation

19c Automatic Indexing Reporting & Hints

- Each auto index task generates a report
  - Reports can be generated via
    - DBMS_AUTO_INDEX.REPORT_ACTIVITY function
      - > Date/Time range
      - > Format (XML, HTML, Text)
      - > Level (basic, typical, all)
      - > Section
        - > Summary, Index Details,
          - Verification Details, Errors, All
- Use hints to control auto indexes
  - /*+ USE_AUTO_INDEXES */
  - /*+ NO_USE_AUTO_INDEXES */

Report_Activity Example

```
SQL> get rpt2.sql
  1  SELECT DBMS_AUTO_INDEX.report_activity(
  2           activity_start => SYSTIMESTAMP-1,
  3           activity_end   => SYSTIMESTAMP,
  4           type           => 'TEXT',
  5           section        => 'ALL')
  6* FROM   dual
SQL> /

GENERAL INFORMATION
-------------------------------------------------------------------------------
 Activity start                : 20-JAN-2020 00:26:59
 Activity end                  : 21-JAN-2020 00:26:59
 Executions completed          : 18
 Executions interrupted        : 0
 Executions with fatal error   : 2
-------------------------------------------------------------------------------

SUMMARY (AUTO INDEXES)
-------------------------------------------------------------------------------
 Index candidates                                   : 21
 Indexes created (visible / invisible)              : 3 (3 / 0)
 Space used (visible / invisible)                   : 94.5 MB (94.5 MB / 0 B)
 Indexes dropped                                    : 0
 SQL statements verified                            : 12
 SQL statements improved (improvement factor)       : 6 (722.5x)
 SQL plan baselines created (SQL statements)        : 2 (2)
 Overall improvement factor                         : 7405x
-------------------------------------------------------------------------------

SUMMARY (MANUAL INDEXES)
-------------------------------------------------------------------------------
 Unused indexes     : 0
 Space used         : 0 B
 Unusable indexes   : 0
-------------------------------------------------------------------------------
```

Report_Activity Cont.

```
INDEX DETAILS
-------------------------------------------------------------------------------
1. The following indexes were created:
-------------------------------------------------------------------------------
| Owner | Table        | Index                | Key                 | Type   | Properties |
-------------------------------------------------------------------------------
| TEST  | AUTO_IX      | SYS_AI_bbtzahkgk9f9s | DIST_NO             | B-TREE | NONE       |
| TEST  | CLASS        | SYS_AI_7yqm1agd9ffnn | NAME                | B-TREE | NONE       |
| TEST  | REGISTRATION | SYS_AI_8h4g2x5u9jx0v | CLASS_ID,CANCELLED  | B-TREE | NONE       |
-------------------------------------------------------------------------------
VERIFICATION DETAILS
-------------------------------------------------------------------------------
1. The performance of the following statements improved:
-------------------------------------------------------------------------------
 Parsing Schema Name  : TEST
 SQL ID               : 0dshxb6zujc75
 SQL Text             : delete from auto_ix where dist_no = 10 and rownum <4950

 Improvement Factor   : 48902x

Execution Statistics:
-----------------------------
                    Original Plan                Auto Index Plan
                    -----------------------------  -----------------------------
 Elapsed Time (s):  364413                       67
 CPU Time (s):      355589                       67
 Buffer Gets:       48902                        3
 Optimizer Cost:    12092                        3
 Disk Reads:        43758                        0
 Direct Writes:     0                            0
 Rows Processed:    4949                         5
 Executions:        1                            1
```

Report_Activity Cont.

```
 Parsing Schema Name  : TEST
 SQL ID               : 26fq0bn6zhkvc
 SQL Text             : select * from auto_ix where dist_no=10
 Improvement Factor   : 44201x

Execution Statistics:
-----------------------------
                    Original Plan                  Auto Index Plan
                    ---------------------------    ---------------------------
 Elapsed Time (s):  8357750                        117
 CPU Time (s):      8103571                        117
 Buffer Gets:       2696264                        8
 Optimizer Cost:    12092                          8
 Disk Reads:        463                            0
 Direct Writes:     0                              0
 Rows Processed:    3050                           5
 Executions:        61                             1

PLANS SECTION
-------------------------------------------------------------------------------
- Original
-----------------------------
 Plan Hash Value  : 548828358

--------------------------------------------------------------------------
| Id | Operation           | Name    | Rows | Bytes  | Cost  | Time     |
--------------------------------------------------------------------------
|  0 | SELECT STATEMENT    |         |      |        | 12092 |          |
|  1 |   TABLE ACCESS FULL | AUTO_IX | 5000 | 295000 | 12092 | 00:00:01 |
--------------------------------------------------------------------------
- With Auto Indexes
-----------------------------
 Plan Hash Value  : 792607439

-----------------------------------------------------------------------------
| Id  | Operation                           | Name                | Rows | Bytes | Cost |
-----------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |                     |    5 |   295 |    8 |
|   1 |   TABLE ACCESS BY INDEX ROWID BATCHED | AUTO_IX           |    5 |   295 |    8 |
| * 2 |     INDEX RANGE SCAN                | SYS_AI_bbtzahkgk9f9s |    5 |       |    3 |
-----------------------------------------------------------------------------
```

Other DBMS_AUTO_INDEX Procedures

- REPORT_LAST_ACTIVITY - Returns a report of the latest operation

```
declare
report clob := null;
begin

report := DBMS_AUTO_INDEX.REPORT_LAST_ACTIVITY (
            type => 'TEXT',
            section=> 'ALL',
            level=>  'TYPICAL');
dbms_output.put_line(report);
end;
```

```
select dbms_auto_index.report_last_activity() from dual;
```

  - Type can be TEXT (default), HTML or XML
  - Section can be SUMMERY, INDEX_DETAILS,VERIFICATION_DETAILS, ERROR or ALL
    - Can combined
      - SUMMARY + INDEX_DETAILS – shows summary and index_details
      - ALL – ERRORS – shows every section except errors
  - Level = Basic, Typical or All

3 Case Studies

- Tuning Examples
  - Used throughout the years with many Oracle versions – 10 & up
  - Manual results were compared with the Tuning Advisor suggestions
    - Consistent in previous releases
      - > Advisor usually missed the mark or got close but required additional DBA intervention
- Oracle 19C – Test Automatic Indexing
  - Billing Query for a University
  - Sale Order Query
  - Popular Airline Flights in USA

Billing Query for a University

- Slow performance was reported by a customer
  - Having trouble with their billing system
  - The following query was identified as performing poorly

```
SELECT s.fname, s.lname, r.signup_date
FROM   student s
   INNER JOIN registration r ON s.student_id = r.student_id
   INNER JOIN class c ON r.class_id = c.class_id
WHERE  c.name  = 'SQL TUNING'
AND    r.signup_date BETWEEN
to_date(:beg_date,'DD-MON-YY') and  to_date(:beg_date,'DD-MON-YY') +1
AND    r.cancelled = 'N';
```

  - Table sizes
    - Registration – 80,000 rows
    - Student – 18,000 rows
    - Class – 1000 rows

TABLE_NAME	INDEX_NAME	COLUMN_NAME	COLUMN_POSITION
CLASS	PK_CLASS	CLASS_ID	1
REGISTRATION	PK_REGISTRATION	STUDENT_ID	1
REGISTRATION	PK_REGISTRATION	CLASS_ID	2
REGISTRATION	PK_REGISTRATION	SIGNUP_DATE	3
STUDENT	PK_STUDENT	STUDENT_ID	1

Auto Indexes Enabled for Schema ‘Test’

```
SQL> EXEC DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_MODE','IMPLEMENT');

PL/SQL procedure successfully completed.

SQL> @d_config

PARAMETER_NAME                    PARAMETER_VALUE
--------------------------------- ------------------------------
AUTO_INDEX_COMPRESSION            OFF
AUTO_INDEX_DEFAULT_TABLESPACE     AUTO_IDX_TS
AUTO_INDEX_MODE                   IMPLEMENT
AUTO_INDEX_REPORT_RETENTION       90
AUTO_INDEX_RETENTION_FOR_AUTO     15
AUTO_INDEX_RETENTION_FOR_MANUAL   373
AUTO_INDEX_SCHEMA                 schema IN (TEST)
AUTO_INDEX_SPACE_BUDGET           20
```

OWNER	INDEX_NAME	AUT	TABLE_NAME
TEST	SYS_AI_76tdrszhyq6sm	YES	CLASS
TEST	SYS_AI_7yqm1agd9ffnn	YES	CLASS
TEST	SYS_AI_8h4g2x5u9jx0v	YES	REGISTRATION
TEST	SYS_AI_9nr176um7dc3x	YES	REGISTRATION
TEST	SYS_AI_b7wfmv59u3nx6	YES	REGISTRATION
TEST	SYS_AI_bbtzahkgk9f9s	YES	AUTO_IX
TEST	SYS_AI_fyjgc63q5mz1d	YES	CUSTOMER

TABLE_NAME	INDEX_NAME	COLUMN_NAME	COLUMN_POSITION
CLASS	SYS_AI_76tdrszhyq6sm	CLASS_ID	1
CLASS	SYS_AI_76tdrszhyq6sm	NAME	2
CLASS	SYS_AI_7yqm1agd9ffnn	NAME	1
REGISTRATION	SYS_AI_8h4g2x5u9jx0v	CLASS_ID	1
REGISTRATION	SYS_AI_8h4g2x5u9jx0v	CANCELLED	2
REGISTRATION	SYS_AI_9nr176um7dc3x	CANCELLED	1
REGISTRATION	SYS_AI_b7wfmv59u3nx6	STUDENT_ID	1
REGISTRATION	SYS_AI_b7wfmv59u3nx6	CLASS_ID	2
AUTO_IX	SYS_AI_bbtzahkgk9f9s	DIST_NO	1
CUSTOMER	SYS_AI_fyjgc63q5mz1d	CREDIT_CARD	1

Review Process of Registration (class_id, canceled)

```
SELECT a.execution_name, a.table_name,
      a.index_name, b.stat_name, a.start_time
FROM dba_auto_index_ind_actions a, dba_auto_index_statistics b
WHERE a.execution_name = b.execution_name
ORDER BY 5,3;
```

EXECUTION_NAME	TABLE_NAME	INDEX_NAME	STAT_NAME	START_TIM
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	SQL statements improved	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	SQL statements managed by SPM	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	SQL plan baselines created	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Improvement percentage	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Index candidates	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	SQL statements verified	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Indexes created (invisible)	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Indexes dropped	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Space used in bytes	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Space reclaimed in bytes	26-FEB-20
SYS_AI_2020-02-26/21:41:56	REGISTRATION	SYS_AI_8h4g2x5u9jx0v	Indexes created (visible)	26-FEB-20

DBA_AUTO_INDEX_VERIFICATIONS

EXECUTION_NAME	SQL_ID	ORIGINAL_PLAN_HASH_VALUE	AUTO_INDEX_PLAN_HASH_VALUE	ORIGINAL_BUFFER_GETS	AUTO_INDEX_BUFFER_GETS	STATUS
SYS_AI_2020-02-26/21:41:56	cqa9shb4n45zq	1244828764	2693604979	334.157974	331	UNCHANGED
SYS_AI_2020-02-27/22:19:47	1m72dnku1am29	309240793	2441908068	9	7	UNCHANGED
SYS_AI_2020-02-27/22:19:47	b461cvfsjcczj	2025025906	3891477460	15	14	UNCHANGED
SYS_AI_2020-02-27/22:19:47	bzc043n9nxt7s	1478357878	2693604979	17087	325	IMPROVED
SYS_AI_2020-02-27/22:19:47	fgday4r6bpfs9	309240793	1378088465	9	6	UNCHANGED
SYS_AI_2020-02-27/22:34:49	cqa9shb4n45zq	13237339	2693604979	167.36152	325	REGRESSED

Auto Indexes Created

- Shows status of indexes
  - 2 indexes are taking up space

```
SQL> select index_name, status, dropped, visibility, segment_created
  2  from user_indexes where auto='YES';

INDEX_NAME                     STATUS   DRO VISIBILIT SEG
------------------------------ -------- --- --------- ---
SYS_AI_bbtzahkgk9f9s            UNUSABLE NO  INVISIBLE NO
SYS_AI_76tdrszhyq6sm            UNUSABLE NO  INVISIBLE NO
SYS_AI_7yqm1agd9ffnn            VALID    NO  INVISIBLE YES
SYS_AI_fyjgc63q5mz1d            UNUSABLE NO  INVISIBLE NO
SYS_AI_b7wfmv59u3nx6            UNUSABLE NO  INVISIBLE NO
SYS_AI_8h4g2x5u9jx0v            VALID    NO  INVISIBLE YES
SYS_AI_9nr176um7dc3x            UNUSABLE NO  INVISIBLE NO
```

```
select segment_name, bytes from dba_segments
where segment_name in
   (select index_name from dba_indexes where tablespace_name like 'AUTO%');

SEGMENT_NAME                      BYTES
------------------------------ ----------
SYS_AI_7yqm1agd9ffnn               131072
SYS_AI_8h4g2x5u9jx0v              2097152

Total size
-----------
   2228224
```

With Compression

EXEC DBMS_AUTO_INDEX.CONFIGURE('AUTO_INDEX_COMPRESSION','ON');

INDEX_NAME	STATUS	VISIBILIT	DRO	COMPRESSION	SEG
SYS_AI_bbtzahkgk9f9s	UNUSABLE	INVISIBLE	NO	ADVANCED LOW	NO
SYS_AI_76tdrszhyq6sm	VALID	INVISIBLE	NO	ADVANCED LOW	YES
SYS_AI_7yqm1agd9ffnn	VALID	VISIBLE	NO	ADVANCED LOW	YES
SYS_AI_fyjgc63q5mz1d	UNUSABLE	INVISIBLE	NO	ADVANCED LOW	NO
SYS_AI_b7wfmv59u3nx6	VALID	INVISIBLE	NO	ADVANCED LOW	YES
SYS_AI_8h4g2x5u9jx0v	VALID	VISIBLE	NO	ADVANCED LOW	YES
SYS_AI_9nr176um7dc3x	UNUSABLE	INVISIBLE	NO	ADVANCED LOW	NO

Report_Activity

```
DBMS_AUTO_INDEX.REPORT_ACTIVITY(SYSTIMESTAMP-3,SYSTIMESTAMP,'TEXT','ALL','ALL')
--------------------------------------------------------------------------------
GENERAL INFORMATION
--------------------------------------------------------------------------------
 Activity start               : 25-FEB-2020 19:26:23
 Activity end                 : 28-FEB-2020 19:26:23
 Executions completed         : 68
 Executions interrupted       : 0
 Executions with fatal error  : 0
--------------------------------------------------------------------------------

SUMMARY (AUTO INDEXES)
--------------------------------------------------------------------------------
 Index candidates                                : 14
 Indexes created (visible / invisible)           : 6 (2 / 4)
 Space used (visible / invisible)                : 6.68 MB (2.23 MB / 4.46 MB)
 Indexes dropped                                 : 0
 SQL statements verified                         : 6
 SQL statements improved (improvement factor)    : 1 (52.6x)
 SQL plan baselines created                      : 0
 Overall improvement factor                      : 17.5x
--------------------------------------------------------------------------------

SUMMARY (MANUAL INDEXES)

DBMS_AUTO_INDEX.REPORT_ACTIVITY(SYSTIMESTAMP-3,SYSTIMESTAMP,'TEXT','ALL','ALL')
--------------------------------------------------------------------------------
 Unused indexes    : 0
 Space used        : 0 B
 Unusable indexes  : 0
--------------------------------------------------------------------------------
INDEX DETAILS
--------------------------------------------------------------------------------
1. The following indexes were created:
*: invisible
--------------------------------------------------------------------------------
| Owner | Table        | Index                  | Key                | Type    |
 Properties |
--------------------------------------------------------------------------------
| TEST  | CLASS        | * SYS_AI_76tdrszhyq6sm | CLASS_ID,NAME      | B-TREE |
| TEST  | CLASS        | SYS_AI_7yqm1agd9ffnn   | NAME               | B-TREE |
| TEST  | REGISTRATION | SYS_AI_8h4g2x5u9jx0v   | CLASS_ID,CANCELLED | B-TREE |
| TEST  | REGISTRATION | * SYS_AI_b7wfmv59u3nx6 | STUDENT_ID,CLASS_ID | B-TREE |
--------------------------------------------------------------------------------
```

```
VERIFICATION DETAILS
--------------------------------------------------------------------------------
1. The performance of the following statements improved:
--------------------------------------------------------------------------------
 Parsing Schema Name  : TEST
 SQL ID               : bzc043n9nxt7s
 SQL Text             : /* SQL Analyze(41,1) */ SELECT s.fname, s.lname,
                        r.signup_date FROM student s INNER JOIN registration r ON
                        s.student_id = r.student_id INNER JOIN class c ON
                        r.class_id = c.class_id WHERE c.name = 'SQL TUNING' AND
                        r.signup_date BETWEEN to_date(:beg_date,'DD-MON-YY') and
                        to_date(:beg_da...

 Improvement Factor   : 52.6x

Execution Statistics:
-----------------------------
                    Original Plan                  Auto Index Plan
                    ------------------------------ ------------------------------
 Elapsed Time (s):  439090                         38276
 CPU Time (s):      273210                         25351
 Buffer Gets:       170870                         342
 Optimizer Cost:    105                            116
 Disk Reads:        36                             1
 Direct Writes:     0                              0
 Rows Processed:    80                             8
 Executions:        10                             1
```

Report_Activity Cont.

```
--------------------------------------------------------------------------------
PLANS SECTION
--------------------------------------------------------------------------------

- Original
------------------------------
 Plan Hash Value  : 1478357878
-------------------------------------------------------------------------------
| Id | Operation                          | Name         | Rows | Bytes | Cost |
-------------------------------------------------------------------------------
|  0 | SELECT STATEMENT                   |              |      |       |  105 |
|  1 |   FILTER                           |              |      |       |      |
|  2 |    NESTED LOOPS                    |              |    1 |   112 |  105 |
|  3 |     NESTED LOOPS                   |              |    1 |    47 |  104 |
|  4 |      TABLE ACCESS FULL             | REGISTRATION |    1 |    18 |  103 |
|  5 |      TABLE ACCESS BY INDEX ROWID   | STUDENT      |    1 |    29 |    1 |
|  6 |       INDEX UNIQUE SCAN            | PK_STUDENT   |    1 |       |    0 |
|  7 |     TABLE ACCESS BY INDEX ROWID    | CLASS        |    1 |    65 |    1 |
|  8 |      INDEX UNIQUE SCAN             | PK_CLASS     |    1 |       |    0 |
-------------------------------------------------------------------------------

- With Auto Indexes
------------------------------
 Plan Hash Value  : 2693604979
-------------------------------------------------------------------------------
| Id  | Operation                                | Name                 | Rows
-------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |                      |    8
| * 1 |   FILTER                                 |                      |
|   2 |    NESTED LOOPS                          |                      |    8
|   3 |     NESTED LOOPS                         |                      |    8
| * 4 |      HASH JOIN                           |                      |    8
|   5 |       TABLE ACCESS BY INDEX ROWID BATCHED | CLASS                |    2
| * 6 |        INDEX RANGE SCAN                  | SYS_AI_7yqm1aqd9ffnn |    2
| * 7 |       TABLE ACCESS FULL                  | REGISTRATION         | 4183
| * 8 |      INDEX UNIQUE SCAN                   | PK_STUDENT           |    1
|   9 |     TABLE ACCESS BY INDEX ROWID          | STUDENT              |    1
-------------------------------------------------------------------------------

Notes
- Dynamic sampling used for this statement ( level = 11 )
 - This is an adaptive plan

--------------------------------------------------------------------------------
ERRORS
No errors found.
```

Did it measure up?

```
Plan hash value: 2281644015

-------------------------------------------------------------------------------------------------------------
| Id  | Operation                                | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |              |     1 |   112 |   107   (2)| 00:00:01 |
|*  1 |  FILTER                                  |              |       |       |            |          |
|   2 |   NESTED LOOPS                           |              |     1 |   112 |   107   (2)| 00:00:01 |
|   3 |    NESTED LOOPS                          |              |     1 |   112 |   107   (2)| 00:00:01 |
|*  4 |     HASH JOIN                            |              |     1 |    83 |   106   (2)| 00:00:01 |
|   5 |      TABLE ACCESS BY INDEX ROWID BATCHED | CLASS        |     1 |    65 |     2   (0)| 00:00:01 |
|*  6 |       INDEX RANGE SCAN                   | SYS_AI_*ffnn |     1 |       |     1   (0)| 00:00:01 |
|*  7 |      TABLE ACCESS FULL                   | REGISTRATION |   199 |  3582 |   104   (2)| 00:00:01 |
|*  8 |     INDEX UNIQUE SCAN                    | PK_STUDENT   |     1 |       |     0   (0)| 00:00:01 |
|   9 |    TABLE ACCESS BY INDEX ROWID           | STUDENT      |     1 |    29 |     1   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------------
```

Auto Cost

107

create index cov_reg on registration(class_id, signup_date, cancelled)

```
Plan hash value: 923900230

-------------------------------------------------------------------------------------------------------------
| Id  | Operation                                | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |              |     1 |   112 |     5   (0)| 00:00:01 |
|*  1 |  FILTER                                  |              |       |       |            |          |
|   2 |   NESTED LOOPS                           |              |     1 |   112 |     5   (0)| 00:00:01 |
|   3 |    NESTED LOOPS                          |              |     1 |   112 |     5   (0)| 00:00:01 |
|   4 |     NESTED LOOPS                         |              |     1 |    83 |     4   (0)| 00:00:01 |
|   5 |      TABLE ACCESS BY INDEX ROWID BATCHED | CLASS        |     1 |    65 |     2   (0)| 00:00:01 |
|*  6 |       INDEX RANGE SCAN                   | CL_NAME      |     1 |       |     1   (0)| 00:00:01 |
|   7 |      TABLE ACCESS BY INDEX ROWID BATCHED | REGISTRATION |     1 |    18 |     2   (0)| 00:00:01 |
|*  8 |       INDEX RANGE SCAN                   | COV_REG      |     1 |       |     1   (0)| 00:00:01 |
|*  9 |     INDEX UNIQUE SCAN                    | PK_STUDENT   |     1 |       |     0   (0)| 00:00:01 |
|  10 |    TABLE ACCESS BY INDEX ROWID           | STUDENT      |     1 |    29 |     1   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------------
```

DBA Tuned

Cost

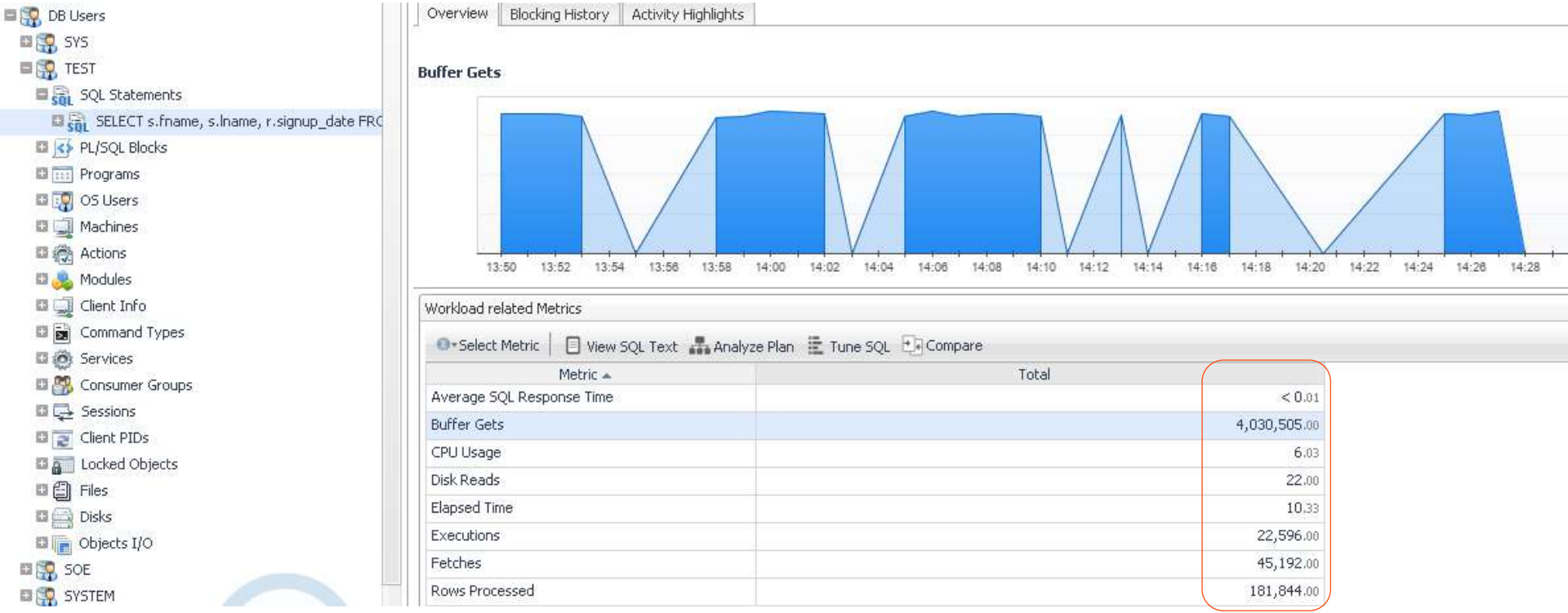
5

Auto Index on Registration

Plan Details | Operation Analysis | Object Analysis

Operation	Object Name	Object Type	Cost	CPU Cost	I/O Cost	Cardinality	Bytes	Time (seconds)	Temp Space	Access Predicates
SELECT STATEMENT			16.84 %	0	0	0	0	0	0	
FILTER			0.00 %	0	0	0	0	0	0	
HASH JOIN			16.84 %	948,135	79	4	448	1	0	"S"."STUDENT_ID"="R"."STUDENT_ID"
NESTED LOOPS			16.84 %	948,135	79	4	448	1	0	
NESTED LOOPS			16.84 %	948,135	79	4	448	1	0	
STATISTICS COLLECTOR			0.00 %	0	0	0	0	0	0	
NESTED LOOPS			15.99 %	911,289	75	4	332	1	0	
TABLE ACCESS FULL	TEST.CLASS	TABLE	1.07 %	312,579	5	1	65	1	0	
TABLE ACCESS BY INDEX ROWID BATCHED	TEST.REGISTRATION	TABLE	14.93 %	598,711	70	4	72	1	0	
INDEX RANGE SCAN	TEST.SYS_AI_8h4g2x5u9jx0v	INDEX	0.21 %	23,971	1	80	0	1	0	"R"."CLASS_ID"="C"."CLASS_ID" AND "R"."CANCELLED"='N'
INDEX UNIQUE SCAN	TEST.PK_STUDENT	INDEX (UNIQUE)	0.00 %	1,900	0	1	0	0	0	"S"."STUDENT_ID"="R"."STUDENT_ID"
TABLE ACCESS BY INDEX ROWID	TEST.STUDENT	TABLE	0.21 %	9,211	1	1	29	1	0	
TABLE ACCESS FULL	TEST.STUDENT	TABLE	0.21 %	9,211	1	1	29	1	0	

With Auto Index



Auto Index on Registration

```
Plan hash value: 2023948573

-----------------------------------------------------------------------------------------------------------------------
| Id  | Operation                                | Name                 | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |                      |     1 |   112 |    76   (0)| 00:00:01 |
|*  1 |  FILTER                                  |                      |       |       |            |          |
|   2 |   NESTED LOOPS                           |                      |     1 |   112 |    76   (0)| 00:00:01 |
|   3 |    NESTED LOOPS                          |                      |     1 |   112 |    76   (0)| 00:00:01 |
|   4 |     NESTED LOOPS                         |                      |     1 |    83 |    75   (0)| 00:00:01 |
|*  5 |      TABLE ACCESS FULL                   | CLASS                |     1 |    65 |     5   (0)| 00:00:01 |
|*  6 |      TABLE ACCESS BY INDEX ROWID BATCHED | REGISTRATION         |     1 |    18 |    70   (0)| 00:00:01 |
|*  7 |       INDEX RANGE SCAN                   | SYS_AI_8h4g2x5u9jx0v |    80 |       |     1   (0)| 00:00:01 |
|*  8 |     INDEX UNIQUE SCAN                    | PK_STUDENT           |     1 |       |     0   (0)| 00:00:01 |
|   9 |    TABLE ACCESS BY INDEX ROWID           | STUDENT              |     1 |    29 |     1   (0)| 00:00:01 |
```

Covered Index on Registration

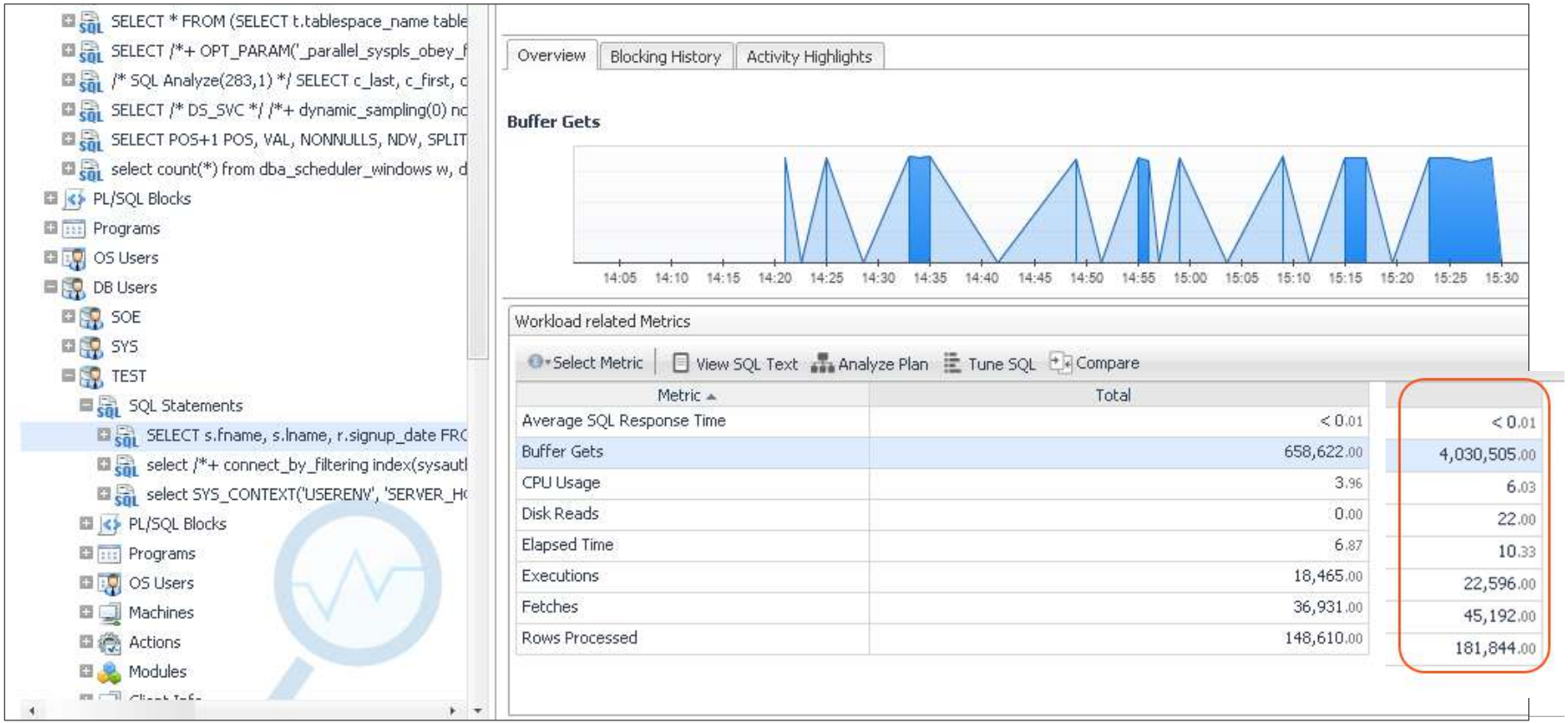
Plan Details | Operation Analysis | Object Analysis

Operation	Object Name	Object Type	Cost	CPU Cost	I/O Cost	Cardinality	Bytes	Time (seconds)	Temp Space
SELECT STATEMENT			14.86 %	0	0	0	0	0	0
FILTER			0.00 %	0	0	0	0	0	0
HASH JOIN			14.86 %	91,186	11	4	448	1	0
NESTED LOOPS			14.86 %	91,186	11	4	448	1	0
NESTED LOOPS			14.86 %	91,186	11	4	448	1	0
STATISTICS COLLECTOR			0.00 %	0	0	0	0	0	0
HASH JOIN			9.46 %	54,340	7	4	332	1	0
NESTED LOOPS			9.46 %	54,340	7	4	332	1	0
STATISTICS COLLECTOR			0.00 %	0	0	0	0	0	0
TABLE ACCESS BY INDEX ROWID BATCHED	TEST.CLASS	TABLE	2.70 %	15,833	2	1	65	1	0
INDEX RANGE SCAN	TEST.CL_NAME	INDEX	1.35 %	8,371	1	1	0	1	0
TABLE ACCESS BY INDEX ROWID BATCHED	TEST.REGISTRATION	TABLE	6.76 %	38,507	5	4	72	1	0
INDEX RANGE SCAN	TEST.COV_REG	INDEX	1.35 %	8,971	1	4	0	1	0
TABLE ACCESS FULL	TEST.REGISTRATION	TABLE	6.76 %	38,507	5	4	72	1	0
INDEX UNIQUE SCAN	TEST.PK_STUDENT	INDEX (UNIQUE)	0.00 %	1,900	0	1	0	0	0
TABLE ACCESS BY INDEX ROWID	TEST.STUDENT	TABLE	1.35 %	9,211	1	1	29	1	0
TABLE ACCESS FULL	TEST.STUDENT	TABLE	1.35 %	9,211	1	1	29	1	0

SQL Text

```
SELECT s.fname, s.lname, r.signup_date
  FROM student s
       INNER JOIN registration r
          ON s.student_id = r.student_id
       INNER JOIN class c
          ON r.class_id = c.class_id
 WHERE     c.name = 'SQL TUNING'
       AND r.signup_date BETWEEN TO_DATE (:beg_date, 'DD-MON-YY')
                             AND TO_DATE (:beg_date, 'DD-MON-YY') + 1
       AND r.cancelled = 'N'
```

Covered Index on Registration



Quest

Covered Index on Registration Wins

- Auto Index on Class(name) cost 107
- Auto Index on Registration(class_id, canceled) cost 76
- DBA Index on Class(name), Registration(class_id, signup_date, cancelled)
  - Cost **5**

```
Plan hash value: 923900230

-------------------------------------------------------------------------------------------------
| Id  | Operation                                | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |              |     1 |   112 |     5   (0)| 00:00:01 |
|*  1 |  FILTER                                  |              |       |       |            |          |
|   2 |   NESTED LOOPS                           |              |     1 |   112 |     5   (0)| 00:00:01 |
|   3 |    NESTED LOOPS                          |              |     1 |   112 |     5   (0)| 00:00:01 |
|   4 |     NESTED LOOPS                         |              |     1 |    83 |     4   (0)| 00:00:01 |
|   5 |      TABLE ACCESS BY INDEX ROWID BATCHED | CLASS        |     1 |    65 |     2   (0)| 00:00:01 |
|*  6 |       INDEX RANGE SCAN                   | CL_NAME      |     1 |       |     1   (0)| 00:00:01 |
|   7 |      TABLE ACCESS BY INDEX ROWID BATCHED | REGISTRATION |     1 |    18 |     2   (0)| 00:00:01 |
|*  8 |       INDEX RANGE SCAN                   | COV_REG      |     1 |       |     1   (0)| 00:00:01 |
|*  9 |     INDEX UNIQUE SCAN                    | PK_STUDENT   |     1 |       |     0   (0)| 00:00:01 |
|  10 |    TABLE ACCESS BY INDEX ROWID           | STUDENT      |     1 |    29 |     1   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------
```

Sale Order Query

- HammerDB load utility – Slow running query

```
SELECT c_last, c_first, c_street_1, c_city, c_state, c_zip,
            c_phone, o_entry_d, d_name, ol_delivery_d, ol_quantity, ol_amount
FROM order_line, orders, district, customer, stock
WHERE o_id = ol_o_id
AND o_c_id=c_id
AND s_i_id = ol_i_id
AND d_id = ol_d_id
AND ol_w_id = :B2
AND ol_d_id = :B4
AND (ol_o_id < :B3 )
AND ol_o_id >= (:B3 - 20)
AND s_w_id = :B2
AND s_quantity < :B1
AND d_id = :B4
AND c_last like :B5 ;
```

Order_line	60,461,709
Orders	6,046,215
District	50
Customer	150,000
Stock	500,000

Existing Indexes

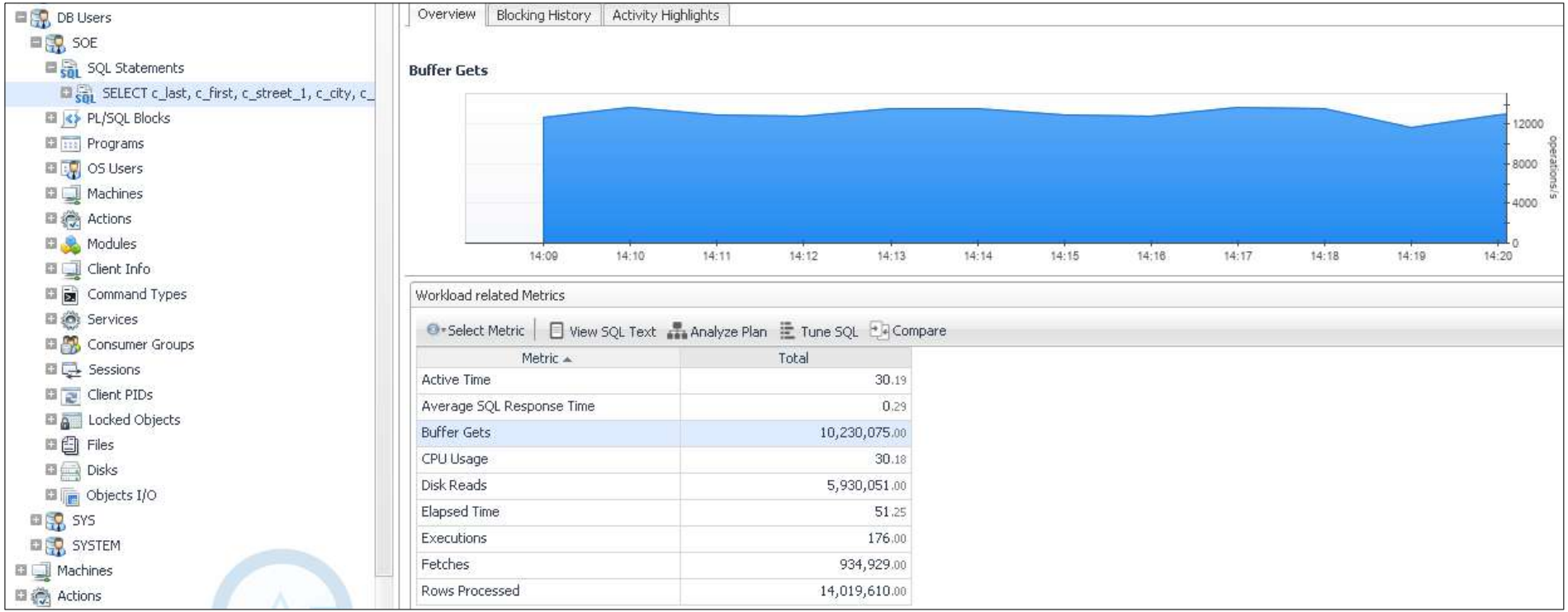
TABLE_NAME	INDEX_NAME	COLUMN_NAME	COLUMN_POSITION
CUSTOMER	CUSTOMER_I1	C_W_ID	1
CUSTOMER	CUSTOMER_I1	C_D_ID	2
CUSTOMER	CUSTOMER_I1	C_ID	3
DISTRICT	DISTRICT_I1	D_W_ID	1
DISTRICT	DISTRICT_I1	D_ID	2
ORDERS	ORDERS_I1	O_W_ID	1
ORDERS	ORDERS_I1	O_D_ID	2
ORDERS	ORDERS_I1	O_ID	3
ORDER_LINE	IORDL	OL_W_ID	1
ORDER_LINE	IORDL	OL_D_ID	2
ORDER_LINE	IORDL	OL_O_ID	3
ORDER_LINE	IORDL	OL_NUMBER	4
STOCK	STOCK_IDX	S_I_ID	1
STOCK	STOCK_IDX	S_W_ID	2
WAREHOUSE	WAREHOUSE_I1	W_ID	1

Original Execution Plan

```
Execution Plan
----------------------------------------------------------
Plan hash value: 1040961599

-------------------------------------------------------------------------------------------------------
| Id  | Operation                                | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |              |  4010 |   650K|  15981   (1)| 00:00:01 |
|*  1 |  FILTER                                  |              |       |       |             |          |
|*  2 |   HASH JOIN                              |              |  4010 |   650K|  15981   (1)| 00:00:01 |
|*  3 |    HASH JOIN                             |              |  1594 |   112K|  12687   (1)| 00:00:01 |
|   4 |     NESTED LOOPS                         |              |  1542 | 84810 |   4631   (1)| 00:00:01 |
|   5 |      NESTED LOOPS                        |              |  1542 | 84810 |   4631   (1)| 00:00:01 |
|*  6 |       HASH JOIN                          |              |  1512 | 66528 |     94   (0)| 00:00:01 |
|   7 |        TABLE ACCESS BY INDEX ROWID BATCHED| DISTRICT     |     5 |    60 |      6   (0)| 00:00:01 |
|*  8 |         INDEX SKIP SCAN                  | DISTRICT_I1  |     5 |       |      1   (0)| 00:00:01 |
|*  9 |        INDEX RANGE SCAN                  | IORDL        |  3023 | 96736 |     88   (0)| 00:00:01 |
|* 10 |       INDEX RANGE SCAN                   | STOCK_IDX    |     1 |       |      2   (0)| 00:00:01 |
|* 11 |      TABLE ACCESS BY INDEX ROWID         | STOCK        |     1 |    11 |      3   (0)| 00:00:01 |
|* 12 |     TABLE ACCESS FULL                    | ORDERS       | 15116 |   250K|   8055   (1)| 00:00:01 |
|* 13 |    TABLE ACCESS FULL                     | CUSTOMER     |  7500 |   688K|   3294   (1)| 00:00:01 |
-------------------------------------------------------------------------------------------------------
```

Original Performance



Include SOE Schema for Auto Indexing

PARAMETER_NAME	PARAMETER_VALUE
AUTO_INDEX_COMPRESSION	ON
AUTO_INDEX_DEFAULT_TABLESPACE	AUTO_IDX_TS
AUTO_INDEX_MODE	IMPLEMENT
AUTO_INDEX_REPORT_RETENTION	90
AUTO_INDEX_RETENTION_FOR_AUTO	15
AUTO_INDEX_RETENTION_FOR_MANUAL	373
AUTO_INDEX_SCHEMA	schema IN (TEST, SOE)
AUTO_INDEX_SPACE_BUDGET	20

INDEX_NAME	TABLE_NAME	AUT	VISIBILIT	COMPRESSION	SEG	STATUS
SYS_AI_8k0xma30nayxn	CUSTOMER	YES	INVISIBLE	ADVANCED LOW	YES	VALID
SYS_AI_0jfsy72532qv3	CUSTOMER	YES	INVISIBLE	ADVANCED LOW	YES	VALID
SYS_AI_a3tc4dj87650q	CUSTOMER	YES	INVISIBLE	ADVANCED LOW	NO	UNUSABLE
SYS_AI_gj2prfsytzu50	CUSTOMER	YES	INVISIBLE	ADVANCED LOW	YES	VALID
SYS_AI_18pkdxrps0j2m	ORDERS	YES	INVISIBLE	ADVANCED LOW	YES	VALID
SYS_AI_97ya3cug4hxpk	ORDERS	YES	INVISIBLE	ADVANCED LOW	YES	VALID
SYS_AI_3ys7c39vs247p	ORDERS	YES	INVISIBLE	ADVANCED LOW	NO	UNUSABLE
SYS_AI_81dnzcja2qhpx	ORDERS	YES	INVISIBLE	ADVANCED LOW	NO	UNUSABLE
SYS_AI_fdbazxb641kwv	STOCK	YES	INVISIBLE	ADVANCED LOW	NO	UNUSABLE

```
SELECT index_name,table_name,
    auto,visibility, compression,
    segment_created, status
FROM user_indexes
WHERE auto='YES';
```

Automatic Indexes

TABLE_NAME	INDEX_NAME	COLUMN_NAME	COLUMN_POSITION
CUSTOMER	SYS_AI_0jfsy72532qv3	C_LAST	1
CUSTOMER	SYS_AI_8k0xma30nayxn	C_ID	1
CUSTOMER	SYS_AI_8k0xma30nayxn	C_D_ID	2
CUSTOMER	SYS_AI_8k0xma30nayxn	C_W_ID	3
CUSTOMER	SYS_AI_a3tc4dj87650q	C_W_ID	1
CUSTOMER	SYS_AI_gj2prfsytzu50	C_D_ID	1
CUSTOMER	SYS_AI_gj2prfsytzu50	C_W_ID	2
CUSTOMER	SYS_AI_gj2prfsytzu50	C_LAST	3
ORDERS	SYS_AI_18pkdxrps0j2m	O_ID	1
ORDERS	SYS_AI_18pkdxrps0j2m	O_W_ID	2
ORDERS	SYS_AI_18pkdxrps0j2m	O_D_ID	3
ORDERS	SYS_AI_3ys7c39vs247p	O_D_ID	1
ORDERS	SYS_AI_81dnzcja2qhpx	O_W_ID	1
ORDERS	SYS_AI_81dnzcja2qhpx	O_D_ID	2
ORDERS	SYS_AI_81dnzcja2qhpx	O_C_ID	3
ORDERS	SYS_AI_97ya3cug4hxpk	O_C_ID	1
ORDERS	SYS_AI_97ya3cug4hxpk	O_ID	2
STOCK	SYS_AI_fdbazxb641kwv	S_W_ID	1

SEGMENT_NAME	BYTES
SYS_AI_18pkdxrps0j2m	109051904
SYS_AI_97ya3cug4hxpk	117440512
SYS_AI_8k0xma30nayxn	3145728
SYS_AI_0jfsy72532qv3	2097152
SYS_AI_gj2prfsytzu50	4194304

Total Space: 225m

Visible: 9m

```
  1  select index_name,table_name, auto,visibility,segment_created
  2  from user_indexes
  3  where auto='YES'
  4* and visibility = 'VISIBLE'
SQL> /

INDEX_NAME                     TABLE_NAME           AUT VISIBILIT SEG
------------------------------ -------------------- --- --------- ---
SYS_AI_8k0xma30nayxn           CUSTOMER             YES VISIBLE   YES
SYS_AI_0jfsy72532qv3           CUSTOMER             YES VISIBLE   YES
SYS_AI_97ya3cug4hxpk           ORDERS               YES VISIBLE   YES
```

New Execution Plan

Plan Analysis

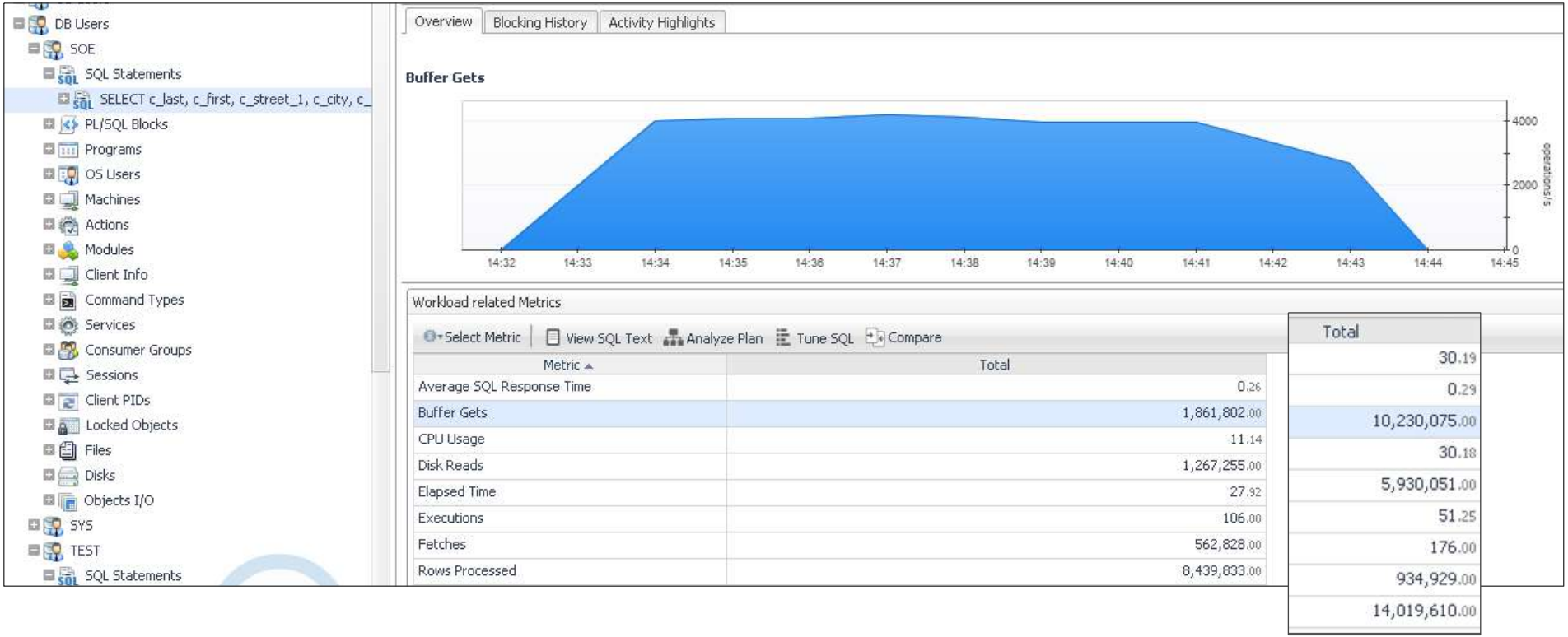
Total cost: 79,718 | **Total I/O cost:** 79,357 | **Total CPU cost:** 10,765,972,870

Plan Details | Operation Analysis | Object Analysis

Operation	Object Name	Object Type	Cost	CPU Cost	I/O Cost	Cardinality	Bytes
NESTED LOOPS			5.81 %	37,065,794	4,630	1,542	84,810
NESTED LOOPS			5.81 %	37,065,794	4,630	1,542	84,810
STATISTICS COLLECTOR			0.00 %	0	0	0	0
HASH JOIN			0.12 %	2,663,115	94	1,512	66,528
NESTED LOOPS			0.12 %	2,663,115	94	1,512	66,528
STATISTICS COLLECTOR			0.00 %	0	0	0	0
TABLE ACCESS BY INDEX ROWID BATCHED	SOE.DISTRICT	TABLE	0.01 %	44,979	6	5	60
INDEX SKIP SCAN	SOE.DISTRICT_I1	INDEX (UNIQUE)	0.00 %	8,121	1	5	0
INDEX RANGE SCAN	SOE.IORDL	INDEX (UNIQUE)	0.11 %	1,715,087	88	302	9,664
INDEX RANGE SCAN	SOE.IORDL	INDEX (UNIQUE)	0.11 %	1,715,087	88	3,023	96,736
INDEX RANGE SCAN	SOE.STOCK_IDX	INDEX	0.00 %	15,293	2	1	0
TABLE ACCESS BY INDEX ROWID	SOE.STOCK	TABLE	0.00 %	22,753	3	1	11
TABLE ACCESS FULL	SOE.STOCK	TABLE	0.00 %	22,753	3	1	11
TABLE ACCESS FULL	SOE.ORDERS	TABLE	10.10 %	2,086,361,577	7,985	15,116	256,972
INDEX RANGE SCAN	SOE.SYS_AI_8k0xma30nayxn	INDEX	0.01 %	298,486	4	1,350	0
TABLE ACCESS BY INDEX ROWID	SOE.CUSTOMER	TABLE	1.66 %	10,219,651	1,327	3	282
TABLE ACCESS BY INDEX ROWID BATCHED	SOE.CUSTOMER	TABLE	1.66 %	10,219,651	1,327	7,500	705,000
INDEX RANGE SCAN	SOE.SYS_AI_0jfsy72532qv3	INDEX	0.01 %	298,486	4	1,350	0

Quest

Performance



Quest

DBA Fine Tunes the Query

- create index orders_i2 on orders(o_id,o_c_id, o_entry_d);

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------------------------------
| Id  | Operation                                | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                         |              |       |       |    64 (100)|          |
|*  1 |  FILTER                                  |              |       |       |            |          |
|*  2 |   HASH JOIN                              |              |     1 |   166 |    64   (0)| 00:00:01 |
|*  3 |    HASH JOIN                             |              |     1 |    72 |    17   (0)| 00:00:01 |
|*  4 |     HASH JOIN                            |              |     1 |    61 |    15   (0)| 00:00:01 |
|*  5 |      HASH JOIN                           |              |   300 | 13200 |    10   (0)| 00:00:01 |
|   6 |       TABLE ACCESS BY INDEX ROWID BATCHED| DISTRICT     |     5 |    60 |     6   (0)| 00:00:01 |
|*  7 |        INDEX SKIP SCAN                   | DISTRICT_I1  |     5 |       |     1   (0)| 00:00:01 |
|*  8 |       INDEX RANGE SCAN                   | IORDL        |    60 |  1920 |     4   (0)| 00:00:01 |
|*  9 |      INDEX RANGE SCAN                    | ORDERS_I2    |   587 |  9979 |     5   (0)| 00:00:01 |
|* 10 |     INDEX FAST FULL SCAN                 | STOCK_IDX1   |     1 |    11 |     2   (0)| 00:00:01 |
|* 11 |    TABLE ACCESS FULL                     | CUSTOMER     |     4 |   376 |    47   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------------------
```

Popular Airline Flights in USA

```
SELECT
o.carrier, uc.description AS carrier_name
,ao.description AS origin_airport,co.Description AS origin_city
,o.fl_date,o.fl_num,o.tail_num
,ad.description AS destination_airport
,cd.Description AS destination_city ,w.Description Day_of_Week
FROM t_ontime o
        INNER JOIN L_UNIQUE_CARRIERS uc ON uc.Code = o.UNIQUE_CARRIER
        INNER JOIN L_AIRPORT_ID ao ON ao.Code = o.ORIGIN_AIRPORT_ID
        INNER JOIN L_AIRPORT_ID ad ON ad.Code = o.DEST_AIRPORT_ID
        INNER JOIN L_CITY_MARKET_ID co ON co.Code = o.ORIGIN_CITY_MARKET_ID
        INNER JOIN L_CITY_MARKET_ID cd ON cd.Code = o.DEST_CITY_MARKET_ID
        INNER JOIN L_WEEKDAYS w ON w.Code = o.DAY_OF_WEEK
WHERE to_date(fl_date,'YYYY-MM-DD') BETWEEN &beg_date AND &end_date
AND co.Description = &city
AND w.Description = &day_of_week;
```

L_UNIQUE_CARRIERS:	1620
L_AIRPORT_ID:	6438
L_CITY_MARKET_ID:	5823
L_WEEKDAYS:	8
T_ONTIME:	6784044

US DOT - On-time Performance

Only Access Path is Full Table Scans

- No Original Indexes

```
Plan hash value: 633429076
-------------------------------------------------------------------------------------------------
| Id  | Operation                | Name                | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT         |                     |       |       | 31176 (100)|          |
|*  1 |  HASH JOIN               |                     |   204 | 45696 | 31176   (1)| 00:00:02 |
|*  2 |   HASH JOIN              |                     |   204 | 36924 | 31163   (1)| 00:00:02 |
|*  3 |    HASH JOIN             |                     |   204 | 28152 | 31150   (1)| 00:00:02 |
|*  4 |     HASH JOIN            |                     |   204 | 23256 | 31141   (1)| 00:00:02 |
|*  5 |      HASH JOIN           |                     |   204 | 18156 | 31136   (1)| 00:00:02 |
|*  6 |       TABLE ACCESS FULL  | L_WEEKDAYS          |     1 |    10 |     3   (0)| 00:00:01 |
|*  7 |       HASH JOIN          |                     |  1426 |  110K| 31133   (1)| 00:00:02 |
|*  8 |        TABLE ACCESS FULL | L_CITY_MARKET_ID    |     1 |    24 |     9   (0)| 00:00:01 |
|*  9 |        TABLE ACCESS FULL | T_ONTIME            |  429K|    22M| 31122   (1)| 00:00:02 |
|  10 |      TABLE ACCESS FULL   | L_UNIQUE_CARRIERS   |  1620 | 40500 |     5   (0)| 00:00:01 |
|  11 |     TABLE ACCESS FULL    | L_CITY_MARKET_ID    |  5823 |  136K|     9   (0)| 00:00:01 |
|  12 |    TABLE ACCESS FULL     | L_AIRPORT_ID        |  6438 |  270K|    13   (0)| 00:00:01 |
|  13 |   TABLE ACCESS FULL      | L_AIRPORT_ID        |  6438 |  270K|    13   (0)| 00:00:01 |
```

Automatic Indexes

TABLE_NAME	INDEX_NAME	COLUMN_NAME	COLUMN_POSITION
L_AIRPORT_ID	SYS_AI_53zguxmr3ss0t	CODE	1
L_CITY_MARKET_ID	SYS_AI_f9bygtwdqxmxm	CODE	1
L_CITY_MARKET_ID	SYS_AI_113vdqswmftr3	DESCRIPTION	1
L_UNIQUE_CARRIERS	SYS_AI_91yyf2dwquw7p	CODE	1
T_ONTIME	SYS_AI_d7c062aqxyz1v	ORIGIN_AIRPORT_ID	1
T_ONTIME	SYS_AI_76tkhqzqyhffq	ORIGIN_CITY_MARKET_ID	1
T_ONTIME	SYS_AI_a0y78qnzu4qrc	DEST_AIRPORT_ID	1
T_ONTIME	SYS_AI_4mdzc0pu2gk6p	DEST_CITY_MARKET_ID	1
T_ONTIME	SYS_AI_2qhg8k60a9gd3	DAY_OF_WEEK	1
T_ONTIME	SYS_AI_1jpp5cssdf0kr	UNIQUE_CARRIER	1

- Visible Indexes

L_CITY_MARKET_ID	SYS_AI_113vdqswmftr3	DESCRIPTION	1
L_AIRPORT_ID	SYS_AI_53zguxmr3ss0t	CODE	1
T_ONTIME	SYS_AI_76tkhqzqyhffq	ORIGIN_CITY_MARKET_ID	1
L_UNIQUE_CARRIERS	SYS_AI_91yyf2dwquw7p	CODE	1
L_CITY_MARKET_ID	SYS_AI_f9bygtwdqxmxm	CODE	1

No Other Option but Full Table Scans

```
Plan hash value: 633429076
-------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name                | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                     |       |       | 31176 (100)|          |
|*  1 |  HASH JOIN                   |                     |   204 | 45696 | 31176   (1)| 00:00:02 |
|*  2 |   HASH JOIN                  |                     |   204 | 36924 | 31163   (1)| 00:00:02 |
|*  3 |    HASH JOIN                 |                     |   204 | 28152 | 31150   (1)| 00:00:02 |
|*  4 |     HASH JOIN                |                     |   204 | 23256 | 31141   (1)| 00:00:02 |
|*  5 |      HASH JOIN               |                     |   204 | 18156 | 31136   (1)| 00:00:02 |
|*  6 |       TABLE ACCESS FULL      | L_WEEKDAYS          |     1 |    10 |     3   (0)| 00:00:01 |
|*  7 |       HASH JOIN              |                     |  1426 |  110K| 31133   (1)| 00:00:02 |
|*  8 |        TABLE ACCESS FULL     | L_CITY_MARKET_ID    |     1 |    24 |     9   (0)| 00:00:01 |
|*  9 |        TABLE ACCESS FULL     | T_ONTIME            |  429K|    22M| 31122   (1)| 00:00:02 |
|  10 |      TABLE ACCESS FULL       | L_UNIQUE_CARRIERS   |  1620 | 40500 |     5   (0)| 00:00:01 |
|  11 |     TABLE ACCESS FULL        | L_CITY_MARKET_ID    |  5823 |  136K|     9   (0)| 00:00:01 |
|  12 |    TABLE ACCESS FULL         | L_AIRPORT_ID        |  6438 |  270K|    13   (0)| 00:00:01 |
|  13 |   TABLE ACCESS FULL          | L_AIRPORT_ID        |  6438 |  270K|    13   (0)| 00:00:01 |
```

Automatic Index Report

select DBMS_AUTO_INDEX.REPORT_LAST_ACTIVITY('TEXT','ALL','ALL') from dual

```
INDEX DETAILS
-------------------------------------------------------------------------------
1. The following indexes were created:
*: invisible
-------------------------------------------------------------------------------
| Owner | Table             | Index                  | Key                   | 
-------------------------------------------------------------------------------
| TEST  | L_AIRPORT_ID      | SYS_AI_53zguxmr3ss0t   | CODE                  | 
| TEST  | L_CITY_MARKET_ID  | SYS_AI_113vdqswmftr3   | DESCRIPTION           | 
| TEST  | L_CITY_MARKET_ID  | SYS_AI_f9bygtwdqxmxm   | CODE                  | 
| TEST  | L_UNIQUE_CARRIERS | SYS_AI_91yyf2dwquw7p   | CODE                  | 
| TEST  | T_ONTIME          | SYS_AI_76tkhqzqyhffq   | ORIGIN_CITY_MARKET_ID | 
-------------------------------------------------------------------------------
VERIFICATION DETAILS
-------------------------------------------------------------------------------
 Parsing Schema Name  : TEST

 SQL ID               : 429sumt3yahs9

 SQL Text             : SELECT O.CARRIER, UC.DESCRIPTION AS CARRIER_NAME
                        ,AO.DESCRIPTION AS ORIGIN_AIRPORT,CO.DESCRIPTION AS
                        ORIGIN_CITY ,O.FL_DATE,O.FL_NUM,O.TAIL_NUM
                        ,AD.DESCRIPTION AS DESTINATION_AIRPORT ,CD.DESCRIPTION AS
                        DESTINATION_CITY ,W.DESCRIPTION DAY_OF_WEEK FROM T_ONTIME
                        O INNER JOIN L_UNIQUE_CARRIERS UC ON UC....

 Improvement Factor   : 1.2x

Execution Statistics:
-----------------------------
                    Original Plan                Auto Index Plan
                    -----------------------------  -----------------------------
 Elapsed Time (s):  195334030                    885494
 CPU Time (s):      186004680                    839174
 Buffer Gets:       12456957                     36005
 Optimizer Cost:    4506                         4506
 Disk Reads:        64548                        0
 Direct Writes:     0                            0
 Rows Processed:    927986                       2317
 Executions:        284                          1
```

New Plan

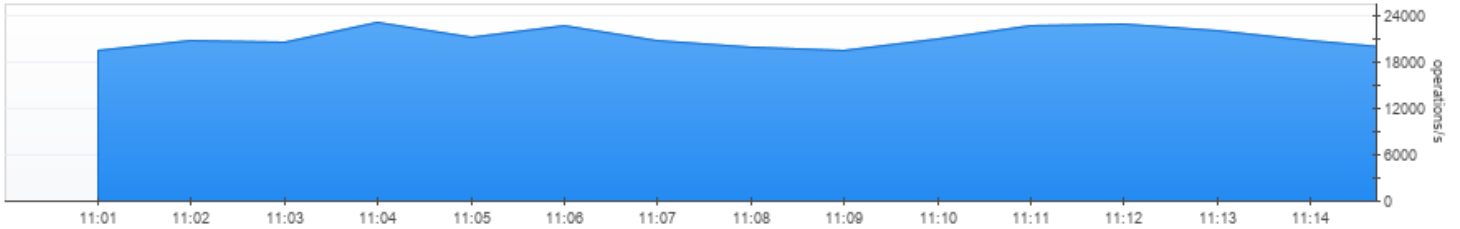
```
Plan hash value: 4160115658

-----------------------------------------------------------------------------------------------------------------------------
| Id  | Operation | Name                    | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |                         |       |       |  4506 (100)|          |
|*  1 |  HASH JOIN|                         |     8 |  1792 |  4506   (1)| 00:00:01 |
|*  2 |   HASH JOIN                         |                         |     8 |  1448 |  4493   (1)| 00:00:01 |
|*  3 |    HASH JOIN                        |                         |     8 |  1104 |  4480   (1)| 00:00:01 |
|*  4 |     HASH JOIN                       |                         |     8 |   912 |  4471   (1)| 00:00:01 |
|*  5 |      HASH JOIN                      |                         |     8 |   712 |  4466   (1)| 00:00:01 |
|   6 |       NESTED LOOPS                  |                         |    56 |  4424 |  4463   (1)| 00:00:01 |
|   7 |        NESTED LOOPS                 |                         | 22538 |  4424 |  4463   (1)| 00:00:01 |
|   8 |         TABLE ACCESS BY INDEX ROWID BATCHED| L_CITY_MARKET_ID        |     1 |    24 |     2   (0)| 00:00:01 |
|*  9 |          INDEX RANGE SCAN           | SYS_AI_113vdqswmftr3    |     1 |       |     1   (0)| 00:00:01 |
|* 10 |         INDEX RANGE SCAN            | SYS_AI_76tkhqzqyhffq    | 22538 |       |    35   (0)| 00:00:01 |
|* 11 |        TABLE ACCESS BY INDEX ROWID  | T_ONTIME                |    56 |  3080 |  4461   (1)| 00:00:01 |
|* 12 |       TABLE ACCESS FULL             | L_WEEKDAYS              |     1 |    10 |     3   (0)| 00:00:01 |
|  13 |      TABLE ACCESS FULL              | L_UNIQUE_CARRIERS       |  1620 | 40500 |     5   (0)| 00:00:01 |
|  14 |     TABLE ACCESS FULL               | L_CITY_MARKET_ID        |  5823 |  136K|     9   (0)| 00:00:01 |
|  15 |    TABLE ACCESS FULL                | L_AIRPORT_ID            |  6438 |  270K|    13   (0)| 00:00:01 |
|  16 |   TABLE ACCESS FULL                 | L_AIRPORT_ID            |  6438 |  270K|    13   (0)| 00:00:01 |
```

Original Performance

Overview | Blocking History | Activity Highlights

Buffer Gets

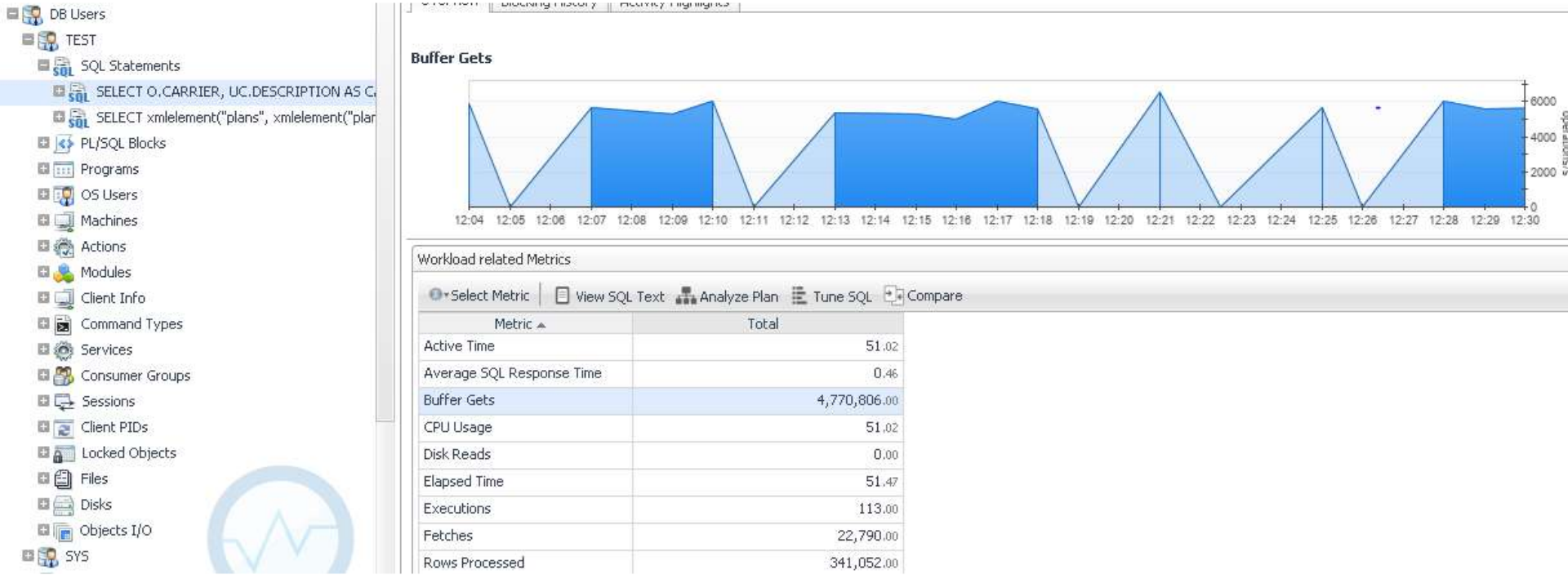


Workload related Metrics

Select Metric | View SQL Text | Analyze Plan | Tune SQL | Compare

Metric	Total
Active Time	1,274.08
Average SQL Response Time	10.69
Buffer Gets	19,096,132.00
CPU Usage	1,251.74
Disk Reads	13,800,356.00
Elapsed Time	1,347.11
Executions	126.00
Fetches	26,899.00
Rows Processed	402,643.00

Auto Index Performance



Metric	Total
Active Time	51.02
Average SQL Response Time	0.46
Buffer Gets	4,770,806.00
CPU Usage	51.02
Disk Reads	0.00
Elapsed Time	51.47
Executions	113.00
Fetches	22,790.00
Rows Processed	341,052.00

Summary

- Automatic Indexing can speed up performance
  - 19c Optimizer has come along way
- Beware of just turning it on blindly
  - Especially in production
  - Watch out for baselines
  - Invisible versus Visible
- Consider using in development / test
  - Be cautious using in production
- Control at schema level
- Turn on compression for space savings

SAVE THE DATE

- ASCEND CONFERENCE 2022

  June 12-15, 2022
  the Aria in Las Vegas, NV
  https://ascendusersconference.com

- MOUS 2022

  October 26, 2022
  Schoolcraft College - VisTaTech Center,
  18600 Haggerty Rd, Livonia, MI
  https://www.mous.us

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