oracle 中默认的索引类型是 B 树索引。还有位图索引，反向键索引，hash 索引，基于函数的索引。
本篇主要介绍 B 树索引，通过转储分析。对于索引的扫描类型，索引的基本操作不做详细的介绍。
系统信息：

```
[oracle@localhost ~]$      cat /etc/issue
Enterprise Linux Enterprise Linux Server release 5.5 (Carthage)
Kernel \r on an \m
```

数据库版本：

```
SQL> select * from v$version   where rownum =1 ;

BANNER
--------------------------------------------------------------------------------
Oracle Database 11g Enterprise Edition Release 11.2.0.1.0 - Production
```

```
SQL> show user;
USER 为 "HR"
SQL> desc tt;
 名称                                      是否为空? 类型
 ----------------------------------------- -------- ----------------------------
 ID                                                 NUMBER
 NAME                                               VARCHAR2(10)
SQL> select count(rownum) from tt;
COUNT(ROWNUM)
-------------
      3670016
```

基于 ID 创建索引 index_t

```
SQL> create index index_t on tt(id) tablespace users;

索引已创建。

SQL> select object_id from dba_objects where object_name=
  2  'INDEX_T';
```

数据库中 segment 有数据段，索引段，undo 段，它们和表名，索引名不是同一概念，但是名字是相同的。

```
 OBJECT_ID
----------
```

76332

转储索引：

SQL> alter session set events 'immediate trace name treedump level 76332';

会话已更改。

```
----- begin tree dump
branch: 0x10038ab 16791723 (0: nrow: 15, level: 2)
     branch: 0x100540b 16798731 (-1: nrow: 503, level: 1)
         leaf: 0x10038ac 16791724 (-1: nrow: 512 rrow: 512)
         leaf: 0x10038ad 16791725 (0: nrow: 512 rrow: 512)
         leaf: 0x10038ae 16791726 (1: nrow: 512 rrow: 512)
         leaf: 0x10038af 16791727 (2: nrow: 512 rrow: 512)
         leaf: 0x10038b0 16791728 (3: nrow: 512 rrow: 512)
         leaf: 0x10038b1 16791729 (4: nrow: 512 rrow: 512)
         leaf: 0x10038b2 16791730 (5: nrow: 512 rrow: 512)
         leaf: 0x10038b3 16791731 (6: nrow: 512 rrow: 512)
         leaf: 0x10038b4 16791732 (7: nrow: 512 rrow: 512)
         leaf: 0x10038b5 16791733 (8: nrow: 512 rrow: 512)
         leaf: 0x10038b6 16791734 (9: nrow: 512 rrow: 512)
         leaf: 0x10038b7 16791735 (10: nrow: 512 rrow: 512)
         leaf: 0x10038b9 16791737 (11: nrow: 512 rrow: 512)
         leaf: 0x10038ba 16791738 (12: nrow: 512 rrow: 512)
         leaf: 0x10038bb 16791739 (13: nrow: 512 rrow: 512)
         leaf: 0x10038bc 16791740 (14: nrow: 512 rrow: 512)
         leaf: 0x10038bd 16791741 (15: nrow: 512 rrow: 512)
         leaf: 0x10038be 16791742 (16: nrow: 512 rrow: 512)
         leaf: 0x10038bf 16791743 (17: nrow: 512 rrow: 512)
         leaf: 0x10038c0 16791744 (18: nrow: 512 rrow: 512)
         leaf: 0x10038c1 16791745 (19: nrow: 512 rrow: 512)
         leaf: 0x10038c2 16791746 (20: nrow: 512 rrow: 512)
         leaf: 0x10038c3 16791747 (21: nrow: 512 rrow: 512)
         leaf: 0x10038c4 16791748 (22: nrow: 512 rrow: 512)
         leaf: 0x10038c5 16791749 (23: nrow: 512 rrow: 512)
```

```
     leaf: 0x10038c6 16791750 (24: nrow: 512 rrow: 512)
     leaf: 0x10038c7 16791751 (25: nrow: 512 rrow: 512)
     leaf: 0x10038c9 16791753 (26: nrow: 512 rrow: 512)
     leaf: 0x10038ca 16791754 (27: nrow: 512 rrow: 512)
     leaf: 0x10038cb 16791755 (28: nrow: 512 rrow: 512)
     leaf: 0x10038cc 16791756 (29: nrow: 512 rrow: 512)
     leaf: 0x10038cd 16791757 (30: nrow: 512 rrow: 512)
     leaf: 0x10038ce 16791758 (31: nrow: 512 rrow: 512)
     leaf: 0x10038cf 16791759 (32: nrow: 512 rrow: 512)
     leaf: 0x10038d0 16791760 (33: nrow: 512 rrow: 512)
     leaf: 0x10038d1 16791761 (34: nrow: 512 rrow: 512)
     leaf: 0x10038d2 16791762 (35: nrow: 512 rrow: 512)
     leaf: 0x10038d3 16791763 (36: nrow: 512 rrow: 512)
     leaf: 0x10038d4 16791764 (37: nrow: 512 rrow: 512)
     leaf: 0x10038d5 16791765 (38: nrow: 512 rrow: 512)
     leaf: 0x10038d6 16791766 (39: nrow: 512 rrow: 512)
     leaf: 0x10038d7 16791767 (40: nrow: 512 rrow: 512)
     leaf: 0x10038d9 16791769 (41: nrow: 512 rrow: 512)
     leaf: 0x10038da 16791770 (42: nrow: 512 rrow: 512)
     leaf: 0x10038db 16791771 (43: nrow: 512 rrow: 512)
     leaf: 0x10038dc 16791772 (44: nrow: 512 rrow: 512)
     leaf: 0x10038dd 16791773 (45: nrow: 512 rrow: 512)
     leaf: 0x10038de 16791774 (46: nrow: 512 rrow: 512)
      ..........................................................................
    ....
    ....
      ....
----- end tree dump
```

这是一棵平衡树，因为平衡树的查找效率很高，根节点到所有的叶子节点的高度相同。

branch 表示的是根节点。以上选取了一部分，已经按从左向右拍好序了。

leaf: 0x10038ac 16791724 (-1: nrow: 512 rrow: 512)　　我们选取这一列：

把十六进制，和十进制数相互转换：

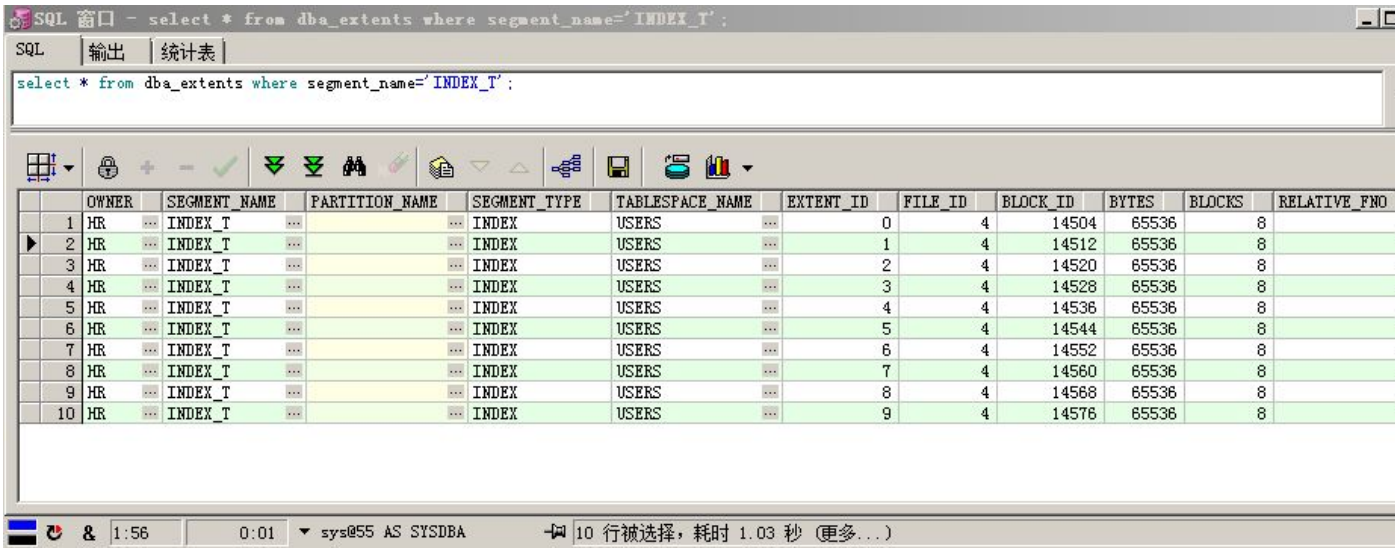
```
SQL> select to_number('10038ac','xxxxxxxxxxxxxxx') from dual;
```

```
TO_NUMBER('10038AC','XXXXXXXXXXXXXXX')
---------------------------------------
                                                16791724

SQL> select to_char('16791724','xxxxxxxxxxxxxxx') from dual;


TO_CHAR('16791724','XXXXXXXXXXXXXX
----------------------------------
                 10038ac
```

我们利用 oracle 中提供的一个包可以求得索引所在的文件号，块号：

```
SQL>   select dbms_utility.data_block_address_file(16791724) from dual;


DBMS_UTILITY.DATA_BLOCK_ADDRESS_FILE(16791724)
----------------------------------------------
                                             4

SQL>   select dbms_utility.data_block_address_block(16791724) from dual;


DBMS_UTILITY.DATA_BLOCK_ADDRESS_BLOCK(16791724)
-----------------------------------------------

                                           14508
```

通过查视图 dba_extends,索引存储在数据文件 4,块 14508 在起始块范围内。



	OWNER	SEGMENT_NAME	PARTITION_NAME	SEGMENT_TYPE	TABLESPACE_NAME	EXTENT_ID	FILE_ID	BLOCK_ID	BYTES	BLOCKS	RELATIVE_FNO
1	HR	INDEX_T		INDEX	USERS	0	4	14504	65536	8	
2	HR	INDEX_T		INDEX	USERS	1	4	14512	65536	8	
3	HR	INDEX_T		INDEX	USERS	2	4	14520	65536	8	
4	HR	INDEX_T		INDEX	USERS	3	4	14528	65536	8	
5	HR	INDEX_T		INDEX	USERS	4	4	14536	65536	8	
6	HR	INDEX_T		INDEX	USERS	5	4	14544	65536	8	
7	HR	INDEX_T		INDEX	USERS	6	4	14552	65536	8	
8	HR	INDEX_T		INDEX	USERS	7	4	14560	65536	8	
9	HR	INDEX_T		INDEX	USERS	8	4	14568	65536	8	
10	HR	INDEX_T		INDEX	USERS	9	4	14576	65536	8	

此时我们 dump 数据文件 4，块 14508：

```
SQL> alter system dump datafile 4 block 14508;
```

系统已更改。

```
row#0[8020] flag: ------, lock: 0, len=12
col 0; len 2; (2):  c1 02
col 1; len 6; (6):  01 00 1b ab 00 01
row#1[8008] flag: ------, lock: 0, len=12
col 0; len 2; (2):  c1 02
col 1; len 6; (6):  01 00 1b ab 00 03
row#2[7996] flag: ------, lock: 0, len=12
col 0; len 2; (2):  c1 02
col 1; len 6; (6):  01 00 1b ab 00 08
row#3[7984] flag: ------, lock: 0, len=12
col 0; len 2; (2):  c1 02
col 1; len 6; (6):  01 00 1b ab 00 0a
row#4[7972] flag: ------, lock: 0, len=12
col 0; len 2; (2):  c1 02
col 1; len 6; (6):  01 00 1b ab 00 0f
row#5[7960] flag: ------, lock: 0, len=12
col 0; len 2; (2):  c1 02
col 1; len 6; (6):  01 00 1b ab 00 11
row#6[7948] flag: ------, lock: 0, len=12
```

col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 16
row#7[7936] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 18
row#8[7924] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 1d
row#9[7912] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 1f
row#10[7900] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 24
row#11[7888] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 26
row#12[7876] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 2b
row#13[7864] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 2d
row#14[7852] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 32
row#15[7840] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 34
row#16[7828] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 39
row#17[7816] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 3b
row#18[7804] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 40
row#19[7792] flag: ------, lock: 0, len=12
col 0; len 2; (2): c1 02
col 1; len 6; (6): 01 00 1b ab 00 42

row#20[7780] flag: ------, lock: 0, len=12

.....

.....

选取这一行为例：

row#0[8020] flag: ------, lock: 0, len=12

col 0; len 2; (2): c1 02

col 1; len 6; (6): 01 00 1b ab 00 01

col 0 表示第一列，长度为 2，c1 02 表示是多少呢？

```
SQL> select * from tt where rownum<4 order by id;


            ID NAME
---------- --------------------
             1 w0
             2 wang
             6 hong

SQL> select dump(1,16) from dual;


DUMP(1,16)
--------------------------------
Typ=2 Len=2: c1,2          ==>这里是 c1 02,0 省略了
```

这下清楚了吧，第一行第一列存储的是 1，orale 存储数据的方法很复杂。

col 1 表示的是第二列，长度是 6， 01 00 1b ab 00 01 就是索引的值，是十六进制数，我们可以转化为二进制数：

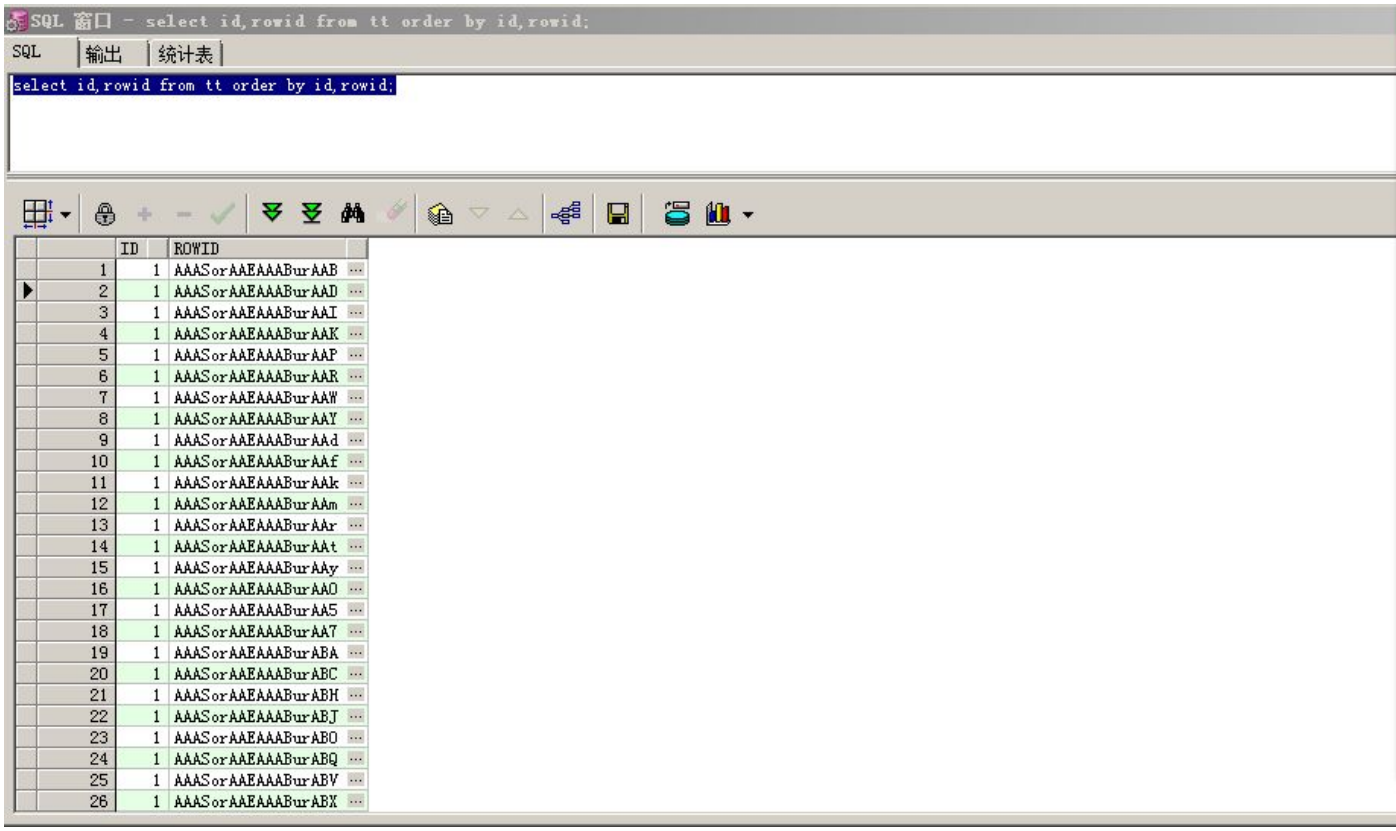
00000001 00000000 00011011 10101011 00000000 0
0000001

00000001 00 ==>1x2x2=4 前 10 位表示了数据文件号

000000 00011011 10101011 ==>4096+2048+512+256+128+32+8+2+1=7083
  这里的 22 位表示了块号

00000000 00000001==>1 16 位代表着行
号

此时排序并查 rowid：



	ID	ROWID
1	1	AAASorAAEAAABurAAB
2	1	AAASorAAEAAABurAAD
3	1	AAASorAAEAAABurAAI
4	1	AAASorAAEAAABurAAK
5	1	AAASorAAEAAABurAAP
6	1	AAASorAAEAAABurAAR
7	1	AAASorAAEAAABurAAW
8	1	AAASorAAEAAABurAAY
9	1	AAASorAAEAAABurAAd
10	1	AAASorAAEAAABurAAf
11	1	AAASorAAEAAABurAAk
12	1	AAASorAAEAAABurAAm
13	1	AAASorAAEAAABurAAr
14	1	AAASorAAEAAABurAAt
15	1	AAASorAAEAAABurAAy
16	1	AAASorAAEAAABurAAO
17	1	AAASorAAEAAABurAA5
18	1	AAASorAAEAAABurAA7
19	1	AAASorAAEAAABurABA
20	1	AAASorAAEAAABurABC
21	1	AAASorAAEAAABurABH
22	1	AAASorAAEAAABurABJ
23	1	AAASorAAEAAABurABO
24	1	AAASorAAEAAABurABQ
25	1	AAASorAAEAAABurABV
26	1	AAASorAAEAAABurABX

此时用第一列的 rowid,

通过 oracle 提供的一个包，可以求出对象编号，文件号，块号：

执行如下图：

```
SQL> create or replace procedure get_rowid(rid varchar2)
  2     is
  3     begin
  4      for x in
  5     ( select DBMS_ROWID.ROWID_OBJECT(rid) objno,
  6               DBMS_ROWID.ROWID_RELATIVE_FNO(rid) rfno,
  7              DBMS_ROWID.ROWID_BLOCK_NUMBER(rid) blockno,
  8              DBMS_ROWID.ROWID_ROW_NUMBER(rid) rownumber
  9       From dual
 10      )
 11
 12     loop
 13         dbms_output.put_line( 'Object No: ' || x.objno );
 14        dbms_output.put_line( 'R Fno: ' || x.rfno );
 15        dbms_output.put_line( 'Block Number: ' || x.blockno );
 16        dbms_output.put_line( 'Row Number: ' || x.rownumber );
 17     end loop;
 18     end;
 19  /

过程已创建。

SQL> set serveroutput on
SQL> exec get_rowid('AAASorAAEAAABurAAB
ERROR:
ORA-01756: 引号内的字符串没有正确结束


SQL> exec get_rowid('AAASorAAEAAABurAAB');
Object No: 76331
R Fno: 4
Block Number: 7083
Row Number: 1

PL/SQL 过程已成功完成。
```

上面从索引存储的段以及数据段进行分析。

我们知道索引不一定会提高查询效率，往往乱建索引会严重影响查询效率，系统用不用索引，我们不能干预（但是 dba 可以手动改变），是 oracle　　CBO 选择的结果。

下面我们可以做一个小实验：

```
SQL> select count(rowid) from t;


COUNT(ROWID)
------------
     4718644


SQL> select count(rowid) from t where id=1;
```

```
COUNT(ROWID)
------------
        4718592


SQL> select count(rowid) from t where id=2;


COUNT(ROWID)
------------
              26


SQL> select count(rowid) from t where id=3;


COUNT(ROWID)
------------
              26


SQL> set autotrace traceonly;
SQL> select * from tt;


执行计划
----------------------------------------------------------
Plan hash value: 264906180


--------------------------------------------------------------------------
| Id  | Operation             | Name | Rows  | Bytes | Cost (%CPU)| Time     |
--------------------------------------------------------------------------
|   0 | SELECT STATEMENT      |      |  3556K|    67M|  1742   (2)| 00:00:21 |
|   1 |  TABLE ACCESS FULL| TT   |  3556K|    67M|  1742   (2)| 00:00:21 |
--------------------------------------------------------------------------


Note
```

```
-----
   - dynamic sampling used for this statement (level=2)
```

此时是全表扫描读取，是多块读取，，这样读取比较快，如果此时用索引，则效率会低。

```
SQL> select * from tt where id=5;

执行计划
----------------------------------------------------------
Plan hash value: 3103123359

--------------------------------------------------------------------------------

-------

| Id  | Operation                           | Name       | Rows  | Bytes | Cost (%CPU)| Tim

e       |

--------------------------------------------------------------------------------

-------

|   0 | SELECT STATEMENT                    |            |     5 |   100 |     4   (0)| 00:

00:01 |

|   1 |  TABLE ACCESS BY INDEX ROWID| TT         |     5 |   100 |     4   (0)| 00:

00:01 |
```

```
|*   2 |    INDEX RANGE SCAN               | INDEX_T |       5 |           |       3    (0)| 00:

00:01 |

---------------------------------------------------------------------------

-------



Predicate Information (identified by operation id):
---------------------------------------------------

     2 - access("ID"=5)


Note
-----
     - dynamic sampling used for this statement (level=2)
```

此时是索引读取。

```
SQL> select * from tt where id=1;


执行计划
----------------------------------------------------------
Plan hash value: 264906180


-----------------------------------------------------------------------------
| Id   | Operation             | Name | Rows   | Bytes | Cost (%CPU)| Time       |
-----------------------------------------------------------------------------
|    0 | SELECT STATEMENT    |          |   2121K|      40M|   3644    (2)| 00:00:44 |
|*   1 |   TABLE ACCESS FULL| TT     |   2121K|      40M|   3644    (2)| 00:00:44 |
```

```
--------------------------------------------------------------------------------


Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter("ID"=1)


Note
-----
   - dynamic sampling used for this statement (level=2)
```

看到了吧，此时是全表扫描读取，数据库是很聪明的吧！