Western Digital® IntelliFlash™ - Oracle® Database
Best Known Methods

Revision 1.0
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Overview

Western Digital’s IntelliFlash arrays enable Oracle Databases and applications to thrive by accelerating transactions and simplifying workflows. With the IntelliFlash’s patented metadata acceleration transaction wait times are dramatically reduced by orders of magnitude which not only provides performance but better economics. IntelliFlash arrays deliver the performance your applications need and eliminate the requirement to run multiple storage silos for online transaction processing (OLTP) and online analytical processing (OLAP) workloads.

IntelliFlash arrays enable you to simultaneously access your Oracle Database instances through block and file protocols from the same array, giving you greater flexibility on how you deploy and manage your storage infrastructure. The multi-protocol support of both block and file gives not only classic Fibre Channel database performance but with integration and support of Oracle direct network file system (See Western Digital IntelliFlash Arrays with Oracle dNFS) you have the flexibility to choose one or the other or both.

Performance is on everyone’s mind but not every Oracle application environment needs sub-millisecond response times. The IntelliFlash’s wide product portfolio gives you a storage solution that allows you to run Oracle Databases for development, test, quality assurance (QA), and production. And all the features are available, from inline deduplication, compression, and replication to data management capabilities like snapshots and clones.

This document describes the current best known methods for deploying Oracle Database with a Western Digital IntelliFlash array. The base testing stems from the perspective of an Oracle Validated Configuration. These configurations are thoroughly tested in conjunction with Oracle. They consist of Oracle Linux® and Grid with Oracle Automatic Storage Manager (ASM LIB) on Western Digital IntelliFlash arrays. Oracle Linux is only one of several supported Linux operating systems and Oracle Grid and ASM are only one example of a RAID disk group that could be used.

Scope

For purposes of this document, Oracle Database 18c and Oracle Linux 7 with Unbreakable Enterprise Kernel (UEK) were used but these recommendations also apply to Oracle Database 12c, 11g and using the Red Hat® kernel with Oracle Linux. This also applies to earlier versions of Oracle Linux as well as other Linux distributions such as Red Hat and SuSE with their default kernels.
As such, this document contains requirements and recommendations for building a basic Linux system with a single database instance. It looks at all aspects of the setup from the IntelliFlash array to the networks and finally the Oracle Database server.

Best practices are provided for the following areas:

- IntelliFlash Storage Array Provisioning
- Fibre Channel Network Configuration
- Oracle Linux Operating System Configuration
  - Multipathing Customization
- Oracle Grid Infrastructure Installation
- Oracle Automatic Storage Manager (ASM) Configuration
- IntelliFlash Features Use Case
  - Snapshots and Clones

Note: This guide does not take into account requirements for security, performance, resilience, and other operational aspects that may vary for individual customer deployments. This document is not an endorsement of Oracle software by Western Digital, and no warranty of the products is either expressed or implied. If recommendations in this document conflict with current operational guidelines, those existing policies should be given higher priority. Western Digital accepts no liability for any issues resulting from following these recommendations.

**Target Audience**

This guide is intended for system, storage, and database administrators, and implementation engineers who manage, monitor, or deploy database servers and storage solutions in the datacenter. It is recommended that those who will implement these best practices have familiarity with networking, storage systems, and Oracle Database concepts and functionality.
Typical Oracle Environment
The software for an Oracle environment is the same for any protocol being used but hardware can vary. Below is a simple listing of the software used and the hardware for a particular protocol.

Software Components
- Oracle, RedHat, or SuSE Linux x86_64
- Oracle Grid Infrastructure 18c for Linux x86-64
- Oracle Database 18c Enterprise Edition – 64 bit Production

Fibre Channel Components
The recommendations and settings for a Fibre Channel environment look like configuration like the setup in Figure 1.

Fibre Channel Hardware
- Western Digital IntelliFlash T-series, HD series or N-Series All-Flash Storage Array
- Two Fibre Channel Switches
IntelliFlash Configuration

The following recommendations are made for optimal performance when provisioning IntelliFlash storage for Oracle Database environments:

**Pool Type**
*Use double-parity storage pools* - With two equal size pools in an active/active configuration, this provides both data redundancy and greater performance by taking advantage of the full capabilities of both controllers in the array.

**Compression**
*Enable data compression* – The IntelliFlash compression technology is a powerful way to reduce the overall storage capacity requirements for Oracle environments. The LZ4 compression algorithm is recommended for database workloads.

**Deduplication**
*Disable deduplication* - Due to the nature of Oracle Database blocks and the underlying data, Oracle deployments are not well suited for data deduplication. Significant savings are not realized in Oracle environments, so data deduplication is not recommended.

**Block Size**
*DATA LUN* – For OLTP and data warehouse workloads a 16 KB block size for the DATA LUN was found to produce optimal performance.

Not all environments are the same and should be tested and modified accordingly. Modify the Oracle DB_BLOCK_SIZE parameter to match the LUN block size selected.

**Thin Provisioning**
*Use thin provisioning when creating LUNs for Oracle ASM disk groups* – Thin provisioning dynamically allocates storage capacity on the array as it is needed. This avoids performance problems associated with wasted capacity when over-allocating storage for future needs.

Use the following sections to configure the above best practices using the IntelliFlash array’s UI.
Pool Configuration

Two pools should be created with Active/Active configuration using 2-way mirroring. Each pool is assigned half of the total number of disks.

---

Project Configuration

Each project is configured with the Purpose configure to Generic, using the Fibre Channel access protocol. This project defines the settings of all the LUNs that reside inside. This simplifies configuring the settings and access to the LUNs. See Figure 3.

---

Figure 2 - Pool Configuration Settings

Figure 3 - Project Configuration Settings
Each project is configured with LZ4 compression. Deduplication is not enabled for Oracle Database workloads. See Figure 4.

![Figure 4 - Project Configuration Settings](image)

**LUN Configuration**

Each LUN is created with thin provisioning, using with a 16 KB block size and the Fibre Channel access protocol. The *Purpose* of the LUNs are set to *Database*. See Figure 5.

During the project creation phase the *Purpose* was set to *Generic*. That was to allow other LUN specific versions to be available during LUN creation. By selecting a particular purpose in this phase it will prepopulate the Block Size setting. Here the *Database* purpose gives a default 16KB block size as mentioned previously.

If there is a need to test other specific block sizes then select a *Generic* purpose for the LUN and pick the desired block size.
Fibre Channel Network Configuration

Western Digital recommends that any server connected to an IntelliFlash array to always utilize redundant paths to protect against hardware failure, which also provides load balancing and superior performance. In Figure 1, a FC configuration with redundant paths is shown connecting a database server to an IntelliFlash array.

In this configuration, all paths of the server’s dual HBAs are utilized in connecting to the storage array. Should a hardware failure occur on either controller in the array, all Pools will be migrated to the surviving controller with all ports in the database server still being utilized for I/O traffic.

We recommend the usage of NPIV when creating projects and zoning. From a host perspective it will only see active paths. When a controller fails and the resources move to the remaining controller the NPIV paths continue to show active to the server as though no failure occurred.

Oracle Linux Configuration

Download the Oracle Linux installation package from the Oracle Software Delivery Cloud.

Install Oracle Linux by booting the system from DVD or the ISO installation file, and follow the prompts. It is recommended to install Linux with the package group “Server with GUI”.

Figure 5 - LUN Configuration Settings
After the Oracle Linux operating system installation is complete, the following Oracle-specific packages should also be installed:

**Note:** For ease of Oracle Database installation – You can use a preinstall package that Oracle provides to configure some of the more tedious tasks. Depending on the version of Oracle Database you’re installing it’ll look something like the following file where ## is the database version:

**For Oracle 12cR2 and later**
- oracle-databaserver-##-preinstall

**For Oracle 12cR1 and earlier**
- oracle-rdbms-server-##-preinstall

The following additional packages are also required:

<table>
<thead>
<tr>
<th>Binutils</th>
<th>compat-libcap1</th>
</tr>
</thead>
<tbody>
<tr>
<td>compat-libstdc++</td>
<td>device-mapper-multipath</td>
</tr>
<tr>
<td>gcc</td>
<td>gcc-c++</td>
</tr>
<tr>
<td>glibc</td>
<td>glibc-devel</td>
</tr>
<tr>
<td>ksh</td>
<td>libgcc</td>
</tr>
<tr>
<td>libstdc++</td>
<td>libstdc++-devel</td>
</tr>
<tr>
<td>libaio</td>
<td>libaio-devel</td>
</tr>
<tr>
<td>libXScrnSaver</td>
<td>make</td>
</tr>
<tr>
<td>nfs-utils</td>
<td>ntp</td>
</tr>
<tr>
<td>openssh-server</td>
<td>sysstat</td>
</tr>
<tr>
<td>telnet</td>
<td>telnet-server</td>
</tr>
<tr>
<td>xinetd</td>
<td>xorg-x11*</td>
</tr>
</tbody>
</table>

**Kernel and Limit Settings**
These settings may vary depending on the physical memory of your database server. It is highly recommended to use the **Oracle Preinstallation RPM** which, among other pre-installation tasks, sets these both the kernel and limit parameters appropriately.

**Kernel Settings**
For optimal performance, Oracle Linux should have the follow kernel parameters configured:

- `fs.file-max = 6815744`
- `kernel.sem = 250 32000 100 128`
- `kernel.shmmni = 4096`
- `kernel.shmmax = 1073741824`
- `kernel.shmall = 439804651104`
- `kernel.panic_on_oops = 1`
Note: The settings above are only examples values. The Oracle Preinstallation RPM will determine the appropriate values.

Limit Settings
The following lines should have been added to the file /etc/security/limits.conf for user oracle:

```
# shell limits for user oracle
oracle soft nofile 1024
oracle hard nofile 65536
oracle soft nproc 2047
oracle hard nproc 16384
oracle soft stack 10240
oracle hard stack 32768
oracle soft memlock 3145728
oracle hard memlock 3145728
```

Note: The settings above are only examples values. The Oracle Preinstallation RPM will determine the appropriate values.

Multipathing Customization
Tegile recommends that Linux multipathing be customized as follows:
Verify that Linux multipathing is installed. As user root:

```
# yum list device-mapper
```

Verify that Linux multipathing is enabled. As user root:

```
# multipath -ll
```

If needed, start Linux multipathing agent. As user root:

```
# service multipathd start
```

Create the /etc/multipath.conf file with the following lines:
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```plaintext
defaults {
    user_friendly_names yes
}
devices {
    device {
        vendor "TEGILE"
        product "INTELLIFLASH"
        hardware_handler "1 alua"
        path_selector "round-robin 0"
        path_grouping_policy "group_by_prio"
        dev_loss_tmo 200
        path_checker tur
        prio alua
        no_path_retry 28
        failback immediate
        rr_min_io 8
    }
}
mutipaths {
    multipath {
        wwid xxxxxxxxxx (substitute WWID of specific LUN here)
        alias DATA1
    }
    multipath {
        wwid xxxxxxxxxx (substitute WWID of specific LUN here)
        alias DATA2
    }
}

After creating the /etc/multipath.conf file, flush the device mapper and rescan. As user root:

# multipath -F
# multipath -v2

Verify that LUNs appear with correct multipathing and aliases as specified in /etc/multipath.conf file. As user root:

# multipath -ll

With NPIV the LUNs should have 1 priority setting. The active controller paths should have priority=50 and status=active.
DATA1 (361c5a0b06b0a9b4b00005ae0f866000a) dm-8 TEGILE ,INTELLIFLASH
size=500G features='1 queue_if_no_path' hwhandler='1 alua' wp=rw
`-> policy='round-robin 0' prio=50 status=active
| 1:0:3:8  sdt  65:48  active ready running
| 2:0:0:8  sdk  8:160 active ready running
| 1:0:2:8  sdw  65:96  active ready running
| 2:0:1:8  sdh  85:112 active ready running

Note: If NPIV is not used and the physical ports are used there will be an additional path
type of priority=1 and a status=enabled. This represents the standby paths.

Oracle Grid Infrastructure Installation

The following steps are recommended to install and configure Oracle Grid Infrastructure
software. Using Oracle Grid and Oracle ASM is not mandatory as there are other
methods for volume management. However, it is recommended by Oracle and has
been thoroughly vetted by Western Digital.

Download the Oracle Grid Infrastructure installation package from the Oracle Software
Delivery Cloud (http://edelivery.oracle.com). For purposes of this document, Oracle Grid
Infrastructure 12.2.0.1.0 for Linux x86-64 was used.

Create directories for the Oracle Grid Infrastructure installation. For purposes of this
document,

```
ORACLE_BASE=/oracle/12c
ORACLE_HOME=/oracle/grid
```

As user root:

```
# mkdir -p /oracle/grid
# chown -R oracle:oinstall /oracle
# chmod -R 775 /oracle
```

Install the Oracle Grid software by first unzipping the installation file. Then run the
Oracle Database Grid Infrastructure installer and follow the prompts. Consult the Oracle
Grid Infrastructure Installation Guide for detailed installation steps.

As user oracle, set the Oracle environment variables to Oracle Grid home. Then run the
Oracle Grid installer.

```
# ./gridSetup.sh
```
Oracle Automatic Storage Manager (ASM) Configuration

For simplicity and performance, it is recommended that Oracle ASM be used for deploying IntelliFlash storage with an Oracle Database environment. The following configuration recommendations are made:

1. Create Oracle ASM disk groups specifying external redundancy. IntelliFlash storage pools are created with built-in redundancy so additional overhead from specifying Oracle ASM redundancy should be avoided.

2. Create separate Oracle ASM disk groups for
   - DATA (tablespaces and temp)
   - LOGS (redo logs) - Redo logs store all changes made to the database as they occur
   - FRA (Fast Recovery Area) - The Fast Recovery Area is an Oracle-managed central storage location for backup and recovery files.

Separate Oracle ASM disk groups for redo logs and Fast Recovery Area can be used to provide for the segregation of disks and redundancy in case a database recovery is required.

3. Add LUNs to Oracle ASM disk groups in pairs, balanced between 2 storage pools. This approach takes advantage of the performance benefits of IntelliFlash’s active/active controller technology. If only using a single pool then still add disks in pairs to absorb any potential space loss from thin provisioning.

4. When creating an Oracle ASM disk group, eight LUNs of equal size per disk group is recommended. Tests show that this can result in greater performance and lower latency.

5. To avoid the unnecessary overhead of Oracle ASM rebalancing, increase the size of existing LUNs rather than add new LUNs to Oracle ASM disk groups.

For deployment of Oracle ASM with IntelliFlash storage, first verify that Oracle ASM is installed. As user root:

```
# yum list oracleasm
```

If needed, install Oracle ASM packages.
As user root:
Assign ASM labels to LUNs using multipathing aliases.

As user root:

```
# /etc/oracleasm createdisk DATA1 /dev/mapper/DATA1
# /etc/oracleasm createdisk DATA2 /dev/mapper/DATA2
```

As user oracle, set the Oracle environment variables to Oracle Grid home. Then run the ASM Configuration Assistant to create ASM disk groups. (Note: This requires a desktop environment. VNC is a suitable option)

```
# asmca
```

**Figure 6 - ASM Configuration Assistant**

**Note:** For Oracle Database versions below 12.1, a known issue exists with ASM on Solaris that could be observed when cloning IntelliFlash snapshots. This is related to Oracle bug 12382627 Solaris: ORA-27063 "number of bytes read/written is incorrect". The fix for this problem is to upgrade Oracle Grid Infrastructure to version 11.2.0.4 or higher. This is relevant to Solaris 64-bit (SPARC) and Sun Solaris x86-64 environments only.
**Oracle Database Installation**

There are an infinite amount of preferences on how to install Oracle Database. Each installation has its own requirements too so this section will be brief.

If installing Oracle Database for the first time consult the Oracle Database Installation Guide for the specific release needed for detailed installation steps.

Download the Oracle Database installation package from the Oracle Software Delivery Cloud.

**IntelliFlash Features - Use Cases**

This section covers specific IntelliFlash features and how to use and integrate them effectively with Oracle Database.

**Snapshots and Clones**

This section discusses best practices for managing IntelliFlash snapshots and clones for an Oracle Database environment. This should not be confused with Oracle snapshots.

IntelliFlash snapshots are widely used to quickly create point-in-time virtual copies of data. However, it is incorrect and dangerous to think of snapshots as a complete backup solution. Unless copied to different media such as a second storage array, IntelliFlash snapshots are not a complete full copy of data.

IntelliFlash snapshots can be helpful for implementing mass deployments or offline computing to ease compute and network loads. The typical use for an IntelliFlash snapshot in an Oracle Database environment is to replicate a target master (i.e. production) to a non-master (i.e. development), or to offload and cache expensive queries in a read-only data warehouse.

Another reason why IntelliFlash snapshots are such a valuable administrative tool is because they take up virtually no additional space due to redirect on write technology. Space is only consumed by new data or pointers to old data when existing data is changed.

**Snapshot - Offline**

One method of taking a snapshot is to do it with the database offline. Before creating an IntelliFlash snapshot of an Oracle Database environment, the database must first be put in backup mode. As user oracle:

```sql
# sqlplus / as sysdba
SQL> alter database begin backup;
```
**Note:** Oracle backup mode is possible only with ARCHIVELOG enabled. NOARCHIVELOG is the default setting, but it does not provide for point-in-time snapshots. If NOARCHIVELOG is enabled, the database must be shutdown cleanly before creating a snapshot to ensure consistency.

The following commands will show the log mode (either ARCHIVELOG or NOARCHIVELOG) for a database. As user oracle:

```
# sqlplus /nolog
SQL> connect / as sysdba;
connected.

SQL> archive log list;
SQL> select log_mode from v$data
```

The log setting for a database can be changed from NOARCHIVELOG to ARCHIVELOG with the following commands. However, this requires that the database be shutdown first. As user oracle:

```
SQL> shutdown immediate;
Database closed.
Database dismounted.
ORACLE instance shut down.

SQL> startup mount;
ORACLE instance started.
Database mounted.

SQL> alter database archivelog;
Database altered.

SQL> alter database open;
Database altered.
```

After the database has been put in backup mode (with ARCHIVELOG) or shutdown (with NOARCHIVELOG), a snapshot can then be created. Tegile projects are convenient organizational structures that holds multiple LUNs. Snapshots are created at the project level and contain a point-in-time virtual copy of all data in that project.

The following screens illustrate the simple process for creating an IntelliFlash snapshot of a Project. Navigate under the Provision tab and then select the Project where the snapshot will be taken. Then pull down the manage menu and select Data Protection (Figure 7).
Now click on the New Snapshot button (Figure 8).

Enter a Snapshot name (Figure 9).

Now the new snapshot is shown in the lower portion of the screen (Figure 10).
Creation of an IntelliFlash snapshot is a very fast operation. After the snapshot has been created, the database should then be taken out of backup mode to resume normal operation.

As user oracle:

```
# sqlplus / as sysdba
SQL> alter database end backup;
```

**Note:** Manual snapshots are never cleaned up by default and are not replicated as part of a replication schedule. The preferred workflow is to install curl on the Linux server and issue API commands to the IntelliFlash array (See the IntelliFlash™ API Reference Guide for specific commands).

**Snapshot to Clone**

After a snapshot has been taken it’s easy to access the data. The process is to take the snapshot and to create clones.

The cloning replicates every LUN in the project while maintaining the original LUNs for continuous use. The cloned LUNs can be assigned alternate access for recovery, data
mining, backup, or test and development purposes. When finished, the clone can be deleted without any disruption to the original data and LUNs.

The following screens illustrate the simple process for creating a clone of a snapshot. Start by clicking on the Clone button shown in Figure 10. A confirmation window will appear (Figure 11) and highlight all of the LUNs within the project that will be cloned. Click Yes to continue.

![Figure 11 - Confirm New Clone](image)

Now enter a name for the clone.

![Figure 12 - Enter Clone Name](image)
Listed in the Projects window (Figure 13) are the original and the cloned LUNs.

![Figure 13 - Cloned LUNs Created](image)

Now the cloned LUNs can be presented to a different server and mounted for recovery, backup, data mining, and development.

*Note: Again the preferred workflow is to use the IntelliFlash API to script these type of tasks.*