

Indexing New Features: Oracle 11g Release 1 and Release 2

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So What Am I Going To Talk About ...

- Index Creation and Rebuild Locking Improvements
- Index Statistics and the Oracle 11g CBO
- Invisible Indexes
- Segment On Demand Indexes
- Zero Storage Unusable Indexes
- New Index Related Hints
- Analyze Validate Structure Improvements
- Bitmap-Join Indexes On IOT
- Virtual Columns Without Function-Based Indexes

Index Rebuild (and Creation) Locks

- Oracle's had the INDEX REBUILD ONLINE option for a long while
- However, only available with Enterprise Edition
- Prevents Parallel Execution
- Still requires two table locks on the base table at the start and at the end of the indexing process
- These table locks can still causes locking issues (before 11g)

Index Rebuild Locks (Pre 11g)

Session 1

```
SQL> CREATE TABLE bowie_stuff AS SELECT rownum id, 'David Bowie' name  
FROM dual CONNECT BY LEVEL <= 10000;
```

Table created.

```
SQL> CREATE INDEX bowie_stuff_i ON bowie_stuff(id);
```

Index created.

Session 2

```
SQL> INSERT INTO bowie_stuff VALUES (10001, 'Pink Floyd');
```

1 row created. (No commit or rollback)

Session 1

```
SQL> ALTER INDEX bowie_stuff_i REBUILD ONLINE;
```

Session hangs !! (Due to transaction in Session 2)

Index Rebuild Locks (Pre 11g)

Session 3

```
SQL> INSERT INTO bowie_stuff VALUES (10002, 'Radiohead');
```

Session hangs !! (Due to lock required by index rebuild in Session 1)

Session 2

```
SQL> COMMIT;
```

Commit complete.

Releases lock in session 3 and index rebuild is free to proceed but it will eventually get stuck again by uncommitted session 3 as it requires another lock to complete the rebuild process...

In session 2, perform another insert before session 3 commits ...

```
SQL> INSERT INTO bowie_stuff VALUES (10003, 'Iggy Pop');
```

Session hangs !! (Due to the second lock required by index rebuild in Session 1)

Index Rebuild Locks (Pre 11g)

Session 3

```
SQL> COMMIT;  
Commit complete.
```

Session 1

```
Index altered.
```

Session 2

```
1 row created.
```

Index Rebuild Locks (11g)

Session 1

```
SQL> CREATE TABLE bowie_stuff AS SELECT rownum id, 'David Bowie' name  
FROM dual CONNECT BY LEVEL <= 10000;
```

Table created.

```
SQL> CREATE INDEX bowie_stuff_i ON bowie_stuff(id);
```

Index created.

Session 2

```
SQL> INSERT INTO bowie_stuff VALUES (10001, 'Pink Floyd');
```

1 row created. (No commit or rollback)

Session 1

```
SQL> ALTER INDEX bowie_stuff_i REBUILD ONLINE;
```

Session hangs !! (Due to transaction in Session 2)

Note: No difference at this point ...

Index Rebuild Locks (11g)

Session 3

```
SQL> INSERT INTO bowie_stuff VALUES (10002, 'Radiohead');
```

1 row created.

Big Difference !! The index table lock no longer locks out other transactions

Session 2

```
SQL> COMMIT;
```

Commit complete.

Releases lock in session 1 and index rebuild is free to proceed but will eventually get stuck by uncommitted session 3 as it requires another lock to complete the rebuild ...

In session 2, perform another insert before session 3 commits ...

```
SQL> INSERT INTO bowie_stuff VALUES (10003, 'Iggy Pop');
```

1 row created.

Again, not a problem as the second index rebuild lock impacts no other transactions

Index Rebuild (and Creation) Locks

- With 11g, far safer to create or rebuild an index during busy Production periods
- The index DDL might be locked out for periods of time and take a while to complete ...
- BUT it won't lock out other transactions
- Of course, most index rebuilds are a waste of time but that's another story

Index Statistics and the 11g CBO

Pre 11g example (Note: There are only **10** distinct combinations of data or **10%** selectivity)

```
SQL> create table radiohead (id number, code varchar2(5), name varchar2(20));
```

Table created.

```
SQL> begin
```

```
 2 for i in 1..10000 loop
```

```
 3 insert into radiohead values(1, 'AAA', 'Description A');
```

```
 4 insert into radiohead values(2, 'BBB', 'Description B');
```

```
 5 insert into radiohead values(3, 'CCC', 'Description C');
```

```
 6 insert into radiohead values(4, 'DDD', 'Description D');
```

```
 7 insert into radiohead values(5, 'EEE', 'Description E');
```

```
 8 insert into radiohead values(6, 'FFF', 'Description F');
```

```
 9 insert into radiohead values(7, 'GGG', 'Description G');
```

```
10 insert into radiohead values(8, 'HHH', 'Description H');
```

```
11 insert into radiohead values(9, 'III', 'Description I');
```

```
12 insert into radiohead values(10, 'JJJ', 'Description J');
```

```
13 end loop;
```

```
14 commit;
```

```
15 end;
```

```
16 /
```

PL/SQL procedure successfully completed.

```
SQL> create index radiohead_idx on radiohead(id, code);
```

Index created.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'RADIOHEAD', estimate_percent=>null, cascade=>true, method_opt=>'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Index Statistics and the 11g CBO

```
SQL> select * from radiohead where id = 2 and code = 'BBB';
```

10000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1000	21000	42 (10)	00:00:01
* 1	TABLE ACCESS FULL	RADIOHEAD	1000	21000	42 (10)	00:00:01

Statistics

```
-----
      1  recursive calls
      0  db block gets
     365  consistent gets
      0  physical reads
      0  redo size
   50684  bytes sent via SQL*Net to client
     407  bytes received via SQL*Net from client
        3  SQL*Net roundtrips to/from client
      0  sorts (memory)
      0  sorts (disk)
   10000  rows processed
```

Note: Oracle assumes the selectivity will be $10 \times 10 = 100$ distinct values (1%), not 10% because there are 10 distinct values of both the ID and CODE columns...

Index Statistics and the 11g CBO

11g Rel 1 example (Note: There are only **10** distinct combinations of data or **10%** selectivity)

```
SQL> create table radiohead (id number, code varchar2(5), name varchar2(20));
```

Table created.

```
SQL> begin
```

```
 2 for i in 1..10000 loop
```

```
 3 insert into radiohead values(1, 'AAA', 'Description A');
```

```
 4 insert into radiohead values(2, 'BBB', 'Description B');
```

```
 5 insert into radiohead values(3, 'CCC', 'Description C');
```

```
 6 insert into radiohead values(4, 'DDD', 'Description D');
```

```
 7 insert into radiohead values(5, 'EEE', 'Description E');
```

```
 8 insert into radiohead values(6, 'FFF', 'Description F');
```

```
 9 insert into radiohead values(7, 'GGG', 'Description G');
```

```
10 insert into radiohead values(8, 'HHH', 'Description H');
```

```
11 insert into radiohead values(9, 'III', 'Description I');
```

```
12 insert into radiohead values(10, 'JJJ', 'Description J');
```

```
13 end loop;
```

```
14 commit;
```

```
15 end;
```

```
16 /
```

PL/SQL procedure successfully completed.

```
SQL> create index radiohead_idx on radiohead(id, code);
```

Index created.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'RADIOHEAD', estimate_percent=>null, cascade=>true, method_opt=>'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Index Statistics and the 11g CBO

```
SQL> select * from radiohead where id = 2 and code = 'BBB';
```

```
10000 rows selected.
```

```
Execution Plan
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10000	205K	100 (1)	00:00:02
* 1	TABLE ACCESS FULL	RADIOHEAD	10000	205K	100 (1)	00:00:02

```
Statistics
```

```
-----
181 recursive calls
0 db block gets
391 consistent gets
0 physical reads
0 redo size
50684 bytes sent via SQL*Net to client
407 bytes received via SQL*Net from client
3 SQL*Net roundtrips to/from client
6 sorts (memory)
0 sorts (disk)
10000 rows processed
```

Note: In 11g, Oracle gets the cardinality estimate exactly correct !!

Index Statistics and the 11g CBO

```
SQL> select index_name, distinct_keys from dba_indexes  
       where index_name = 'RADIOHEAD_IDX';
```

INDEX_NAME	DISTINCT_KEYS
RADIOHEAD_IDX	10

Note: In 11g, Oracle can use the index `DISTINCT_KEYS` statistic to determine the selectivity of a predicate

There are only 10 distinct index key values, therefore one combination of values will return 10% of the data ...

Index Statistics and the 11g CBO

```
SQL> DROP INDEX radiohead_idx;
```

Index dropped.

```
SQL> select * from radiohead where id = 2 and code = 'BBB';
```

10000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1000	21000	100 (1)	00:00:02
* 1	TABLE ACCESS FULL	RADIOHEAD	1000	21000	100 (1)	00:00:02

Statistics

```
-----
      1 recursive calls
      0 db block gets
     365 consistent gets
      0 physical reads
      0 redo size
  50684 bytes sent via SQL*Net to client
     407 bytes received via SQL*Net from client
      3 SQL*Net roundtrips to/from client
      0 sorts (memory)
      0 sorts (disk)
  10000 rows processed
```

After dropping the index, the CBO now gets cardinality estimates incorrect ...

Index Statistics and the 11g CBO

Let's create another table ...

```
SQL> create table ok_computer (id number, code varchar2(5), description varchar2(20));  
Table created.
```

```
SQL> begin
```

```
 2 insert into ok_computer values(1, 'AAA', 'Description A');  
 3 insert into ok_computer values(2, 'BBB', 'Description B');  
 4 insert into ok_computer values(3, 'CCC', 'Description C');  
 5 insert into ok_computer values(4, 'DDD', 'Description D');  
 6 insert into ok_computer values(5, 'EEE', 'Description E');  
 7 insert into ok_computer values(6, 'FFF', 'Description F');  
 8 insert into ok_computer values(7, 'GGG', 'Description G');  
 9 insert into ok_computer values(8, 'HHH', 'Description H');  
10 insert into ok_computer values(9, 'III', 'Description I');  
11 insert into ok_computer values(10, 'JJJ', 'Description J');  
12 commit;  
13 end;  
14 /
```

```
PL/SQL procedure successfully completed.
```

```
SQL> alter table ok_computer add primary key(id, code);
```

```
Table altered.
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'OK_COMPUTER', estimate_percent=>null,  
cascade=>true, method_opt=>'FOR ALL COLUMNS SIZE 1');
```

```
PL/SQL procedure successfully completed.
```

Index Statistics and the 11g CBO

```
SQL> CREATE INDEX radiohead_idx on radiohead(id, code);
Index created.
```

```
SQL> select * from radiohead r, ok_computer o where r.id = 5 and r.code = 'EEE';
100000 rows selected.
```

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		100K	4101K	989 (2)	00:00:12
1	MERGE JOIN CARTESIAN		100K	4101K	989 (2)	00:00:12
2	TABLE ACCESS FULL	OK_COMPUTER	10	210	2 (0)	00:00:01
3	BUFFER SORT		10000	205K	987 (2)	00:00:12
* 4	TABLE ACCESS FULL	RADIOHEAD	10000	205K	99 (2)	00:00:02

Statistics

```
1 recursive calls
0 db block gets
376 consistent gets
0 physical reads
0 redo size
1203277 bytes sent via SQL*Net to client
605 bytes received via SQL*Net from client
21 SQL*Net roundtrips to/from client
1 sorts (memory)
0 sorts (disk)
100000 rows processed
```

Note: although index not used in execution plan, it has used the index statistics to get the cardinality correct and uses a plan with 376 consistent gets.

Index Statistics and the 11g CBO

```
SQL> DROP INDEX radiohead_idx;
```

Index dropped.

```
SQL> select * from radiohead r, ok_computer o where r.id = 5 and r.code = 'EEE';
```

100000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10000	410K	373 (1)	00:00:05
1	MERGE JOIN CARTESIAN		10000	410K	373 (1)	00:00:05
* 2	TABLE ACCESS FULL	RADIOHEAD	1000	21000	100 (1)	00:00:02
3	BUFFER SORT		10	210	272 (0)	00:00:04
4	TABLE ACCESS FULL	OK_COMPUTER	10	210	0 (0)	00:00:01

Statistics

```
165 recursive calls
0 db block gets
404 consistent gets
0 physical reads
0 redo size
2603137 bytes sent via SQL*Net to client
605 bytes received via SQL*Net from client
21 SQL*Net roundtrips to/from client
6 sorts (memory)
0 sorts (disk)
100000 rows processed
```

Note: Drop the index, Oracle now gets the cardinality wrong as it can't use the index statistics and chooses a more expensive execution plan ...

Index Statistics and the 11g CBO

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'RADIOHEAD', estimate_percent=>null, cascade=>true, method_opt=>'FOR COLUMNS (id, code) SIZE 1');
```

PL/SQL procedure successfully completed.

```
SQL> select * from radiohead r, ok_computer o where r.id = 5 and r.code = 'EEE';
```

100000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		100K	4101K	989 (2)	00:00:12
1	MERGE JOIN CARTESIAN		100K	4101K	989 (2)	00:00:12
2	TABLE ACCESS FULL	OK_COMPUTER	10	210	2 (0)	00:00:01
3	BUFFER SORT		10000	205K	987 (2)	00:00:12
* 4	TABLE ACCESS FULL	RADIOHEAD	10000	205K	99 (2)	00:00:02

Statistics

```
      8 recursive calls
      0 db block gets
    378 consistent gets
      0 physical reads
      0 redo size
1203277 bytes sent via SQL*Net to client
   605 bytes received via SQL*Net from client
    21 SQL*Net roundtrips to/from client
      1 sorts (memory)
      0 sorts (disk)
100000 rows processed
```

Note: 11g extended statistics can also be used to collect accurate statistics across column combinations and restore the efficient execution plan ...

Index Monitoring Trap

This new capability of using the DISTINCT_KEYS index statistic introduces a new trap when monitoring indexes.

```
SQL> alter index radiohead_idx monitoring usage;
```

Index altered.

```
SQL> select * from v$object_usage where index_name = 'RADIOHEAD_IDX';
```

INDEX_NAME	TABLE_NAME	MON	USE	START_MONITORING	END_MONITORING
RADIOHEAD_IDX	RADIOHEAD	YES	NO	09/16/2008 11:08:05	

Let's see what happens when we begin to monitor the index ...

Index Monitoring – Index Cardinality Trap

```
SQL> select * from radiohead where id = 2 and code = 'BBB';
```

10000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10000	205K	100 (1)	00:00:02
* 1	TABLE ACCESS FULL	RADIOHEAD	10000	205K	100 (1)	00:00:02

Statistics

```
-----
      181 recursive calls
         0 db block gets
      391 consistent gets
         0 physical reads
         0 redo size
  50684 bytes sent via SQL*Net to client
   407 bytes received via SQL*Net from client
         3 SQL*Net roundtrips to/from client
         6 sorts (memory)
         0 sorts (disk)
  10000 rows processed
```

Note: In 11g, Oracle gets the cardinality estimate exactly correct !!

Index Monitoring – Index Cardinality Trap

```
SQL> select * from v$object_usage where index_name = 'RADIOHEAD_IDX';
```

INDEX_NAME	TABLE_NAME	MON	USE	START_MONITORING	END_MONITORING
RADIOHEAD_IDX	RADIOHEAD	YES	NO	09/16/2008 11:08:05	

Index Monitoring (in 11g Rel 1 and 2) does not pick up the index was “used” ...

As the index was not used within the execution plan, index monitoring doesn't consider the index as being “used”.

Index Monitoring – Index Cardinality Trap

```
SQL> DROP INDEX radiohead_idx;
```

Index dropped.

```
SQL> select * from radiohead where id = 2 and code = 'BBB';
```

10000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1000	21000	100 (1)	00:00:02
* 1	TABLE ACCESS FULL	RADIOHEAD	1000	21000	100 (1)	00:00:02

Statistics

```
-----  
1 recursive calls  
0 db block gets  
365 consistent gets  
0 physical reads  
0 redo size  
50684 bytes sent via SQL*Net to client  
407 bytes received via SQL*Net from client  
3 SQL*Net roundtrips to/from client  
0 sorts (memory)  
0 sorts (disk)  
10000 rows processed
```

After dropping the index, the CBO now gets the cardinality estimates and potentially the whole plan incorrect ...

Invisible Indexes

Invisible Indexes

```
SQL> SELECT * FROM invisible_bowie  
      WHERE date_field BETWEEN '25-DEC-2006' AND '26-DEC-2006';
```

100 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost(%CPU)	Time
0	SELECT STATEMENT		300	3600	304 (0)	00:00:04
1	TABLE ACCESS BY INDEX ROWID	INVISIBLE_BOWIE	300	3600	304 (0)	00:00:04
* 2	INDEX RANGE SCAN	INVISIBLE_BOWIE_I	300		3 (0)	00:00:01

Note: By default, indexes are “visible” to the CBO and can potentially be used

Invisible Indexes

If an index:

- becomes problematic, or
- you think index is not being used and might be safe to drop

you can make it “**invisible**” ...

```
SQL> ALTER INDEX invisible_bowie_i INVISIBLE;
```

Index altered.

```
SQL> SELECT index_name, visibility FROM user_indexes  
       WHERE index_name = 'INVISIBLE_BOWIE_I';
```

INDEX_NAME	VISIBILITY
-----	-----
INVISIBLE_BOWIE_I	INVISIBLE

Invisible Indexes

```
SQL> SELECT * FROM invisible_bowie  
      WHERE date_field BETWEEN '25-DEC-2006' AND '26-DEC-2006';
```

100 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		300	3600	699 (2)	00:00:09
* 1	TABLE ACCESS FULL	INVISIBLE_BOWIE	300	3600	699 (2)	00:00:09

Note: The index is now invisible and is not considered by the CBO ...

Invisible Indexes

```
SQL> ALTER SESSION SET OPTIMIZER_USE_INVISIBLE_INDEXES = true;
```

Session altered.

```
SQL> SELECT * FROM invisible_bowie WHERE date_field > sysdate - 1;
```

100 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost(%CPU)	Time
0	SELECT STATEMENT		100	1200	103 (0)	00:00:02
1	TABLE ACCESS BY INDEX ROWID	INVISIBLE_BOWIE	100	1200	103 (0)	00:00:02
* 2	INDEX RANGE SCAN	INVISIBLE_BOWIE_I	100		3 (0)	00:00:01

Note: You can alter a session to make invisible indexes visible to the session ...

Invisible Indexes

```
SQL> ALTER INDEX invisible_bowie_i VISIBLE;
```

Index altered.

```
SQL> ALTER SESSION SET OPTIMIZER_USE_INVISIBLE_INDEXES = false;
```

Session altered.

```
SQL> SELECT * FROM invisible_bowie WHERE date_field > sysdate - 1;
```

100 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		100	1200	103 (0)	00:00:02
1	TABLE ACCESS BY INDEX ROWID	INVISIBLE_BOWIE	100	1200	103 (0)	00:00:02
* 2	INDEX RANGE SCAN	INVISIBLE_BOWIE_I	100		3 (0)	00:00:01

Note: An index can instantly be converted visible again as the index is always being maintained by Oracle, even when invisible ...

Invisible Indexes – Foreign Key Indexes

First, create a “Parent” table with 3 parent values ...

```
SQL> create table daddy (id number constraint daddy_pk primary key, name varchar2(20));
```

Table created.

```
SQL> insert into daddy values (1, 'BOWIE');
```

1 row created.

```
SQL> insert into daddy values (2, 'ZIGGY');
```

1 row created.

```
SQL> insert into daddy values (3, 'THIN WHITE DUKE');
```

1 row created.

```
SQL> commit;
```

Commit complete.

Invisible Indexes – Foreign Key Indexes

Next create a “Child” table that references the table with an **indexed** FK constraint

```
SQL> create table kiddie (id number, name varchar2(20), fk number,  
constraint kiddie_fk foreign key(fk) references daddy(id));
```

Table created.

```
SQL> insert into kiddie select rownum, 'MAJOR TOM', 1 from dual connect by level <= 1000000;
```

1000000 rows created.

```
SQL> commit;
```

Commit complete.

```
SQL> create index kiddie_fk_i on kiddie(fk);
```

Index created.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'DADDY', estimate_percent=>null, cascade=>true,  
method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'KIDDIE', estimate_percent=>null, cascade=>true,  
method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Invisible Indexes – Foreign Key Indexes

```
SQL> delete daddy where id = 2;
```

```
1 row deleted.
```

```
Execution Plan
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	DELETE STATEMENT		1	3	0 (0)	00:00:01
1	DELETE	DADDY				
* 2	INDEX UNIQUE SCAN	SYS_C009714	1	3	0 (0)	00:00:01

```
Statistics
```

```
1 recursive calls
8 db block gets
1 consistent gets
1 physical reads
0 redo size
674 bytes sent via SQL*Net to client
554 bytes received via SQL*Net from client
3 SQL*Net roundtrips to/from client
1 sorts (memory)
0 sorts (disk)
1 rows processed
```

At **8 db block gets**, Oracle has used index on FK to determine whether any child rows exist ...

Invisible Indexes – Foreign Key Indexes

In Oracle 11g Release 1

```
SQL> rollback;
```

```
Rollback complete.
```

```
SQL> alter index kiddie_fk_i invisible;
```

```
Index altered.
```

If now make the index Invisible, does this change the manner in which the delete operation is performed ?

Invisible Indexes – Foreign Key Indexes

```
SQL> delete daddy where id = 2;
```

```
1 row deleted.
```

```
Execution Plan
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	DELETE STATEMENT		1	3	0 (0)	00:00:01
1	DELETE	DADDY				
* 2	INDEX UNIQUE SCAN	SYS_C009714	1	3	0 (0)	00:00:01

```
Statistics
```

```
1 recursive calls
8 db block gets
1 consistent gets
1 physical reads
0 redo size
674 bytes sent via SQL*Net to client
554 bytes received via SQL*Net from client
3 SQL*Net roundtrips to/from client
1 sorts (memory)
0 sorts (disk)
1 rows processed
```

No !! The index, although invisible is still being used ...

Invisible Indexes– Foreign Key Indexes

```
SQL> drop index kiddie_fk_i;
```

```
Index dropped.
```

```
SQL> delete daddy where id = 3;
```

```
1 row deleted.
```

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	DELETE STATEMENT		1	3	0 (0)	00:00:01
1	DELETE	DADDY				
* 2	INDEX UNIQUE SCAN	SYS_C009714	1	3	0 (0)	00:00:01

Statistics

```
7 recursive calls
7 db block gets
3172 consistent gets
0 physical reads
632 redo size
674 bytes sent via SQL*Net to client
554 bytes received via SQL*Net from client
3 SQL*Net roundtrips to/from client
1 sorts (memory)
0 sorts (disk)
1 rows processed
```

Note: dropped index can't be used to lookup child table and FTS on "KIDDIE" table is performed

Index Monitoring – Foreign Key Trap

```
SQL> select * from v$object_usage where index_name = 'KIDDIE_FK_I';
```

INDEX_NAME	TABLE_NAME	MON	USE	START_MONITORING	END_MONITORING
KIDDIE_FK_I	KIDDIE	YES	NO	09/10/2008 12:10:52	

```
SQL> drop index kiddie_fk_i;
```

Index dropped.

Note: Index Monitoring (in 11g Rel 1 and 2) also does not pick up the fact the index on the FK column of the KIDDIE table was actually used to ensure no record has the deleted value (2) ...

Deleting such a so-called “unused” index can be disastrous !!

Invisible Indexes: Index Statistics

Remember how Oracle11g can use index DISTINCT_KEY statistic

```
SQL> select * from radiohead where id = 2 and code = 'BBB';
```

10000 rows selected.

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10000	205K	100 (1)	00:00:02
* 1	TABLE ACCESS FULL	RADIOHEAD	10000	205K	100 (1)	00:00:02

Statistics

```
-----
181  recursive calls
0    db block gets
391  consistent gets
0    physical reads
0    redo size
50684 bytes sent via SQL*Net to client
407  bytes received via SQL*Net from client
3    SQL*Net roundtrips to/from client
6    sorts (memory)
0    sorts (disk)
10000 rows processed
```

Invisible Indexes: Index Statistics

```
SQL> alter index radiohead_idx invisible;  
Index altered.
```

```
SQL> select * from radiohead where id = 2 and code = 'BBB';  
10000 rows selected.
```

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10000	205K	100 (1)	00:00:02
* 1	TABLE ACCESS FULL	RADIOHEAD	10000	205K	100 (1)	00:00:02

Statistics

```
-----  
181 recursive calls  
0 db block gets  
391 consistent gets  
0 physical reads  
0 redo size  
50684 bytes sent via SQL*Net to client  
407 bytes received via SQL*Net from client  
3 SQL*Net roundtrips to/from client  
6 sorts (memory)  
0 sorts (disk)  
10000 rows processed
```

In 11g Rel 1, Oracle stills sees index statistics of invisible indexes ...

“Visible” Invisible Indexes

- In Oracle11g Release 1, Invisible Indexes are still visible:
 - When used to check and police FK consistency
 - When use by the CBO to lookup index statistics
- Both these issues have been fixed in Oracle11g Release 2

Invisible Indexes: PK and UK Constraints

Unique Indexes and indexes used to police Primary Key and Unique Key constraints can also be made “Invisible”.

```
SQL> create table bowie (id number constraint bowie_pk primary key using index(create unique index bowie_pk_i on bowie(id)), name varchar2(20));
```

Table created.

```
SQL> insert into bowie select rownum, 'DAVID BOWIE' from dual connect by level <= 10000;
```

10000 rows created.

```
SQL> commit;
```

Commit complete.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tablename=>'BOWIE', estimate_percent=>null, cascade=>true, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Invisible Indexes: PK and UK Constraints

```
SQL> select * from bowie where id = 42;
```

```
   ID NAME  
-----  
  42 DAVID BOWIE
```

```
-----  
| Id | Operation                               | Name          | Rows | Bytes | Cost (%CPU)|Time     |  
-----  
|  0 | SELECT STATEMENT                       |               |    1 |    15 |    2   (0)|00:00:01 |  
|  1 | TABLE ACCESS BY INDEX ROWID          | BOWIE         |    1 |    15 |    2   (0)|00:00:01 |  
|*  2 | INDEX UNIQUE SCAN                     | BOWIE_PK_I   |    1 |          |    1   (0)|00:00:01 |  
-----
```

Statistics

```
-----  
  0 recursive calls  
  0 db block gets  
  3 consistent gets  
  0 physical reads  
  0 redo size  
471 bytes sent via SQL*Net to client  
396 bytes received via SQL*Net from client  
  2 SQL*Net roundtrips to/from client  
  0 sorts (memory)  
  0 sorts (disk)  
  1 rows processed
```

Invisible Indexes: PK and UK Constraints

```
SQL> alter index bowie_pk_i invisible;
```

Index altered.

```
SQL> select * from bowie where id = 42;
```

```
      ID NAME  
-----
```

```
      42 DAVID BOWIE  
-----
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	15	8 (0)	00:00:01
* 1	TABLE ACCESS FULL	BOWIE	1	15	8 (0)	00:00:01

```
Statistics  
-----
```

```
0 recursive calls  
0 db block gets  
33 consistent gets  
0 physical reads  
0 redo size  
471 bytes sent via SQL*Net to client  
396 bytes received via SQL*Net from client  
2 SQL*Net roundtrips to/from client  
0 sorts (memory)  
0 sorts (disk)  
1 rows processed
```

Invisible Indexes: PK and UK Constraints

However, if you attempt to insert a duplicate row that violates the constraint ...

```
SQL> insert into bowie values (1, 'ZIGGY');
insert into bowie values (1, 'ZIGGY')
*
ERROR at line 1:
ORA-00001: unique constraint (BOWIE.BOWIE_PK) violated
```

In both Oracle11g Release 1 & 2, the index is still “visible” in that it’s used to police the constraint.

Invisible Indexes: PK and UK Constraints

Same scenario if you use a Non-Unique Index to police a PK or UK constraint

```
SQL> create table bowie (id number constraint bowie_pk primary key using index(create index bowie_pk_i
on bowie(id)), name varchar2(20));
```

Table created.

```
SQL> insert into bowie select rownum, 'DAVID BOWIE' from dual connect by level <= 10000;
10000 rows created.
```

```
SQL> commit;
Commit complete.
```

```
SQL> alter index bowie_pk_i invisible;
Index altered.
```

```
SQL> insert into bowie values (1, 'ZIGGY');
insert into bowie values (1, 'ZIGGY')
*
```

```
ERROR at line 1:
ORA-00001: unique constraint (BOWIE.BOWIE_PK) violated
```

Invisible Indexes: Unique Indexes

Same scenario if you just create a Unique Index ...

```
SQL> create table bowie as select rownum id, 'DAVID_BOWIE' name from dual connect by level <=10000;
```

Table created.

```
SQL> create unique index bowie_id_i on bowie(id);
```

Index created.

```
SQL> alter index bowie_id_i invisible;
```

Index altered.

```
SQL> insert into bowie values (1, 'ZIGGY');
```

```
insert into bowie values (1, 'ZIGGY')
```

```
*
```

```
ERROR at line 1:
```

```
ORA-00001: unique constraint (BOWIE.BOWIE_ID_I) violated
```

Invisible Indexes: 11g Rel. 1 Bug

Nasty bug with Oracle11g Release 1 when it comes to collecting statistics on an Invisible index:

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'BOWIE', estimate_percent=>null,
cascade=>true, method_opt=> 'FOR ALL COLUMNS SIZE 1');
BEGIN dbms_stats.gather_table_stats(ownname=>null, tabname=>'BOWIE', estimate_percent=>null,
cascade=>true, method_opt=> 'FOR ALL COLUMNS SIZE 1'); END;
```

*

ERROR at line 1:

ORA-00904: : invalid identifier

ORA-06512: at "SYS.DBMS_STATS", line 17806

ORA-06512: at "SYS.DBMS_STATS", line 17827

ORA-06512: at line 1

Fixed In Oracle11g Release 2

Bitmap-Join Indexes

- Useful index structure for Data Warehouses
- Can create a bitmap index on a table based on the column of another table
- Can potentially make joins unnecessary and associated SQL queries more efficient
- But has a big restriction prior to Oracle11g ...

Bitmap-Join Indexes

```
SQL> CREATE TABLE big_dwh_table (id NUMBER PRIMARY KEY, album_id NUMBER, artist_id NUMBER, country_id NUMBER, format_id NUMBER, release_date DATE, total_sales NUMBER);
```

Table created.

```
SQL> CREATE SEQUENCE dwh_seq;
```

Sequence created.

```
SQL> create or replace procedure pop_big_dwh_table as
```

```
 2 v_id      number;
 3 v_artist_id number;
 4 begin
 5   for v_album_id in 1..10000 loop
 6     v_artist_id:= ceil(dbms_random.value(0,100));
 7     for v_country_id in 1..100 loop
 8       select dwh_seq.nextval into v_id from dual;
 9       insert into big_dwh_table values (v_id, v_album_id, v_artist_id, v_country_id, ceil(dbms_random.value(0,4)), trunc(sysdate-
mod(v_id,ceil(dbms_random.value(0,1000))))), ceil(dbms_random.value(0,500000)));
10     end loop;
11   end loop;
12 commit;
13 end;
14 /
```

Procedure created.

```
SQL> exec pop_big_dwh_table
```

PL/SQL procedure successfully completed.

```
SQL> create bitmap index big_dwh_table_album_id_i on big_dwh_table(album_id);
```

Index created.

```
SQL> exec dbms_stats.gather_table_stats(ownname=> 'BOWIE', tabname=> 'BIG_DWH_TABLE', estimate_percent=> null, cascade=> true, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Bitmap-Join Indexes

```
SQL> CREATE TABLE albums (album_id number, album_details varchar2(30));
```

Table created.

```
SQL> INSERT INTO albums SELECT rownum, substr(object_name,1,30) FROM dba_objects WHERE rownum <= 10000;
```

10000 rows created.

```
SQL> commit;
```

Commit complete.

```
SQL> alter table albums add primary key(album_id);
```

Table altered.

```
SQL> create index albums_details_i on albums(album_details);
```

Index created.

```
SQL> exec dbms_stats.gather_table_stats(ownname=> 'BOWIE', tabname=> 'ALBUMS', estimate_percent=> null,  
cascade=> true, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Bitmap-Join Indexes

```
SQL> SELECT b.id, b.album_id, b.format_id FROM big_dwh_table b, albums a WHERE b.album_id = a.album_id and a.album_details = 'TAB$';
```

100 rows selected.

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		125	4250	25 (0)	00:00:01
1	NESTED LOOPS					
2	NESTED LOOPS		125	4250	25 (0)	00:00:01
3	TABLE ACCESS BY INDEX ROWID	ALBUMS	1	22	2 (0)	00:00:01
* 4	INDEX RANGE SCAN	ALBUMS_DETAILS_I	1		1 (0)	00:00:01
5	BITMAP CONVERSION TO ROWIDS					
* 6	BITMAP INDEX SINGLE VALUE	BIG_DWH_TABLE_ALBUM_ID_I				
7	TABLE ACCESS BY INDEX ROWID	BIG_DWH_TABLE	100	1200	25 (0)	00:00:01

Statistics

```
0 recursive calls
0 db block gets
10 consistent gets
0 physical reads
0 redo size
1648 bytes sent via SQL*Net to client
396 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
100 rows processed
```

Bitmap-Join Indexes

Let's now create a Bitmap-Join Index ...

```
SQL> drop index albums_details_i;
```

Index dropped.

```
SQL> CREATE BITMAP INDEX big_dwh_album_details_i ON big_dwh_table(a.album_details)
FROM big_dwh_table b, albums a
WHERE b.album_id = a.album_id;
```

Index created.

Bitmap-Join Indexes

```
SQL> SELECT b.id, b.album_id, b.format_id FROM big_dwh_table b, albums a WHERE b.album_id = a.album_id and a.album_details = 'TAB$';
```

100 rows selected.

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		125	1500	26 (0)	00:00:01
1	TABLE ACCESS BY INDEX ROWID	BIG_DWH_TABLE	125	1500	26 (0)	00:00:01
2	BITMAP CONVERSION TO ROWIDS					
* 3	BITMAP INDEX SINGLE VALUE	BIG_DWH_ALBUM_DETAILS_I				

Statistics

```
0 recursive calls
0 db block gets
6 consistent gets
0 physical reads
0 redo size
1648 bytes sent via SQL*Net to client
396 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
100 rows processed
```

There is no join step in the execution plan, the ALBUMS table is not even referenced and consistent gets has dropped down from 10 to 6

Bitmap-Join Indexes

```
SQL> drop table albums;  
Table dropped.
```

```
SQL> CREATE TABLE albums (album_id number primary key, album_details varchar2(30)) organization index;  
Table created.
```

```
SQL> INSERT INTO albums SELECT rownum, substr(object_name,1,30) FROM dba_objects WHERE rownum <= 10000;  
10000 rows created.
```

```
SQL> commit;  
Commit complete.
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=> 'BOWIE', tabname=> 'ALBUMS', estimate_percent=> null, cascade=> true,  
method_opt=> 'FOR ALL COLUMNS SIZE 1');  
PL/SQL procedure successfully completed.
```

```
SQL> CREATE BITMAP INDEX big_dwh_album_details_i ON big_dwh_table(a.album_details)  
2 FROM big_dwh_table b, albums a  
3 WHERE b.album_id = a.album_id;  
CREATE BITMAP INDEX big_dwh_album_details_i ON big_dwh_table(a.album_details)
```

```
ERROR at line 1:
```

```
ORA-25966: join index cannot be based on an index organized table
```

However, can't create a Bitmap-Join Index if either table is an Index Organized Table

11g Bitmap-Join Indexes on IOTs

However, since Oracle11g Rel 1, Bitmap-Join Indexes on IOTs are fully supported ...

```
SQL> CREATE BITMAP INDEX big_dwh_album_details_i ON big_dwh_table(a.album_details)
FROM big_dwh_table b, albums a
WHERE b.album_id = a.album_id;
Index created.
```

```
SQL> SELECT b.id, b.album_id, b.format_id FROM big_dwh_table b, albums a WHERE b.album_id = a.album_id and a.album_details = 'TAB$';
100 rows selected.
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		125	1500	26 (0)	00:00:01
1	TABLE ACCESS BY INDEX ROWID	BIG_DWH_TABLE	125	1500	26 (0)	00:00:01
2	BITMAP CONVERSION TO ROWIDS					
* 3	BITMAP INDEX SINGLE VALUE	BIG_DWH_ALBUM_DETAILS_I				

Statistics

```
0 recursive calls
0 db block gets
6 consistent gets
0 physical reads
0 redo size
1648 bytes sent via SQL*Net to client
396 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
100 rows processed
```

Creation On Demand Segments

- Prior to 11g Release 2, when a segment is created, it's allocated at least 1 initial extent
- However, many large applications create many segments that are not actually used (e.g. SAP)
- Many tables can have many associated indexes which are likewise never used
- This can result in a large amount of essentially wasted storage overall

Creation On Demand Segments

```
SQL> create table empty (a number, b number, c number, d number, e number);
```

```
Table created.
```

```
SQL> create index empty_a_i on empty(a);
```

```
Index created.
```

```
SQL> create index empty_b_i on empty(b);
```

```
Index created.
```

```
SQL> create index empty_c_i on empty(c);
```

```
Index created.
```

```
SQL> create index empty_d_i on empty(d);
```

```
Index created.
```

```
SQL> create index empty_e_i on empty(e);
```

```
Index created.
```

```
SQL> select segment_name, blocks, bytes, extents from dba_segments where segment_name like 'EMPTY%';
```

SEGMENT_NAME	BLOCKS	BYTES	EXTENTS
EMPTY	128	1048576	1
EMPTY_A_I	128	1048576	1
EMPTY_B_I	128	1048576	1
EMPTY_C_I	128	1048576	1
EMPTY_D_I	128	1048576	1
EMPTY_E_I	128	1048576	1

```
6 rows selected.
```

Creation On Demand Segments

However, create the same segments in Oracle11g Release 2 and no storage is allocated at all ...

```
SQL> create table empty (a number, b number, c number, d number, e number);  
Table created.
```

```
SQL> create index empty_a_i on empty(a);  
Index created.
```

```
SQL> create index empty_b_i on empty(b);  
Index created.
```

```
SQL> create index empty_c_i on empty(c);  
Index created.
```

```
SQL> create index empty_d_i on empty(d);  
Index created.
```

```
SQL> create index empty_e_i on empty(e);  
Index created.
```

```
SQL> select segment_name, blocks, bytes, extents from dba_segments where segment_name like  
'EMPTY%';  
no rows selected
```

Creation On Demand Segments

If we now create another table with lots of rows ...

```
SQL> create table bowie as select rownum id, 'BOWIE' name from dual connect by level <= 1000000;  
Table created.
```

```
SQL> create index bowie_id_i on bowie(id);  
Index created.
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'BOWIE', cascade=>true,  
estimate_percent=>null, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'EMPTY', cascade=>true,  
estimate_percent=>null, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Creation On Demand Segments

```
SQL> select * from bowie, empty where bowie.id=empty.a and bowie.id = 42;
no rows selected
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	76	2 (0)	00:00:01
1	MERGE JOIN CARTESIAN		1	76	2 (0)	00:00:01
2	TABLE ACCESS BY INDEX ROWID	EMPTY	1	65	1 (0)	00:00:01
* 3	INDEX RANGE SCAN	EMPTY_A_I	1		1 (0)	00:00:01
4	BUFFER SORT		1	11	1 (0)	00:00:01
5	TABLE ACCESS BY INDEX ROWID	BOWIE	1	11	1 (0)	00:00:01
* 6	INDEX RANGE SCAN	BOWIE_ID_I	1		0 (0)	00:00:01

Statistics

```
0 recursive calls
0 db block gets
0 consistent gets
0 physical reads
0 redo size
303 bytes sent via SQL*Net to client
239 bytes received via SQL*Net from client
1 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
0 rows processed
```

Creation On Demand Segments

If we insert the first row in a pre-Oracle11g Rel 2 table:

```
SQL> insert into empty2 (a, b) values (1,1);
```

```
1 row created.
```

Id	Operation	Name	Rows	Cost (%CPU)	Time
0	INSERT STATEMENT		1	1 (0)	00:00:01
1	LOAD TABLE CONVENTIONAL	EMPTY2			

```
Statistics
```

```
-----  
3 recursive calls  
10 db block gets  
6 consistent gets  
0 physical reads  
1056 redo size  
389 bytes sent via SQL*Net to client  
322 bytes received via SQL*Net from client  
3 SQL*Net roundtrips to/from client  
2 sorts (memory)  
0 sorts (disk)  
1 rows processed
```

Overheads are minimal ...

Creation On Demand Segments

However, when we insert the first row in an Oracle11g Rel 2 table

```
SQL> insert into empty (a, b) values (1,1);
```

```
1 row created.
```

Id	Operation	Name	Rows	Cost (%CPU)	Time
0	INSERT STATEMENT		1	1 (0)	00:00:01
1	LOAD TABLE CONVENTIONAL	EMPTY			

```
Statistics
```

```
-----  
759 recursive calls  
129 db block gets  
133 consistent gets  
3 physical reads  
21232 redo size  
389 bytes sent via SQL*Net to client  
321 bytes received via SQL*Net from client  
3 SQL*Net roundtrips to/from client  
2 sorts (memory)  
0 sorts (disk)  
1 rows processed
```

Creation On Demand Segments

The first row creates all dependent segments, even if indexes are not populated

```
SQL> select segment_name, blocks, bytes, extents from dba_segments where segment_name like 'EMPTY%';
```

SEGMENT_NAME	BLOCKS	BYTES	EXTENTS
EMPTY	128	1048576	1
EMPTY_A_I	128	1048576	1
EMPTY_B_I	128	1048576	1
EMPTY_C_I	128	1048576	1
EMPTY_D_I	128	1048576	1
EMPTY_E_I	128	1048576	1

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'EMPTY', cascade=>true,
estimate_percent=>null, method_opt=> 'FOR ALL COLUMNS SIZE 1');
PL/SQL procedure successfully completed.
```

```
SQL> select index_name, blevel, leaf_blocks, status from dba_indexes where index_name like 'EMPTY%';
```

INDEX_NAME	BLEVEL	LEAF_BLOCKS	STATUS
EMPTY_A_I	0	1	VALID
EMPTY_B_I	0	1	VALID
EMPTY_C_I	0	0	VALID
EMPTY_D_I	0	0	VALID
EMPTY_E_I	0	0	VALID

Quotas With Creation On Demand Segments

Prior to 11g R2, could not create a segment in a tablespace without sufficient quotas ...

```
SQL> create user muse identified by muse default tablespace user_data temporary tablespace temp;
```

User created.

```
SQL> grant create session, create table to muse;
```

Grant succeeded.

```
SQL> connect muse/muse;
```

Connected.

```
SQL> create table fred (id number primary key using index (create index fred_pk on fred(id)
tablespace user_data), name varchar2(20));
create table fred (id number primary key using index (create index fred_pk on fred(id) tablespace
user_data), name varchar2(20))
```

*

ERROR at line 1:

ORA-01950: no privileges on tablespace 'USER_DATA'

Quotas With Creation On Demand Segments

However, in 11g R2, you can with quotas only enforced when data is actually inserted ...

```
SQL> create user muse identified by muse default tablespace user_data temporary tablespace temp;
```

User created.

```
SQL> grant create session, create table to muse;
```

Grant succeeded.

```
SQL> connect muse/muse
```

Connected.

```
SQL> create table fred (id number primary key using index (create index fred_pk on fred(id) tablespace user_data), name varchar2(20));
```

Table created.

```
SQL> insert into fred values (1, 'BOWIE');
```

```
insert into fred values (1, 'BOWIE')
```

*

ERROR at line 1:

ORA-01950: no privileges on tablespace 'USER_DATA'

Zero Sized Unusable Indexes

Prior to Oracle11g Release 2

```
SQL> create table bowie as select rownum id, 'BOWIE' name from dual connect by level <= 1000000;  
Table created.
```

```
SQL> create index bowie_id_i on bowie(id);  
Index created.
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'BOWIE', cascade=> true,  
estimate_percent=> null, method_opt=> 'FOR ALL COLUMNS SIZE 1');  
PL/SQL procedure successfully completed.
```

```
SQL> alter index bowie_id_i unusable;  
Index altered.
```

```
SQL> select index_name, blevel, leaf_blocks, num_rows, status, dropped from dba_indexes where index_name  
= 'BOWIE_ID_I';
```

<u>INDEX_NAME</u>	<u>BLEVEL</u>	<u>LEAF_BLOCKS</u>	<u>NUM_ROWS</u>	<u>STATUS</u>	<u>DRO</u>
BOWIE_ID_I	2	2226	1000000	UNUSABLE	NO

```
SQL> select segment_name, bytes, blocks, extents from dba_segments where segment_name = 'BOWIE_ID_I';
```

<u>SEGMENT_NAME</u>	<u>BYTES</u>	<u>BLOCKS</u>	<u>EXTENTS</u>
BOWIE_ID_I	18874368	2304	18

Zero Sized Unusable Indexes

Oracle11g Release 2

```
SQL> create table bowie as select rownum id, 'BOWIE' name from dual connect by level <= 1000000;  
Table created.
```

```
SQL> create index bowie_id_i on bowie(id);  
Index created.
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=>null, tabname=>'BOWIE', cascade=> true,  
estimate_percent=> null, method_opt=> 'FOR ALL COLUMNS SIZE 1');  
PL/SQL procedure successfully completed.
```

```
SQL> alter index bowie_id_i unusable;  
Index altered.
```

```
SQL> select index_name, blevel, leaf_blocks, num_rows, status, dropped from dba_indexes where index_name  
= 'BOWIE_ID_I';
```

INDEX_NAME	BLEVEL	LEAF_BLOCKS	NUM_ROWS	STATUS	DRO
BOWIE_ID_I	2	2226	1000000	UNUSABLE	NO

```
SQL> select segment_name, bytes, blocks, extents from dba_segments where segment_name = 'BOWIE_ID_I';  
no rows selected
```

Oracle automatically drops the storage associated with such unusable indexes

Zero Sized Unusable Indexes

Create and populate a simple partitioned table

```
SQL> CREATE TABLE big_album_sales(id number, album_id number, country_id number,  
    release_date date, total_sales number) PARTITION BY RANGE (release_date)  
(PARTITION ALBUMS_2006 VALUES LESS THAN (TO_DATE('01-JAN-2007', 'DD-MON-YYYY')),  
PARTITION ALBUMS_2007 VALUES LESS THAN (TO_DATE('01-JAN-2008', 'DD-MON-YYYY')),  
PARTITION ALBUMS_2008 VALUES LESS THAN (TO_DATE('01-JAN-2009', 'DD-MON-YYYY')),  
PARTITION ALBUMS_2009 VALUES LESS THAN (MAXVALUE));
```

Table created.

```
SQL> INSERT INTO big_album_sales SELECT rownum, mod(rownum,5000)+1, mod(rownum,100)+1, sysdate-  
mod(rownum,2000), ceil(dbms_random.value(1,500000)) FROM dual CONNECT BY LEVEL <= 1000000;
```

1000000 rows created.

```
SQL> commit;
```

Commit complete.

Zero Sized Unusable Indexes

Create a non-partition index, a global index and a local index on the partitioned table

```
SQL> CREATE INDEX big_album_tot_sales_i ON big_album_sales(total_sales);
```

Index created.

```
SQL> CREATE INDEX big_album_country_id_i ON big_album_sales(country_id)
 2 GLOBAL PARTITION BY RANGE (country_id)
 3 (PARTITION TS1 VALUES LESS THAN (26),
 4 PARTITION TS2 VALUES LESS THAN (51),
 5 PARTITION TS3 VALUES LESS THAN (76),
 6 PARTITION TS4 VALUES LESS THAN (MAXVALUE));
```

Index created.

```
SQL> CREATE INDEX big_album_album_id_i ON big_album_sales(album_id) LOCAL;
```

Index created.

```
SQL> exec dbms_stats.gather_table_stats(ownname=> 'BOWIE', tabname=> 'BIG_ALBUM_SALES',
estimate_percent=> null, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

Zero Sized Unusable Indexes

```
SQL> ALTER TABLE big_album_sales SPLIT PARTITION ALBUMS_2009
 2 AT (TO_DATE('01-JAN-2010', 'DD-MON-YYYY'))
 3 INTO (PARTITION ALBUMS_2009, PARTITION ALBUMS_2010);
```

Table altered.

```
SQL> select index_name, status from dba_indexes where table_name = 'BIG_ALBUM_SALES';
```

INDEX_NAME	STATUS
BIG_ALBUM_TOT_SALES_I	UNUSABLE
BIG_ALBUM_COUNTRY_ID_I	N/A
BIG_ALBUM_ALBUM_ID_I	N/A

```
SQL> select index_name, partition_name, status, leaf_blocks from dba_ind_partitions where index_name like
'BIG_ALBUM_%';
```

INDEX_NAME	PARTITION_NAME	STATUS	LEAF_BLOCKS
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2006	USABLE	807
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2007	USABLE	381
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2008	USABLE	383
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2009	UNUSABLE	
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2010	UNUSABLE	
BIG_ALBUM_COUNTRY_ID_I	TS1	UNUSABLE	629
BIG_ALBUM_COUNTRY_ID_I	TS2	UNUSABLE	629
BIG_ALBUM_COUNTRY_ID_I	TS3	UNUSABLE	629
BIG_ALBUM_COUNTRY_ID_I	TS4	UNUSABLE	629

Zero Sized Unusable Indexes

All unusable index partitions from both the global and local index no longer have allocated storage.

However, the unusable non-partitioned index segment has not been dropped ...

```
SQL> select segment_name, partition_name, bytes, blocks from dba_segments where segment_name like 'BIG_ALBUM_%' and segment_type like 'INDEX%';
```

SEGMENT_NAME	PARTITION_NAME	BYTES	BLOCKS
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2006	7340032	896
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2007	3145728	384
BIG_ALBUM_ALBUM_ID_I	ALBUMS_2008	4194304	512
BIG_ALBUM_TOT_SALES_I		23068672	2816

Zero Sized Unusable Indexes

Can use zero sized unusable indexes to your advantage to index only useful portions of a table. Most data here is processed:

```
SQL> create table bowie_stuff (id number, processed varchar2(10));
```

```
Table created.
```

```
SQL> insert into bowie_stuff select rownum, 'YES' from dual connect by level <= 1000000;
```

```
1000000 rows created.
```

```
SQL> commit;
```

```
Commit complete.
```

```
SQL> update bowie_stuff set processed = 'NO' where id in (999990, 999992, 999994, 999996, 999998);
```

```
5 rows updated.
```

```
SQL> commit;
```

```
Commit complete.
```

```
SQL> create index bowie_stuff_i on bowie_stuff(processed) pctfree 0;
```

```
Index created.
```


Zero Sized Unusable Indexes

```
SQL> select index_name, leaf_blocks from dba_indexes where index_name =  
'BOWIE_STUFF_I';
```

INDEX_NAME	LEAF_BLOCKS
BOWIE_STUFF_I	1877

```
SQL> select segment_name, blocks from dba_segments where segment_name =  
'BOWIE_STUFF_I';
```

SEGMENT_NAME	BLOCKS
BOWIE_STUFF_I	1920

```
SQL> exec dbms_stats.gather_table_stats(ownname=>'BOWIE', tabname=>'BOWIE_STUFF',  
estimate_percent=>null, cascade=> true, method_opt=> 'FOR ALL COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

```
SQL> exec dbms_stats.gather_table_stats(ownname=>'BOWIE', tabname=>'BOWIE_STUFF',  
estimate_percent=>null, method_opt=> 'FOR COLUMNS PROCESSED SIZE 5');
```

PL/SQL procedure successfully completed.

Zero Sized Unusable Indexes

```
SQL> select * from bowie_stuff where processed = 'NO';
```

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		5	40	4 (0)	00:00:01
1	TABLE ACCESS BY INDEX ROWID	BOWIE_STUFF	5	40	4 (0)	00:00:01
* 2	INDEX RANGE SCAN	BOWIE_STUFF_I	5		3 (0)	00:00:01

Statistics

```
0 recursive calls
0 db block gets
6 consistent gets
0 physical reads
0 redo size
540 bytes sent via SQL*Net to client
396 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
5 rows processed
```

Zero Sized Unusable Indexes

However in 11g R2, if we now recreate the index as a partitioned index with only the “useful” portion of the index usable ...

```
SQL> drop index bowie_stuff_i;
```

Index dropped.

```
SQL> create index bowie_stuff_i on bowie_stuff(processed)
 2 global partition by range (processed)
 3 (partition not_processed_part values less than ('YES'),
 4  partition processed_part values less than (MAXVALUE))
 5 unusable;
```

Index created.

```
SQL> alter index bowie_stuff_i rebuild partition not_processed_part;
```

Index altered.

Zero Sized Unusable Indexes

We now only use a fraction of the storage for the index and the “useful” portion of the indexed data is just a single leaf block in size ...

```
SQL> select index_name, partition_name, leaf_blocks from dba_ind_partitions where  
index_name = 'BOWIE_STUFF_I';
```

INDEX_NAME	PARTITION_NAME	LEAF_BLOCKS
BOWIE_STUFF_I	PROCESSED_PART	0
BOWIE_STUFF_I	NOT_PROCESSED_PART	1

```
SQL> select segment_name, partition_name, blocks from dba_segments where segment_name  
= 'BOWIE_STUFF_I';
```

SEGMENT_NAME	PARTITION_NAME	BLOCKS
BOWIE_STUFF_I	NOT_PROCESSED_PART	8

Zero Sized Unusable Indexes

```
SQL> select * from bowie_stuff where processed = 'NO';
```

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		5	45	1 (0)	00:00:01		
1	PARTITION RANGE SINGLE		5	45	1 (0)	00:00:01	1	1
2	TABLE ACCESS BY INDEX ROWID	BOWIE_STUFF	5	45	1 (0)	00:00:01		
* 3	INDEX RANGE SCAN	BOWIE_STUFF_I	5		1 (0)	00:00:01	1	1

Statistics

```
0 recursive calls
0 db block gets
4 consistent gets
0 physical reads
0 redo size
542 bytes sent via SQL*Net to client
395 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
5 rows processed
```

Note: The query itself is also more efficient with consistent gets reduced from 6 down to 4 ...

IGNORE_ROW_ON_DUPKEY_INDEX

Create table with a PK and attempt to insert duplicate PK rows ...

```
SQL> create table radiohead (id number constraint radiohead_pk_i primary key using index (create unique index radiohead_pk_i on radiohead(id)), name varchar2(20));
```

Table created.

```
SQL> select index_name, uniqueness, table_name from dba_indexes where index_name = 'RADIOHEAD_PK_I';
```

INDEX_NAME	UNIQUENES	TABLE_NAME
RADIOHEAD_PK_I	UNIQUE	RADIOHEAD

```
SQL> insert into radiohead select rownum, 'OK COMPUTER' from dual connect by level <= 10;
```

10 rows created.

```
SQL> commit;
```

Commit complete.

```
SQL> insert into radiohead select rownum, 'OK COMPUTER' from dual connect by level <= 12;  
insert into radiohead select rownum, 'OK COMPUTER' from dual connect by level <= 12
```

*

ERROR at line 1:

ORA-00001: unique constraint (BOWIE.RADIOHEAD_PK_I) violated

IGNORE_ROW_ON_DUPKEY_INDEX

With the new Oracle11g Rel. 1 hint, duplicate violation rows are automatically ignored.

```
SQL> insert /*+ ignore_row_on_dupkey_index(radiohead,radiohead_pk_i) */ into radiohead select rownum, 'OK COMPUTER'
from dual connect by level <= 12;
2 rows created.
```

```
SQL> insert /*+ ignore_row_on_dupkey_index(radiohead(id)) */ into radiohead select rownum, 'OK COMPUTER' from dual
connect by level <= 13;
1 row created.
```

```
SQL> commit;
Commit complete.
```

```
SQL> select * from radiohead;
```

ID	NAME
1	OK COMPUTER
2	OK COMPUTER
3	OK COMPUTER
4	OK COMPUTER
5	OK COMPUTER
6	OK COMPUTER
7	OK COMPUTER
8	OK COMPUTER
9	OK COMPUTER
10	OK COMPUTER
11	OK COMPUTER
12	OK COMPUTER
13	OK COMPUTER

```
13 rows selected.
```

IGNORE_ROW_ON_DUPKEY_INDEX

The index must be Unique for the hint to be valid ...

```
SQL> create table radiohead (id number constraint radiohead_pk_i primary key using index (create index radiohead_pk_i on radiohead(id)), name varchar2(20));
```

Table created.

```
SQL> insert into radiohead select rownum, 'OK COMPUTER' from dual connect by level <= 10;
```

10 rows created.

```
SQL> commit;
```

Commit complete.

```
SQL> select index_name, uniqueness, table_name from dba_indexes where index_name='RADIOHEAD_PK_I';
```

INDEX_NAME	UNIQUENES	TABLE_NAME
RADIOHEAD_PK_I	NONUNIQUE	RADIOHEAD

```
SQL> insert /*+ ignore_row_on_dupkey_index(radiohead,radiohead_pk_i) */ into radiohead select rownum, 'OK COMPUTER' from dual connect by level <= 12;
```

```
insert /*+ ignore_row_on_dupkey_index(radiohead,radiohead_pk_i) */ into radiohead select rownum, 'OK COMPUTER' from dual connect by level <= 12
```

ERROR at line 1:

ORA-38913: Index specified in the index hint is invalid

IGNORE_ROW_ON_DUPKEY_INDEX

The UPDATE statement is not allowed with this hint ...

```
SQL> update /*+ ignore_row_on_dupkey_index(radiohead,radiohead_pk_i) */ radiohead set id = 13 where id = 3;  
update /*+ ignore_row_on_dupkey_index(radiohead,radiohead_pk_i) */ radiohead set id = 13 where id = 3  
*  
ERROR at line 1:  
ORA-38917: IGNORE_ROW_ON_DUPKEY_INDEX hint disallowed for this operation
```

ANALYZE VALIDATE STRUCTURE FAST

Oracle11g Release 1 introduces a new “FAST”, more efficient VALIDATE STRUCTURE command option

Will identified a corruption exists but no specific details about the corruption

```
SQL> analyze table general_audit_log validate structure cascade;
Table analyzed.
Elapsed: 00:01:34.12
SQL> analyze table general_audit_log validate structure cascade fast;
Table analyzed.
Elapsed: 00:01:45.75
SQL> analyze table general_audit_log validate structure cascade;
Table analyzed.
Elapsed: 00:01:34.12
SQL> analyze table general_audit_log validate structure cascade fast;
Table analyzed.
Elapsed: 00:01:53.73
```

However, initial investigation with FAST option has sometimes yielded “disappointing” results ...

ANALYZE VALIDATE STRUCTURE FAST

If we trace a session using just the VALIDATE STRUCTURE CASCADE option:

```
analyze table log_entries validate structure cascade
```

call	count	cpu	elapsed	disk	query	current	rows
Parse	1	0.01	0.06	0	0	0	0
Execute	1	37.56	127.03	44679	14300957	2	0
Fetch	0	0.00	0.00	0	0	0	0
total	2	37.57	127.10	44679	14300957	2	0

We notice that it causes a massive number of query based I/Os

ANALYZE VALIDATE STRUCTURE FAST

If we trace a session using the new VALIDATE STRUCTURE CASCADE **FAST** option:

```
analyze table log_entries validate structure cascade fast
```

```
select /*+ full(LOG_ENTRIES) */ ORA_HASH(DATE_TIME_ACTIONED || rowid)
from LOG_ENTRIES MINUS select /*+ index_ffs(LOG_ENT_DATE_ACT_I) */
ORA_HASH(DATE_TIME_ACTIONED || rowid) from LOG_ENTRIES
```

call	count	cpu	elapsed	disk	query	current	rows
Parse	1	0.01	0.01	0	0	0	0
Execute	1	0.00	0.00	0	0	0	0
Fetch	1	5.93	15.49	13022	13190	0	0
total	3	5.94	15.50	13022	13190	0	0

```
select /*+ full(LOG_ENTRIES) */ ORA_HASH(CASE_ID || DATE_TIME_ADDED || rowid)
from LOG_ENTRIES MINUS select /*+ index_ffs(LOG_ENT_CASE_ID_DTETME_ADDED_I) */ ORA_HASH(CASE_ID ||
DATE_TIME_ADDED || rowid) from LOG_ENTRIES
```

call	count	cpu	elapsed	disk	query	current	rows
Parse	1	0.01	0.00	0	0	0	0
Execute	1	0.00	0.00	0	0	0	0
Fetch	1	6.22	7.64	1345	3148	0	0
total	3	6.23	7.65	1345	3148	0	0

We notice it utilises the ORA_HASH function to compare differences between a full table scan and a fast full index scan

ANALYZE VALIDATE STRUCTURE FAST

If we look at the overall total resources:

OVERALL TOTALS FOR ALL NON-RECURSIVE STATEMENTS

call	count	cpu	elapsed	disk	query	current	rows
Parse	2	0.00	0.01	2	5	0	0
Execute	2	0.03	0.00	55212	77243	2	0
Fetch	0	0.00	0.00	0	0	0	0
total	4	0.03	0.02	55214	77248	2	0

OVERALL TOTALS FOR ALL RECURSIVE STATEMENTS

call	count	cpu	elapsed	disk	query	current	rows
Parse	42	0.07	0.07	0	0	0	0
Execute	87	0.05	0.07	11	5	60	4
Fetch	140	80.33	111.80	55203	77243	0	240
total	269	80.45	111.95	55214	77248	60	244

We notice it's using significantly less I/Os but much more CPU

Overall, this can sometimes result in the overall elapsed times actually being greater with FAST than without ...

Function-Based Indexes

```
SQL> CREATE TABLE func_tab AS SELECT ROWNUM id, 'DAVID BOWIE '||  
ceil(dbms_random.value(0,10000000)) name FROM DUAL CONNECT BY LEVEL <= 100000;  
Table created.
```

```
SQL> INSERT INTO func_tab VALUES (100001, 'Ziggy');  
1 row created.
```

```
SQL> INSERT INTO func_tab VALUES (100002, 'ZIGGY');  
1 row created.
```

```
SQL> INSERT INTO func_tab VALUES (100003, 'ZiGgY');  
1 row created.
```

```
SQL> commit;  
Commit complete.
```

```
SQL> CREATE INDEX func_tab_name_i ON func_tab(name);  
Index created.
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=>'BOWIE', tabname=>  
'FUNC_TAB',cascade=> true, estimate_percent=>null, method_opt=> 'FOR ALL COLUMNS  
SIZE 1');  
PL/SQL procedure successfully completed.
```

Function-Based Indexes

The use of the UPPER function negates the use of the index.

```
SQL> SELECT * FROM func_tab WHERE UPPER(name) = 'ZIGGY';
```

```
-----  
ID NAME  
-----  
100001 Ziggy  
100002 ZIGGY  
100003 ZiGgY
```

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1000	24000	89 (5)	00:00:01
* 1	TABLE ACCESS FULL	FUNC_TAB	1000	24000	89 (5)	00:00:01

Statistics

```
-----  
1 recursive calls  
0 db block gets  
421 consistent gets  
0 physical reads  
0 redo size  
530 bytes sent via SQL*Net to client  
396 bytes received via SQL*Net from client  
2 SQL*Net roundtrips to/from client  
0 sorts (memory)  
0 sorts (disk)  
3 rows processed
```

Note also that the cardinality estimate of 1000 rows is way off ...

Function-Based Indexes

```
SQL> CREATE INDEX func_tab_upper_name_i ON func_tab(UPPER(name))  
      COMPUTE STATISTICS;  
Index created.
```

```
SQL> SELECT * FROM func_tab WHERE UPPER(name) = 'ZIGGY';
```

```
ID NAME  
-----
```

```
100001 Ziggy  
100002 ZIGGY  
100003 ZiGgY
```

```
Execution Plan  
-----
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1000	24000	84 (0)	00:00:01
1	TABLE ACCESS BY INDEX ROWID	FUNC_TAB	1000	24000	84 (0)	00:00:01
* 2	INDEX RANGE SCAN	FUNC_TAB_UPPER_NAME_I	400		3 (0)	00:00:01

The cardinality estimate is still way off at 1000 rows when only 3 rows are actually returned ...

Function-based index has fortunately been used but such wrong cardinality estimates can potentially result in disastrous execution plans.

Virtual Columns

- When a Function-Based Index is created, Oracle creates a “Virtual” column for the table
- Prior to 11g, these Virtual columns were “Hidden”
- These columns are used to store column statistics to be subsequently used by the CBO
- The table, not the index, needs to have statistics collected to populate Virtual columns

Virtual Columns

```
SQL> SELECT table_name, column_name, num_distinct, density
       FROM dba_tab_columns WHERE table_name = 'FUNC_TAB';
```

TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	DENSITY
FUNC_TAB	ID	100003	9.9997E-06
FUNC_TAB	NAME	99495	.000010051

```
SQL> SELECT table_name, column_name, num_distinct, density, virtual_column,
       hidden_column FROM dba_tab_cols WHERE table_name = 'FUNC_TAB';
```

TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	DENSITY	VIR	HID
FUNC_TAB	SYS_NC00003\$			YES	YES
FUNC_TAB	NAME	99495	.000010051	NO	NO
FUNC_TAB	ID	100003	9.9997E-06	NO	NO

```
SQL> SELECT column_name, num_distinct, density, avg_col_len
       FROM dba_tab_col_statistics WHERE table_name = 'FUNC_TAB';
```

COLUMN_NAME	NUM_DISTINCT	DENSITY	AVG_COL_LEN
ID	100003	9.9997E-06	5
NAME	99495	.000010051	18

Virtual Columns

```
SQL> exec dbms_stats.gather_table_stats(ownname=>'BOWIE', tabname=>
'FUNC_TAB', cascade=> true, estimate_percent=>null, method_opt=> 'FOR ALL
HIDDEN COLUMNS SIZE 1');
```

PL/SQL procedure successfully completed.

```
SQL> SELECT table_name, column_name, num_distinct, density, virtual_column,
hidden_column FROM dba_tab_cols WHERE table_name = 'FUNC_TAB';
```

TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	DENSITY	VIR	HID
FUNC_TAB	SYS_NC00003\$	99493	.000010051	YES	YES
FUNC_TAB	NAME	99495	.000010051	NO	NO
FUNC_TAB	ID	100003	9.9997E-06	NO	NO

Note: the virtual statistics are now populated ...

Virtual Columns

```
SQL> SELECT * FROM func_tab WHERE UPPER(name) = 'ZIGGY';
```

```
ID NAME
```

```
-----  
100001 Ziggy  
100002 ZIGGY  
100003 ZiGgY
```

```
Execution Plan
```

```
-----  
| Id | Operation | Name | Rows | Bytes | Cost (%CPU) | Time |  
-----  
| 0 | SELECT STATEMENT | | 1 | 44 | 5 (0) | 00:00:01 |  
| 1 | TABLE ACCESS BY INDEX ROWID | FUNC_TAB | 1 | 44 | 5 (0) | 00:00:01 |  
|* 2 | INDEX RANGE SCAN | FUNC_TAB_UPPER_NAME_I | 1 | | 3 (0) | 00:00:01 |  
-----
```

Note: statistics are now much more accurate, remembering that all rows are unique, except the “ZIGGY” rows ...

11g Virtual Columns

- Prior to 11g, virtual columns were created through Function-Based Indexes
- Virtual columns useful due to statistics but had to create index even if it wasn't required
- Virtual columns were “hidden” and had to be manually derived in queries
- 11g now allows Virtual Columns to be defined and visible in a table definition

11g Virtual Columns

```
SQL> drop index func_tab_upper_name_i;  
Index dropped.
```

```
SQL> ALTER TABLE func_tab ADD (upper_name AS (UPPER(name)));  
Table altered.
```

```
SQL> desc func_tab
```

Name	Null?	Type
ID		NUMBER
NAME		VARCHAR2(52)
UPPER_NAME		VARCHAR2(52)

```
SQL> SELECT * FROM user_indexes WHERE table_name = 'FUNC_TAB';  
no rows selected
```

```
SQL> exec dbms_stats.gather_table_stats(ownname=>'BOWIE', tabname=>  
'FUNC_TAB', cascade=> true, estimate_percent=>null, method_opt=> 'FOR ALL  
COLUMNS SIZE 1');  
PL/SQL procedure successfully completed.
```

Can define a visible, virtual column to a table ...

11g Virtual Columns

```
SQL> SELECT table_name, column_name, num_distinct, density
       FROM dba_tab_columns WHERE table_name = 'FUNC_TAB';
```

TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	DENSITY
FUNC_TAB	ID	100003	9.9997E-06
FUNC_TAB	NAME	99495	.000010051
FUNC_TAB	UPPER_NAME	99493	.000010051

```
SQL> SELECT table_name, column_name, num_distinct, density, virtual_column,
       hidden_column FROM dba_tab_cols WHERE table_name = 'FUNC_TAB';
```

TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	DENSITY	VIR	HID
FUNC_TAB	UPPER_NAME	99493	.000010051	YES	NO
FUNC_TAB	NAME	99495	.000010051	NO	NO
FUNC_TAB	ID	100003	9.9997E-06	NO	NO

```
SQL> SELECT column_name, num_distinct, density, avg_col_len FROM dba_tab_col_statistics
       WHERE table_name = 'FUNC_TAB';
```

COLUMN_NAME	NUM_DISTINCT	DENSITY	AVG_COL_LEN
UPPER_NAME	99493	.000010051	18
NAME	99495	.000010051	18
ID	100003	9.9997E-06	5

11g Virtual Columns

Partial block dump of table

```
block_row_dump:
tab 0, row 0, @0x1f69
tl: 23 fb: --H-FL-- lb: 0x0  cc: 2
col 0: [ 3] c2 06 58
col 1: [15] 44 41 56 49 44 20 42 4f 57 49 45 20 35 38 37
tab 0, row 1, @0x1f52
tl: 23 fb: --H-FL-- lb: 0x0  cc: 2
col 0: [ 3] c2 06 59
col 1: [15] 44 41 56 49 44 20 42 4f 57 49 45 20 35 38 38
tab 0, row 2, @0x1f3b
tl: 23 fb: --H-FL-- lb: 0x0  cc: 2
col 0: [ 3] c2 06 5a
col 1: [15] 44 41 56 49 44 20 42 4f 57 49 45 20 35 38 39
```

Note each row only has the 2 column values physically stored in the table

11g Virtual Columns

```
SQL> SELECT * FROM func_tab WHERE UPPER(name) = 'ZIGGY';
```

ID	NAME	UPPER_NAME
100001	Ziggy	ZIGGY
100002	ZIGGY	ZIGGY
100003	ZiGgY	ZIGGY

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	44	89 (5)	00:00:01
* 1	TABLE ACCESS FULL	FUNC_TAB	1	44	89 (5)	00:00:01

Statistics

```
0 recursive calls
0 db block gets
421 consistent gets
0 physical reads
0 redo size
596 bytes sent via SQL*Net to client
396 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
3 rows processed
```

11g Virtual Columns

```
SQL> create index upper_name_idx on func_tab(upper(name));
create index upper_name_idx on func_tab(upper(name))
```

*

```
ERROR at line 1:
ORA-54018: A virtual column exists for this expression
```

```
SQL> create index upper_name_idx on func_tab(upper_name);
```

Index created.

```
SQL> SELECT index_name, index_type FROM user_indexes WHERE index_name = 'UPPER_NAME_IDX';
```

INDEX_NAME	INDEX_TYPE
UPPER_NAME_IDX	FUNCTION-BASED NORMAL

```
SQL> SELECT index_name, column_expression FROM user_ind_expressions WHERE index_name = 'UPPER_NAME_IDX';
```

INDEX_NAME	COLUMN_EXPRESSION
UPPER_NAME_IDX	UPPER("NAME")

11g Virtual Columns

```
SQL> select * from func_tab where upper_name = 'ZIGGY';
```

ID	NAME	UPPER_NAME
100001	Ziggy	ZIGGY
100002	ZIGGY	ZIGGY
100003	Ziggy	ZIGGY

Execution Plan

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	45	5 (0)	00:00:01
1	TABLE ACCESS BY INDEX ROWID	FUNC_TAB	1	45	5 (0)	00:00:01
* 2	INDEX RANGE SCAN	UPPER_NAME_IDX	1		3 (0)	00:00:01

Statistics

```
0 recursive calls
0 db block gets
6 consistent gets
0 physical reads
0 redo size
336 bytes sent via SQL*Net to client
247 bytes received via SQL*Net from client
2 SQL*Net roundtrips to/from client
0 sorts (memory)
0 sorts (disk)
3 rows processed
```

11g Virtual Columns

Virtual columns can be used where non-virtual columns are used, including as the partitioning key in a partitioned table:

```
SQL> CREATE TABLE album_sales(id number, album_id number, country_id number,  
 2 release_date date, total_sales number, total_value as (total_sales*10.95)) PARTITION BY RANGE  
(total_value)  
 3 (PARTITION ALBUMS_POOR      VALUES LESS THAN (100000),  
 4 PARTITION ALBUMS_500000    VALUES LESS THAN (500001),  
 5 PARTITION ALBUMS_1000000   VALUES LESS THAN (1000001),  
 6 PARTITION ALBUMS_2000000   VALUES LESS THAN (2000001),  
 7 PARTITION ALBUMS_3000000   VALUES LESS THAN (3000001),  
 8 PARTITION ALBUMS_4000000   VALUES LESS THAN (4000001),  
 9 PARTITION ALBUMS_5000000   VALUES LESS THAN (5000001),  
10 PARTITION ALBUMS_6000000   VALUES LESS THAN (6000001),  
11 PARTITION ALBUMS_7000000   VALUES LESS THAN (7000001),  
12 PARTITION ALBUMS_8000000   VALUES LESS THAN (8000001),  
13 PARTITION ALBUMS_9000000   VALUES LESS THAN (9000001),  
14 PARTITION ALBUMS_BESTSELLERS VALUES LESS THAN (MAXVALUE));
```

Table created.

http://richardfoote.wordpress.com/

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Introduction To Reverse Key Indexes: Part III (A Space Oddity) January 18, 2008

Posted by Richard Foote in [Oracle Indexes](#).
9 comments

A possibly significant difference between a Reverse and a Non-Reverse index is the manner in which space is used in each index and the type of block splitting that takes place.

Most Reverse Key Indexes are created to resolve contention issues as a result of monotonically increasing values. As monotonically increasing values get inserted, each value is greater than all previous values (providing there are no outlier values present) and so fill the "right-most" leaf block. If the "right-most" block is filled by the maximum current value in the index, Oracle performs 90-10 block splits meaning that full index blocks are left behind in the index structure. Assuming no deletes or updates, the index should have virtually 100% used space.

However, it's equivalent Reverse Key index will have the values reversed and dispersed evenly throughout the index structure. As index blocks fill, there will be a very remote chance of it being due to the maximum indexed value and 50-50 block splits will result. The PCT_USED is likely therefore to be significantly less, averaging approximately 70-75% over time.

Therefore, for indexes with no deletions, a Reverse Key index is likely to be less efficient from a space usage point of view.

However, if there are deletions, the story may differ.

Deleted space can be reused if an insert is subsequently made into an index block with deleted entries or if a leaf block is totally emptied. However, if a leaf block contains any non-deleted entries and if subsequent inserts don't hit the leaf block, then the deleted space can not be reused. As monotonically increasing values in a non-reverse index only ever insert into the "right-most" leaf block, it won't be able to reuse deleted space if leaf blocks are not totally emptied. Overtime, the number of such "almost but not quite empty" index leaf blocks may in some scenarios increase to significant levels and the index may continue to grow at a greater proportional rate than the table (where the reuse of space is set and controlled by the PCTUSED physical property).

Contact Details

If you wish to contact me directly, please do so at richard.foote@bigpond.com

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Richard Foote

Thank you 😊