# ASM Internals

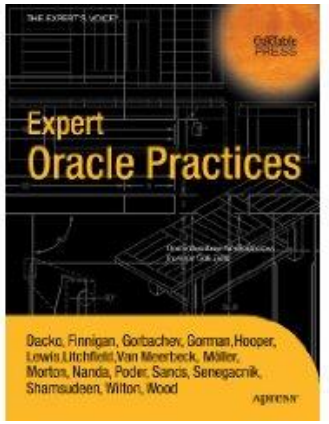
By

Riyaj Shamsudeen

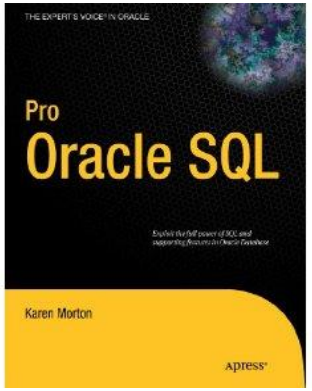
# Me

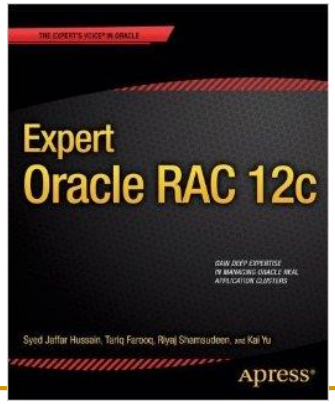
- *20+ years as DBA*
- *OakTable member*
- *Oracle ACE Director Alumni*
- *Specializes in RAC, performance tuning and Internals.*
- *Slowly in to BigData*

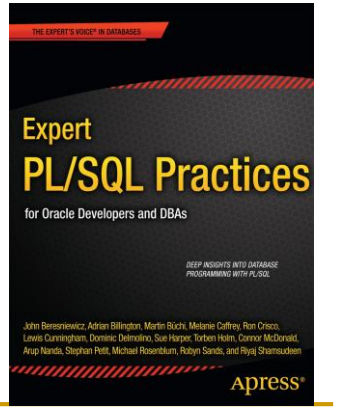
- *rshamsud@orainternals.com*
- *orainternals.wordpress.com*
- *Web: www.orainternals.com*





# WARNING

Most of the topics in this presentations are from my research.

Writing about internals have issues:

a. I completely misunderstood the data and trace files.

b. Future version changed the feature, so, information is outdated.

Tested in version 11g, 12.1.0.2, Linux and Solaris 11 platform.

# AGENDA

ASM overview: Instance, asmb etc

Tools: kfod, kfed, amdu

Disk group, redundancy, AU

ASM rebalance

Asmcmd

Conclusion

# Architecture

- ASM is an Oracle Instance with instance_type='ASM'
- ASM manages disks, luns and externalizes files to RDBMS
- ASM instance is never opened. **Simply in a mount state**.

Demo: v$instance

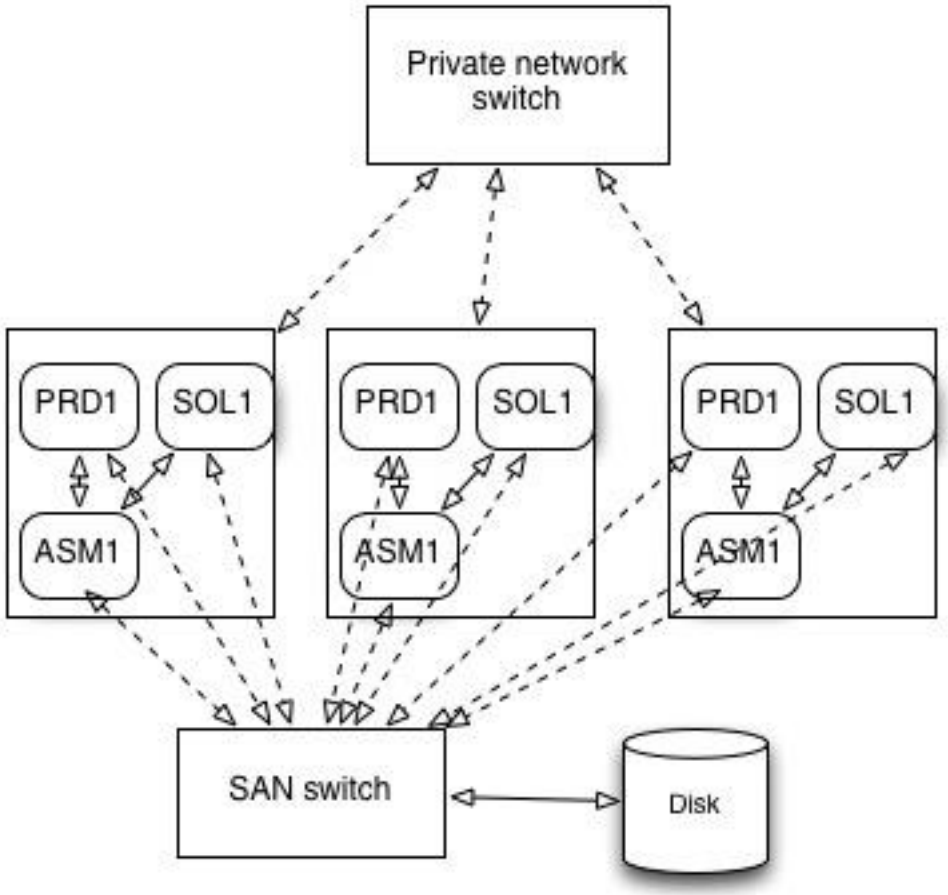
## Is ASM involved in I/O calls issued from RDBMS?

# Architecture

- ASM provides an extent map of files to RDBMS.
- **RDBMS directly accesses the disk to perform I/O**. ASM is not involved in I/O operation.
- Extending files or adding data files will involve refresh of extent map from ASM to RDBMS.

Demo: v$instance

# Architecture: With ASM



# RDBMS I/O

- Truss of DBWR: ASM is not involved for RDBMS I/O to the devices.

***Write calls to file pointer 262: (truss output)***

```
/1:     kaio(AIOWRITE, 262 , 0x6DD3C000, 8192, 0xFC17E6380F4E4000) = 0
...
/1:     kaio(AIOWRITE, 262 , 0x7DF3F000, 49152, 0xFC17D7080BD8A000) = 0
```

***File pointer 262 is a SCSI device (pfiles output)***

```
 262: S_IFCHR mode:0755 dev:291,0 ino:15728902 uid:601 gid:503 rdev:30,129
      O_RDWR|O_NONBLOCK|O_DSYNC|O_LARGEFILE FD_CLOEXEC
      /devices/iscsi/disk@0000iqm.demo.volumes-san0001,1:b,raw
```

# ASM extent pointer array

- v$sgastat shows the extent pointer array in the RDBMS. This array is retrieved from ASM instance.

```
select * from gv$sgastat where name like '%ASM extent%';
   INST_ID POOL         NAME                            BYTES
---------- ------------ -------------------------- ----------
         1 shared pool  ASM extent pointer array       171824
         2 shared pool  ASM extent pointer array       171824
```

- For large databases, this area will be bigger.

- To improve instance startup performance, only minimal extent mapping is retrieved initially. More data added to this array on need basis.

## How does RDBMS instance "knows" if local ASM instance fails?

# RDBMS is a client (aka umbilical process)

- **asmb process running in RDBMS instance makes a connection to ASM instance**, as a foreground process for ASM instance.
- asmb process sleeps in a loop and is the primary mechanism to detect ASM crash.
- If ASM instance crashes, asmb connection will die leading to an RDBMS instance crash.

Demo: asm_connections.sql, asm_clients.sql

# RDBMS as a client

- Truss of a RDBMS startup shows that a LOCAL connection was made to the ASM instance.

```
1821: 2.9102 execve("/u02/app/11.2.0/grid/bin/oracle",0x0E8E87F0,0x0E9ED510)
```

- Instance restart alone opens 6 different connections to ASM instance.

```
grep execve  truss_startup.lst |grep grid
1821:    2.9102  0.0015 execve("/u02/app/11.2.0/grid/bin/oracle", 0x0E8E87F0, 0x0E9ED510)  argc = 2
1941:    8.8772  0.0019 execve("/u02/app/11.2.0/grid/bin/oracle", 0x0E8E8090, 0x0EA11970)  argc = 2
1966:   10.0884  0.0019 execve("/u02/app/11.2.0/grid/bin/oracle", 0x0E8E8090, 0x0EA11970)  argc = 2
2002:   12.7198  0.0020 execve("/u02/app/11.2.0/grid/bin/oracle", 0x0E8E7550, 0x0E99B220)  argc = 2
2010:   13.1669  0.0020 execve("/u02/app/11.2.0/grid/bin/oracle", 0x0E8E7550, 0x0E99B220)  argc = 2
2066:   29.0296  0.0024 execve("/u02/app/11.2.0/grid/bin/oracle", 0x0E8E7550, 0x0E99B220)  argc = 2
```

# Death of asmb process

- asmb process sleeps on "ASM background timer" with 5s sleep cycle.

***** 2011-10-05 00:38:11.486**

**WAIT #0: nam='ASM background timer' ela= 5001967 p1=0 p2=0 p3=0 obj#=-1 tim=1247836548**

- I killed the connection from ASM instance, resulting in asmb process death, followed by RDBMS instance crash

NOTE: ASMB terminating

Errors in file /u01/app/oracle/diag/rdbms/solrac/solrac1/trace/solrac1_asmb_1492.trc:

ORA-15064: communication failure with ASM instance

ORA-03113: end-of-file on communication channel

Process ID:

Session ID: 30 Serial number: 3

…

ASMB (ospid: 1492): **terminating** the instance due to error 15064

Demo: Killing asmb connection

## ASM disks

- During ASM startup, ASM instance scans the disks to identify all ASM disks.
- Parameter asm_diskstring identifies the disks to scan.
- To improve ASM startup time, set this parameter properly.
- For example,

  asm_diskstring = /dev/rdsk/c2t*d0s1

## How to validate the asm_diskstring parameter from OS?

# kfod

Kfod –h for help

- kfod utility can be used to check all devices that qualifies asm_diskstring.

```
$kfod status=TRUE asm_diskstring='/dev/mapper/' disks=ALL
verbose=TRUE
--------------------------------------------------------------------------------
 Disk          Size Header    Path                                       User     Group
================================================================================
   1:      20473 Mb MEMBER    /dev/mapper/asmdisk1p1                     oracle   oinstall
   2:      20473 Mb MEMBER    /dev/mapper/asmdisk2p1                     oracle   oinstall
--------------------------------------------------------------------------------
ORACLE_SID ORACLE_HOME
================================================================================
     +ASM1 /u01/app/12.1.0/grid
KFOD-00311: Error scanning device /dev/mapper/control
ORA-27041: unable to open file
Linux-x86_64 Error: 13: Permission denied
Additional information: 42
KFOD-00311: Error scanning device /dev/mapper/36000c29d5fb1e04764ebbedd94bb6acd
ORA-27041: unable to open file
Linux-x86_64 Error: 13: Permission denied
```

…

**Must you have the same LUN path in all nodes of a RAC cluster?**

## kfed disk header

- kfed utility can be used to dump the metadata block(s) of the device.
  - Without any parameter, kfed reads disk header.

```
$ kfed read  /dev/rdsk/c2t9d0s1
kfbh.endian:                          1 ; 0x000: 0x01
..
kfbh.type:                            1 ; 0x002: KFBTYP_DISKHEAD
..
kfbh.block.blk:                       0 ; 0x004: T=0 NUMB=0x0
kfbh.block.obj:              2147483655 ; 0x008: TYPE=0x8 NUMB=0x7…
kfdhdb.compat:                186646528 ; 0x020: 0x0b200000
kfdhdb.dsknum:                        7 ; 0x024: 0x0007
kfdhdb.grptyp:                        1 ; 0x026: KFDGTP_EXTERNAL
kfdhdb.hdrsts:                        3 ; 0x027: KFDHDR_MEMBER
kfdhdb.dskname:              DATA_0007 ; 0x028: length=9
kfdhdb.grpname:                   DATA ; 0x048: length=4
kfdhdb.fgname:               DATA_0007 ; 0x068: length=9
kfdhdb.capname:                       ; 0x088: length=0
```

Demo: kfed read

# kfed ..2

```
kfdhdb.secsize:                 512 ; 0x0b8: 0x0200
kfdhdb.blksize:                4096 ; 0x0ba: 0x1000
kfdhdb.ausize:              1048576 ; 0x0bc: 0x00100000
kfdhdb.mfact:                113792 ; 0x0c0: 0x0001bc80
kfdhdb.dsksize:                2000 ; 0x0c4: 0x000007d0
kfdhdb.pmcnt:                     2 ; 0x0c8: 0x00000002
kfdhdb.fstlocn:                   1 ; 0x0cc: 0x00000001
kfdhdb.altlocn:                   2 ; 0x0d0: 0x00000002
kfdhdb.f1b1locn:                  0 ; 0x0d4: 0x00000000
kfdhdb.redomirrors[0]:            0 ; 0x0d8: 0x0000
kfdhdb.redomirrors[1]:            0 ; 0x0da: 0x0000
kfdhdb.redomirrors[2]:            0 ; 0x0dc: 0x0000
kfdhdb.redomirrors[3]:            0 ; 0x0de: 0x0000
kfdhdb.dbcompat:          168820736 ; 0x0e0: 0x0a100000
```

Demo: kfed read

# ASM disks - RAC

- A LUN must be visible in all nodes of a cluster with proper permissions for ASM to consider a lun.
- This means that the path need not be the same, but lun should exist and visible through asm_diskstring parameter.

- For example, same device have different names in two nodes:

```
node1 /dev/rdsk/c2t9d0s1
node2 /dev/rdsk/c2t11d0s1
```

- ASM identifies Lun even if configuration changes later

- Metadata kept in every disk header.

Demo: show parameter asm_diskstring

## How to handle minor corruptions ?

# kfed other blocks

- kfed can be used to read other blocks in the lun also.

```
$ kfed read  /dev/rdsk/c2t9d0s1 aun=0 blkn=1 |grep kfbh.type
kfbh.type:                                2 ; 0x002: KFBTYP_FREESPC

$ kfed read  /dev/rdsk/c2t9d0s1 aun=0 blkn=2 |grep kfbh.type
kfbh.type:                                3 ; 0x002: KFBTYP_ALLOCTBL

# ASM also stores backup disk header in the second allocation
   unit, last 2 blocks.
$ kfed read  /dev/rdsk/c2t9d0s1 aun=1 blkn=254 |more
kfbh.type:                                1 ; 0x002: KFBTYP_DISKHEAD
kfbh.datfmt:                              1 ; 0x003: 0x01
…
```

Demo: kfed read

# Corrupting header

- Minor header related **repair** possible

```
$ kfed read /dev/mapper/asmdisk4p1 |more
kfbh.endian:                          1 ; 0x000: 0x01
kfbh.hard:                          130 ; 0x001: 0x82
kfbh.type:                            1 ; 0x002: KFBTYP_DISKHEAD

$ dd if=/dev/zero of=/dev/mapper/asmdisk4p1  bs=1M count=1
1+0 records in
1+0 records out

$ kfed read /dev/mapper/asmdisk4p1 |more
kfbh.endian:                          0 ; 0x000: 0x00
kfbh.hard:                            0 ; 0x001: 0x00
kfbh.type:                            0 ; 0x002: KFBTYP_INVALID
```

Demo: kfed read

# Kfed repair

```
$ kfed repair /dev/mapper/asmdisk4p1

$ kfed read /dev/mapper/asmdisk4p1 |more
kfbh.endian:                          1 ; 0x000: 0x01
kfbh.hard:                          130 ; 0x001: 0x82
kfbh.type:                            1 ; 0x002: KFBTYP_DISKHEAD
```

Demo: kfed read

# amdu

amdu can be used to extract files using extract option, even when the disks are corrupt.

```
$ amdu -diskstring=/dev/mapper/asmdisk3p1
amdu_2017_01_14_07_36_15/

$ ls -lt amdu_2017_01_14_07_36_15/
total 4
-rw-r--r--. 1 oracle oinstall 1834 Jan 14 07:36 report.txt

$ more amdu_2017_01_14_07_36_15/report.txt
-*-amdu-*-
******************************** AMDU Settings
   ********************************
ORACLE_HOME = /u01/app/12.1.0/grid
System name:    Linux
Node name:      rac1.localdomain
Release:        3.8.13-44.el6uek.x86_64
Version:        #2 SMP Fri Aug 8 21:59:01 PDT 2014
Machine:        x86_64
amdu run:       14-JAN-17 07:36:15
Endianess:      1
```

# amdu

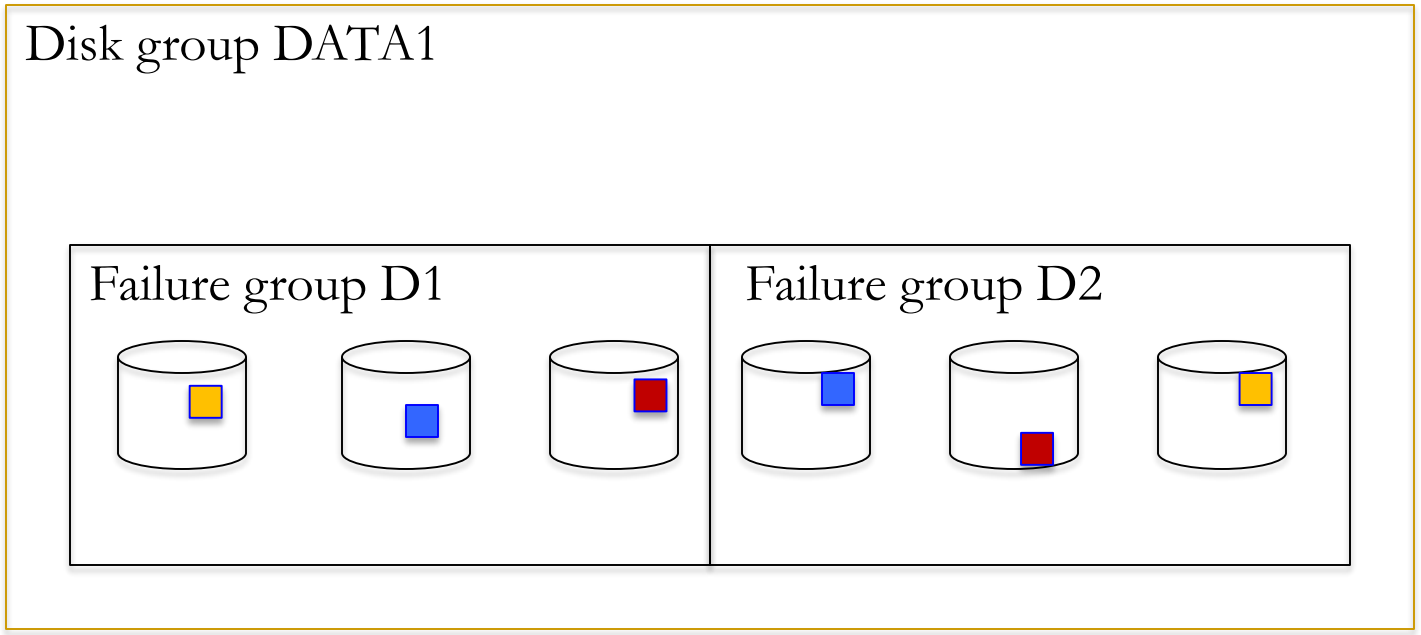
```
---------------------------- DISK REPORT N0001 ------------------------------
                Disk Path: /dev/mapper/asmdisk3p1
           Unique Disk ID:
               Disk Label:
    Physical Sector Size: 512 bytes
               Disk Size: 2047 megabytes
              Group Name: TEST
               Disk Name: TEST_0000
      Failure Group Name: TEST_0000
             Disk Number: 0
           Header Status: 3
     Disk Creation Time: 2017/01/11 23:49:59.434000
        Last Mount Time: 2017/01/14 07:32:17.969000
   Compatibility Version: 0x0a100000(10010000)
        Disk Sector Size: 512 bytes
        Disk size in AUs: 2047 AUs
        Group Redundancy: 2
     Metadata Block Size: 4096 bytes
                 AU Size: 1048576 bytes
                  Stride: 113792 AUs
```

...

**What is the critical difference between ASM mirroring and OS mirroring?**

# ASM disk group

- Picture of a Disk group with Normal redundancy. Two failure groups are allocated since this is a mirrored disk group.
- ASM does not mirror disks, rather extents are kept in two separate failure groups.



# Example

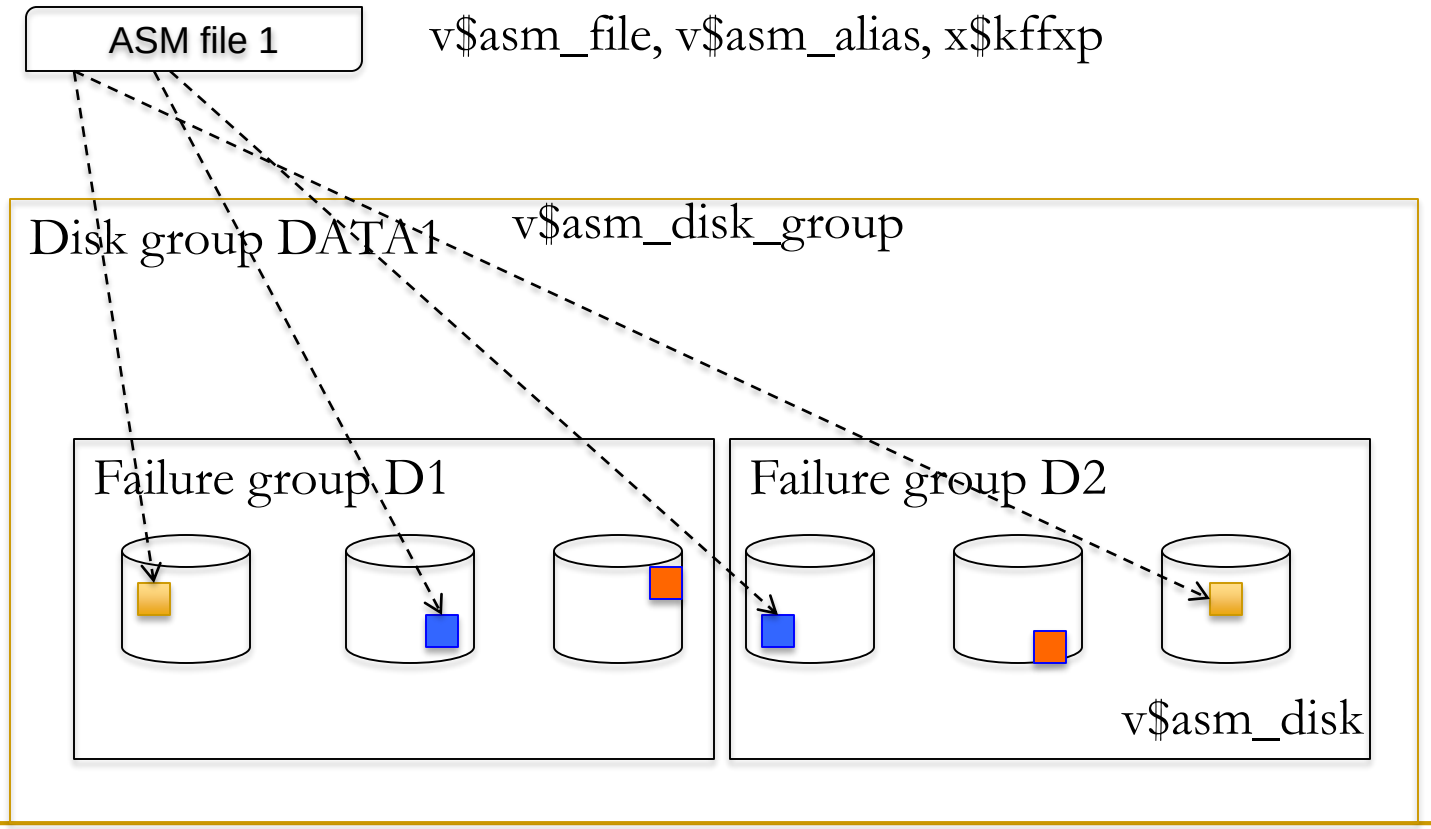
Construct the failure groups such a way that one component failure affects at the most one failure group.

```
create diskgroup DATA normal redundancy
    Failure group fl1 disk
    '/dev/rdsk/c3t11d3s4','/dev/rdsk/c3t11d4s4','/dev/rdsk/c3t11d5s4',
    '/dev/rdsk/c3t11d6s4'
    Failure group fl2 disk
    '/dev/rdsk/c4t12d3s4','/dev/rdsk/c4t12d4s4','/dev/rdsk/c4t12d5s4',
    '/dev/rdsk/c4t11ds4'
    Failure group fl3 disk
    /dev/rdsk/c5t13d3s4','/dev/rdsk/c5t13d4s4','/dev/rdsk/c5t13d5s4',
    '/dev/rdsk/c5t13ds4'
    Failure group fl4 disk
    /dev/rdsk/c6t14d3s4','/dev/rdsk/c6t14d4s4','/dev/rdsk/c6t14d5s4',
    '/dev/rdsk/c6t14ds4';
```

# Hierarchy of ASM files, disks, etc

# ASM files – Normal redundancy

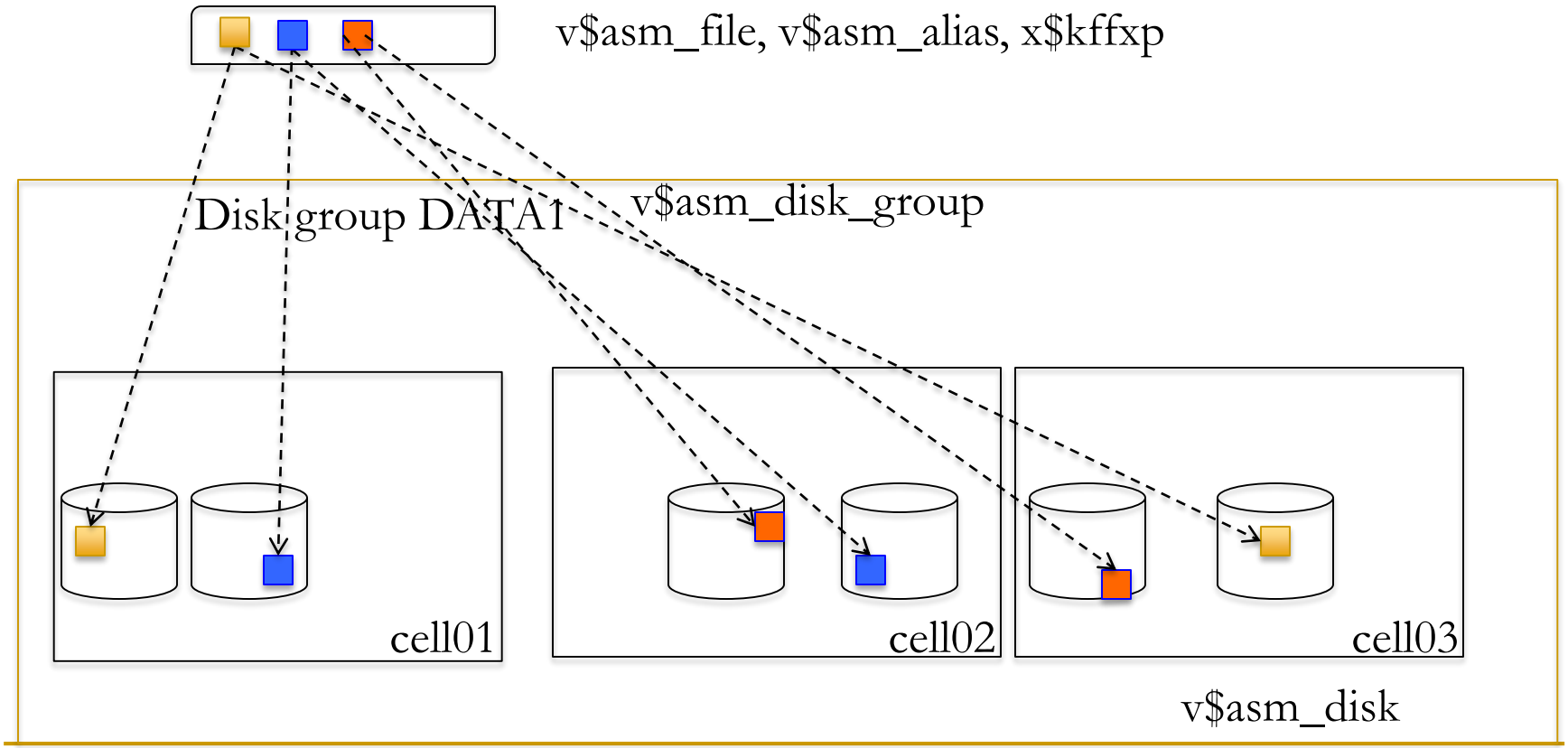
- ASM files are allocated from mirrored extents between the failure groups.




Demo: asm_file_analysis.sql

# ASM files – Normal redundancy - Exadata

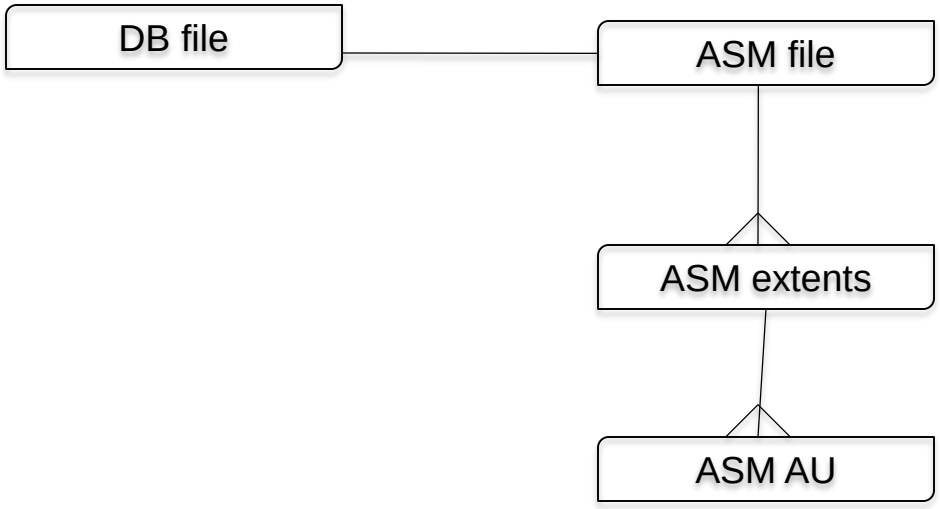
- ASM files are allocated from mirrored extents between the failure groups.




Demo: asm_file_analysis.sql

# Extents vs Files

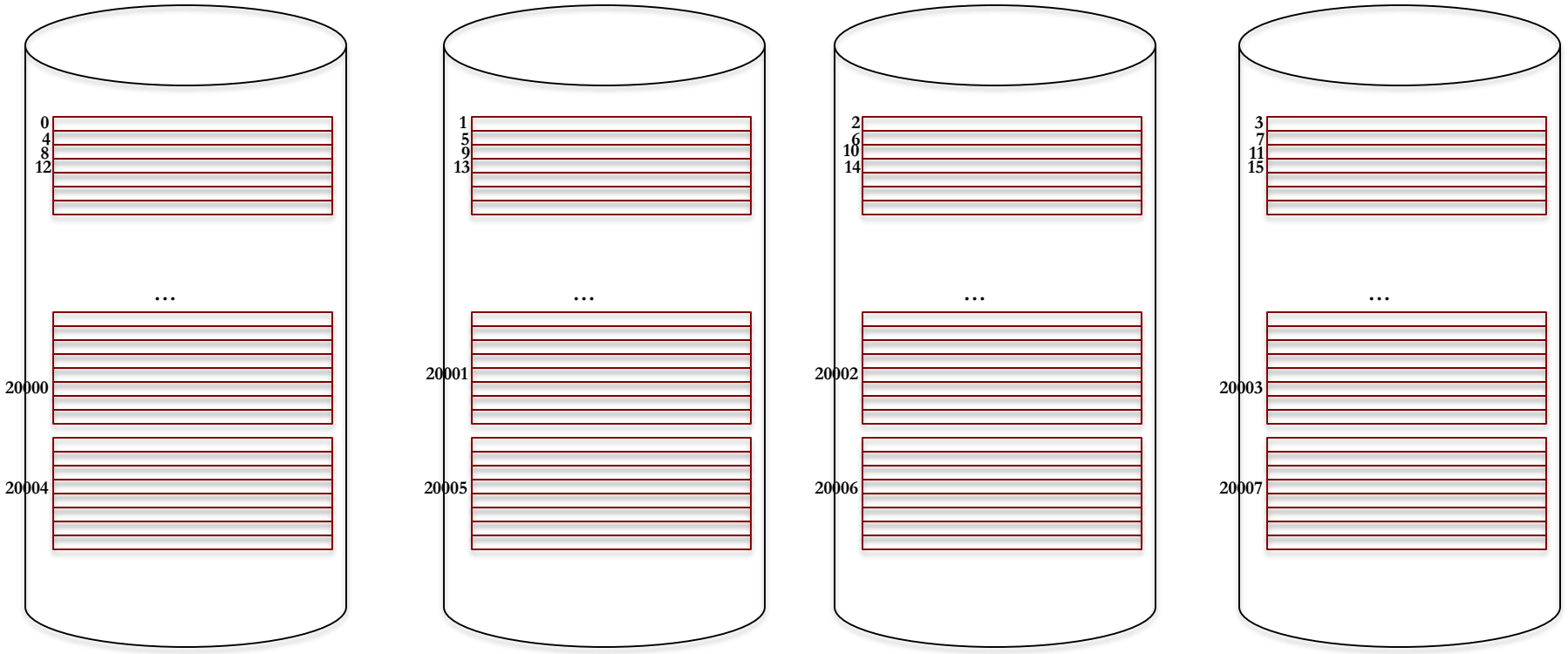
- ASM files are allocated as series of extents.
- ASM extents are made up of one or more allocation units.




- ASM extents are contained within an ASM disk though.

# Extent vs AU

- 1 extent = 1 AU up to 20000 extents. 1 extent=8 AUs after 20000 extents.
- This is one asm file and so extents are distributed between the devices (striping).



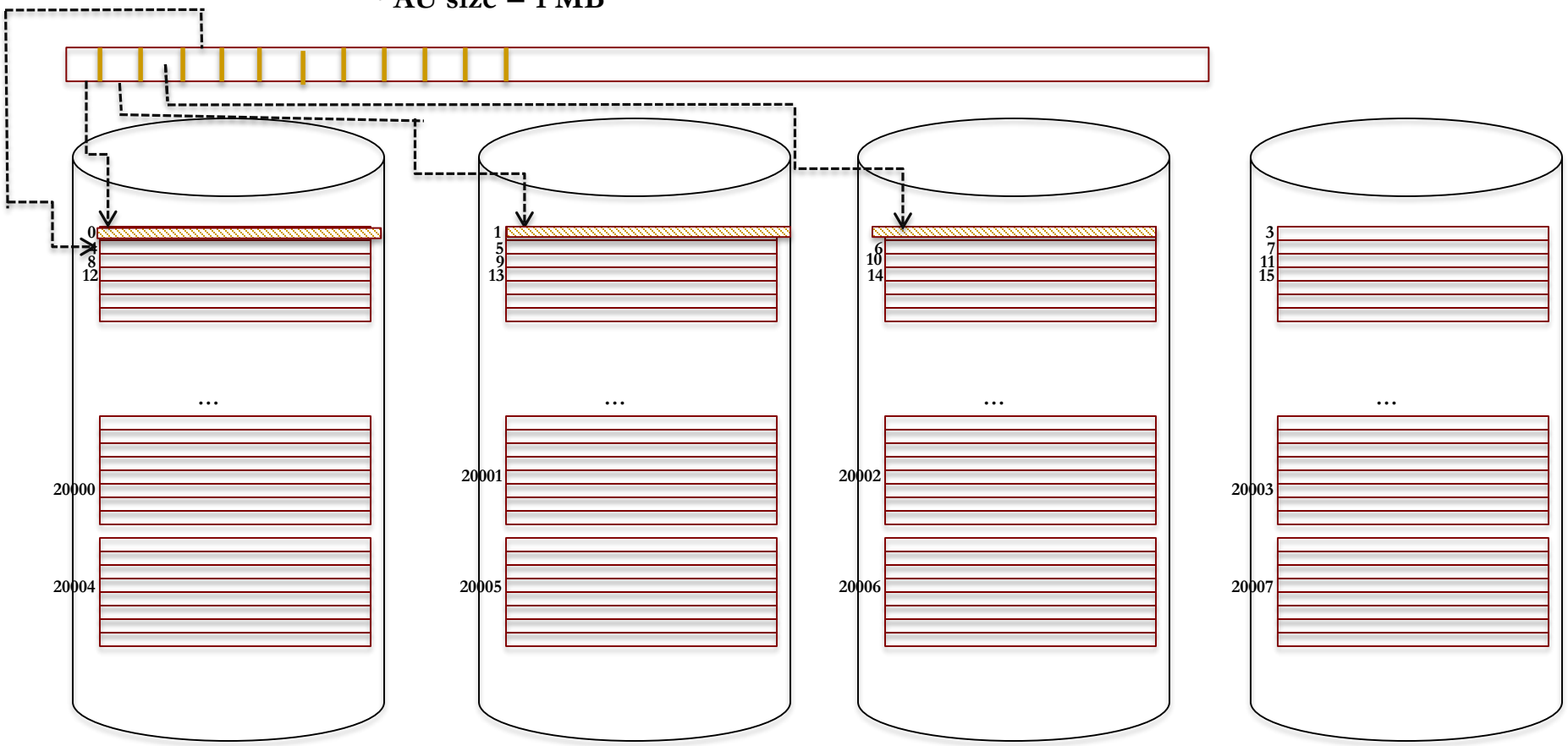

- Source: Concepts manual

# Allocation_unit (AU)

- Allocation unit defines a smallest size disk segment that can be allocated, at disk group level.
- Allocation_unit defaults to 1MB. It can be increased in multiples of 2 i.e. 2,4,8,16MB etc while creating a diskgroup. (11g). 4MB recommended.
- Increased allocation_unit is useful in VLDB daabases. 32MB/64MB possible if compatible>=11.1.
- Once a disk group is created with an allocation unit it can not be altered.
- In 10g, underscore parameters _asm_ausize can be used to modify the allocation_unit.

# AU & Striping (course grained)

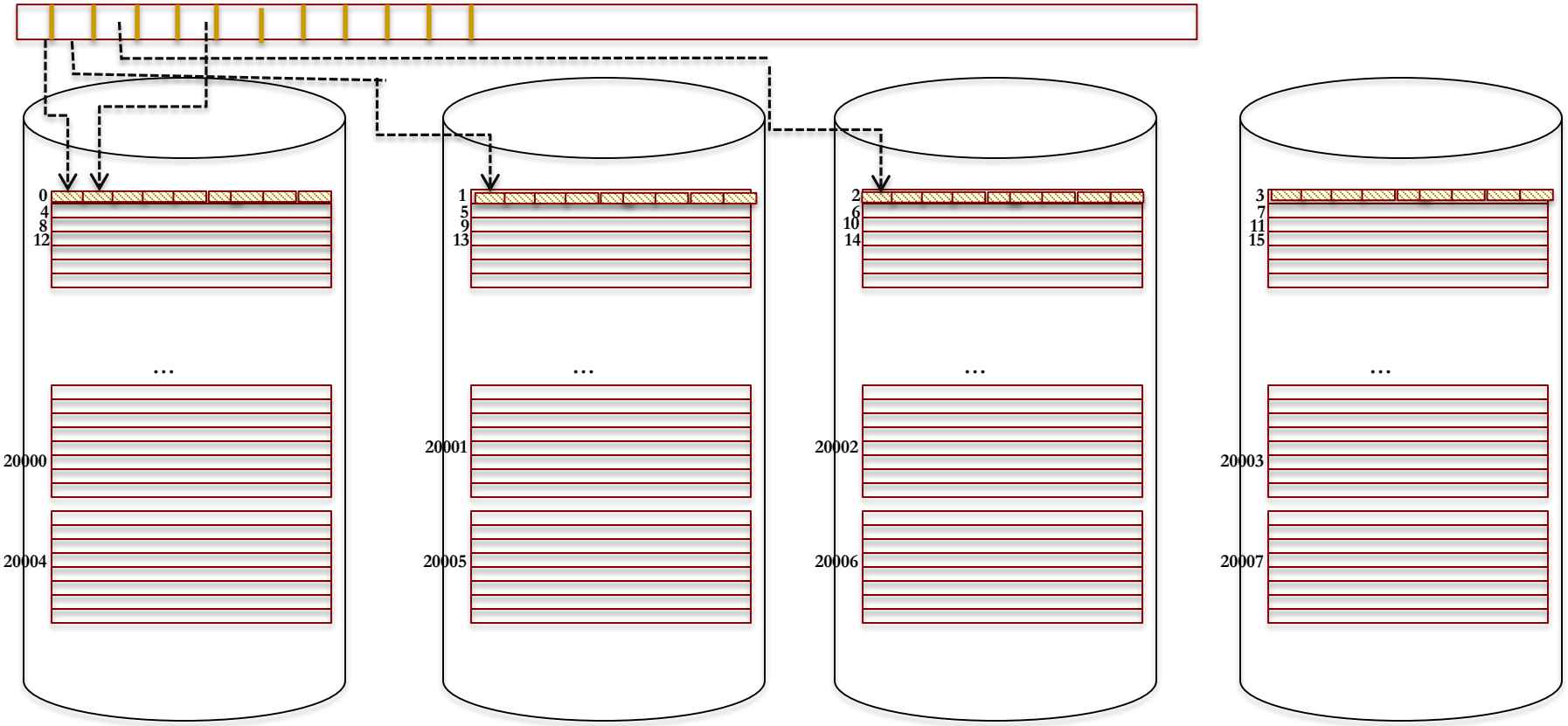
- Stripe size = 1MB for better read size such as data files
- AU size = 1 MB




- Source: Concepts manual

# AU & Striping (fine grained)

- Stripe size = 128KB for higher latency files such control file and redo log files
- AU size = 1 MB

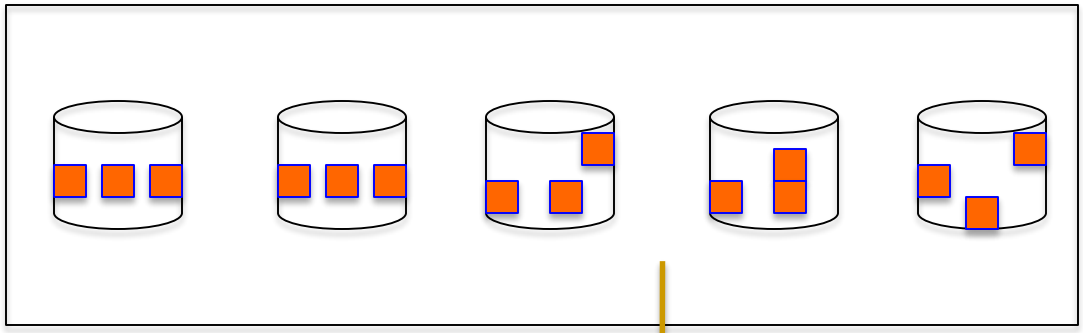


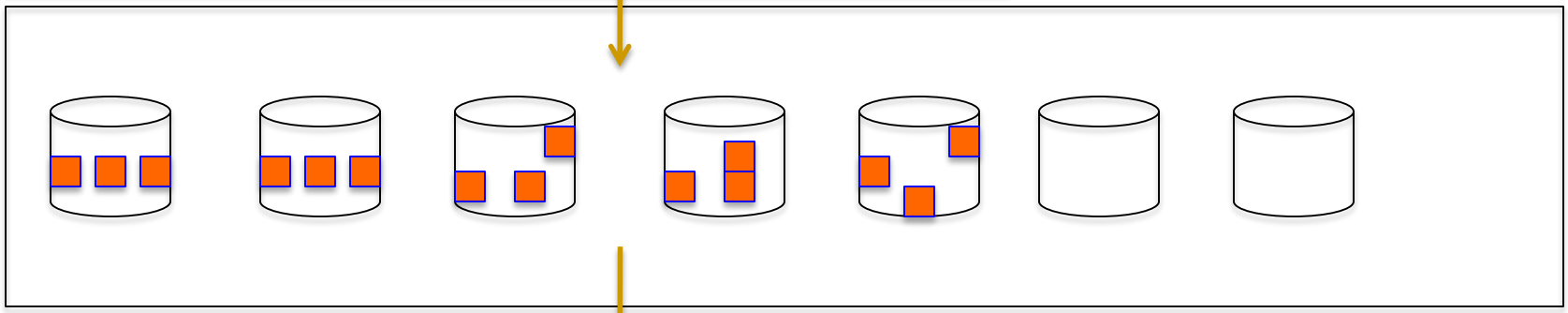

- Source: Concepts manual

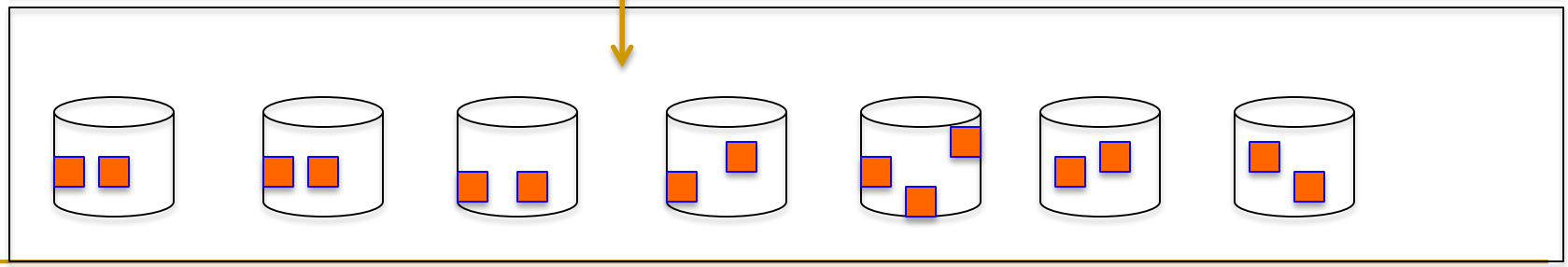
# Rebalance

# Rebalance

- Addition or deletion of asm disk from a disk group will trigger a rebalance operation.





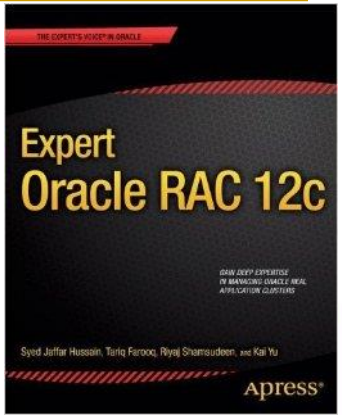


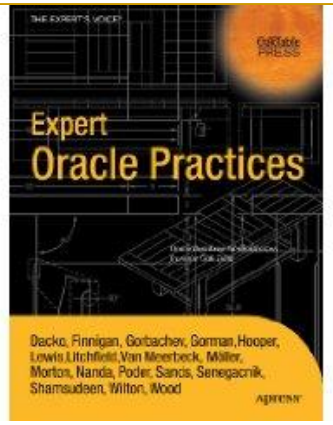
Extents are moved from existing disks to new disks, rebalancing the disk usage.

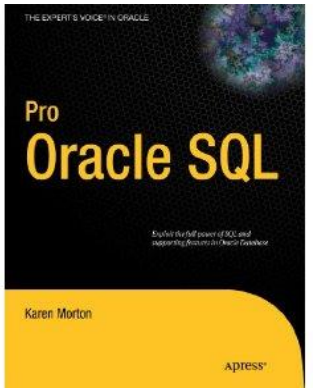
## Processing details

- RBAL is triggered when there is addition/deletion/resize of disks.
- RBAL acts as a co-ordinator process, updates metadata that ASM rebalance is underway.
- Determines the extent to move and the target disk. Hands off the work to ARBx process.
- ARBx process moves the extent and replies back to RBAL after the successful completion.
- This goes on until RBAL completes the rebalance operation.

# THANK YOU


- Email: rshamsud@orainternals.com
- Blog : orainternals.wordpress.com
- Web: www.orainternals.com