



Technical Report

## NetApp Cloning Plug-in for Oracle Multitenant Database 12c

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### Executive Summary

Innovative technologies from NetApp and Oracle enable organizations to extract benefits from their virtual database infrastructures by seamless integration of Oracle® Multitenant 12c databases with an advanced virtualized NetApp® Data ONTAP® storage controller (7-Mode and clustered Data ONTAP).

This technical report provides a step-by-step guide for deploying the NetApp Cloning Plug-in for Oracle Multitenant Database. The scenarios corresponding to shared and dedicated infrastructure for the pluggable databases are covered using NetApp FlexClone® technology.

## TABLE OF CONTENTS

<b>Executive Summary</b> .....	<b>1</b>
<b>1 Introduction</b> .....	<b>4</b>
1.1 Purpose and Scope of the Document .....	4
1.2 Intended Audience .....	4
<b>2 Business Benefits</b> .....	<b>4</b>
<b>3 Technical Benefits</b> .....	<b>4</b>
<b>4 Overview</b> .....	<b>5</b>
4.1 Advantages of Multi-Tenant Architecture in Cloud .....	5
4.2 Oracle Multitenant Database 12c Snapshot Clones for PDB .....	5
4.3 Use of NetApp Technology to Enable Enterprise Readiness and Database Virtualization .....	6
4.4 NetApp Software Products Used in NetApp Cloning Plug-In for Oracle Multitenant Database .....	7
<b>5 NetApp Cloning Plug-In for Oracle Multitenant Database</b> .....	<b>8</b>
5.1 PDB Features .....	8
5.2 CDB High-Level Architecture with Snapshot Copy .....	9
5.3 Features in Version 1.0 .....	9
5.4 Minimum Requirements .....	9
5.5 Download and Installation .....	10
5.6 NetApp Cloning Plug-In for Oracle Database .....	11
<b>6 Use Cases</b> .....	<b>13</b>
6.1 Create PDB in Dedicated Cloud Infrastructure Using Directory Structure .....	13
6.2 Create PDB in Shared Infrastructure Using String Pattern .....	13
<b>7 Troubleshooting</b> .....	<b>13</b>
<b>8 Conclusion</b> .....	<b>14</b>
<b>Acknowledgements</b> .....	<b>14</b>
<b>References</b> .....	<b>14</b>
<b>Version History</b> .....	<b>15</b>

## LIST OF TABLES

Table 1) Oracle patch for source and destination folders. ....	10
Table 2) Download files for Linux and Solaris operating systems. ....	10

## LIST OF FIGURES

Figure 1) Oracle Multitenant Architecture (graphic supplied by Oracle). .....	5
Figure 2) CDB high-level architecture with Snapshot copy.....	9
Figure 3) NetApp cloning plug-in for Oracle Database. ....	11

# 1 Introduction

The NetApp Cloning Plug-in for Oracle Multitenant Database is a cloud-class storage application that seamlessly integrates with the Oracle Multitenant option for Oracle Database 12c to manage the duplication of pluggable databases (PDBs), which are provisioned from a NetApp storage controller. This integration leverages NetApp FlexClone technology, which allows you to develop and test applications more quickly by creating instant, space-efficient clones of PDBs that shorten design cycles and improve service levels. The NetApp Cloning Plug-in is a joint effort from Oracle and NetApp that facilitates the management of PDBs and uses the Oracle Multitenant container database (CDB) architecture, which enables you to easily consolidate multiple databases, without modifying the settings of the application.

## 1.1 Purpose and Scope of the Document

This technical report is an overview and a step-by-step guide for deploying the NetApp Cloning Plug-in for Oracle Multitenant Database with NetApp storage using Oracle Direct NFS (DNFS). It does not provide a comprehensive overview of the features available with Oracle Multitenant Database 12c and should not be used as a replacement for the Oracle Multitenant Database 12c official documentation.

## 1.2 Intended Audience

This technical report is intended for the following audiences:

- Oracle and NetApp partners
- Technical decision makers
- Database administrators
- Storage administrators
- Product and IT infrastructure managers

Readers should be familiar with Oracle Database 12c and its architecture, NetApp Data ONTAP operating in 7-Mode, and clustered NetApp Data ONTAP.

# 2 Business Benefits

The NetApp Cloning Plug-in for Oracle Multitenant Database offers the following business benefits:

- Easy installation, configuration, management, and maintenance
- Faster time to market for application development
- Multitenant database architecture for business applications
- Flexible backup and recovery
- Increased resource utilization
- Simple consolidation without having to change applications: Plug and unplug as needed
- Enables private cloud deployments built on Oracle Database 12c
- Empowers the DBA with cloning capabilities

# 3 Technical Benefits

The NetApp Cloning Plug-in for Oracle Multitenant Database offers the following technical benefits:

- Clones a PDB by using NetApp FlexClone technology from the Oracle Database 12c SQL command line, Oracle Cloud Control, or the PDB Apex Self-Service Provisioning application
- Supports directory structure and string pattern methodology to create cloned PDBs
- Provides rapid provisioning for accelerated deployment

- Consumes no additional space when a new PDB (clone) is created from an existing PDB
- Maximizes utilization of storage systems
- Enables application development and testing more quickly by creating instant, space-efficient clones of PDBs that shorten design and provision cycles that improve service levels
- Allows more database copies to be available to more people with minimal effect on performance

## 4 Overview

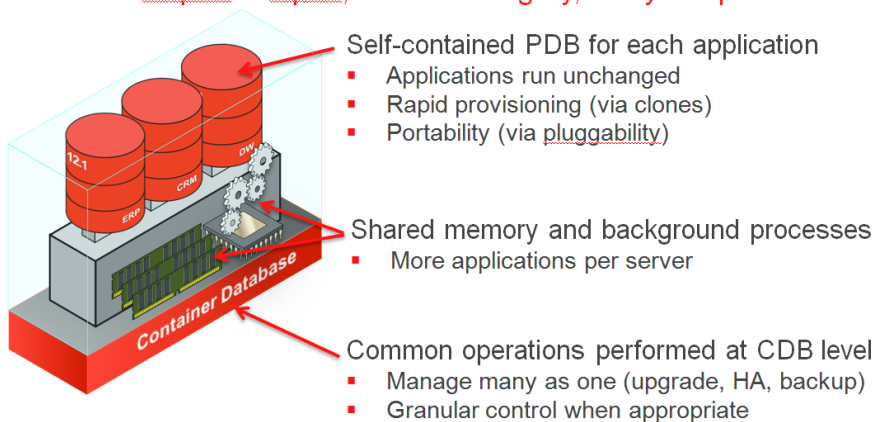
### 4.1 Advantages of Multitenant Architecture in Cloud

The Oracle Multitenant option for Oracle Database 12c is an innovative in-database virtualization solution for consolidation of Oracle 12c databases. As shown in Figure 1, the innovation is driven by efficient use of the container database (CDB) memory and background processes to provide measurable efficiencies and greater consolidation density of distinct pluggable databases (PDBs).

Figure 1) Oracle multitenant architecture (graphic supplied by Oracle).

### Advantages of Multitenant Architecture

Reduced CapEx & OpEx, Increased Agility, Easy Adoption



The CDB architecture has the added advantages of fine-grained/coarse-grained management. It can be configured so that a user can manage all PDBs in a CDB, leveraging the Manage Many Databases as one functionality of Oracle Multitenant. Or it can be configured so that database management is restricted to an individual DBA and the selected PDB.

Each PDB is a self-contained database with schemas, objects, privileges, and metadata stored in the PDB system, sysaux, and user tables. Each PDB has its own set of datafiles distinct from the CDB, which allows easy unplug/plug database mobility and rapid PDB provisioning through snapshot cloning.

No application changes are required to take advantage of this architecture.

### 4.2 Oracle Multitenant Database 12c Snapshot Clones for PDB

The challenges for test and development database provisioning can be daunting. The build cycles, time to provision, and test/dev database library management are labor intensive and expensive. Oracle Multitenant enables the DBA to manage the entire process. Oracle Multitenant PDB thin provisioning allows the DBA to snap clone test and development databases by using the SQL command line, with Oracle Cloud Control 12c or with the standalone APEX PDB Self-Provisioning application, available on

the Oracle Technology Network. The DBA can maintain a library of master databases from which snapshots can be cloned and provisioned on demand.

The integration of Oracle Multitenant and NetApp FlexClone technology increases productivity and reduces the cost of PDB thin provisioning.

### **4.3 Use of NetApp Technology to Enable Enterprise Readiness and Database Virtualization**

This section describes how the following NetApp technologies enable enterprise readiness and database virtualization:

- NetApp Unified Storage Architecture includes innovative features that distinguish it from the competition
- Storage virtual machines (SVMs)
- Nondisruptive operations

#### **Unified Storage Architecture**

The NetApp Unified Storage Architecture spans the entire hardware lineup, from the smallest entry-level model to the largest enterprise model. It provides SAN for both Fibre Channel (FC) and iSCSI, as well as NAS protocol support, in addition to scalable performance and capacity, and a single application interface for the entire product lineup.

The NetApp Unified Storage Architecture improves data center efficiency and enhances virtualization and consolidation. NetApp storage systems are unified not only across protocols and disks, but also in storage efficiency, processes, data management, and data protection. This level of unification is crucial for data center virtualization and consolidation.

Different enterprise applications can share NetApp storage controllers by using different protocols on the same physical disks; for example:

- Oracle Multitenant Database accesses the database files through Oracle Direct NFS.
- Oracle VM for server virtualization accesses the server pool, repository, and virtual machine (VM) disk through SAN protocols.
- Oracle Enterprise Manager monitors entities that can retrieve their data from NetApp storage controllers by using NFS.

#### **Storage Virtual Machine**

The secure logical storage partition through which data is accessed in clustered Data ONTAP is known as a storage virtual machine (SVM), formerly called Vserver. A cluster serves data through at least one and possibly multiple SVMs. An SVM is a logical abstraction that represents a set of physical resources of the cluster. Data volumes and logical network interfaces (LIFs) are created and assigned to an SVM and can reside on any node in the cluster to which the SVM has been given access. An SVM can own resources on multiple nodes concurrently, and those resources can be moved nondisruptively from one node to another. For example, a flexible volume can be nondisruptively moved to a new node, and an aggregate, or a data LIF, can be transparently reassigned to a different physical network port. The SVM abstracts the cluster hardware and is not tied to specific physical hardware.

An SVM is capable of supporting multiple data protocols concurrently. Volumes within the SVM can be junctioned together to form a single NAS namespace, which makes all of an SVM's data available to NFS and CIFS clients through a single share or mount point. SVMs also support block-based protocols, and LUNs can be created and exported by using iSCSI, Fibre Channel, or Fibre Channel over Ethernet (FCoE). Any or all of these data protocols can be configured for use within a given SVM.

An SVM is a secure entity; therefore, it is only aware of the resources that have been assigned to it and has no knowledge of other SVMs and their resources. Each SVM operates as a separate and distinct entity with its own security domain. Tenants can manage the resources allocated to them through a delegated SVM administration account. Each SVM can connect to unique authentication zones such as Microsoft® Active Directory®, Lightweight Directory Access Protocol (LDAP), or Network Information Service (NIS). SVM complements database consolidation in the multitenant database architecture.

## Nondisruptive Operations

Clustered Data ONTAP is highly scalable, and additional storage controllers and disks can easily be added to existing clusters to scale capacity and performance to meet rising demands. Because there are virtual storage servers within the cluster, SVMs are also highly scalable. As new nodes or aggregates are added to the cluster, the SVM can be nondisruptively configured to use them. New disk, cache, and network resources can be made available to the SVM to create new data volumes or to migrate existing workloads to these new resources to balance performance.

This scalability also enables the SVM to be highly resilient. SVMs are no longer tied to the lifecycle of a given storage controller. As new replacement hardware is introduced, SVM resources can be nondisruptively moved from the old controllers to the new controllers, and the old controllers can be retired from service while the SVM is still online and available to serve data.

In Oracle Multitenant Database 12c, dependent applications are based on the database operations; therefore, any downtime results in a loss of productivity and can erode customer satisfaction. NetApp nondisruptive operations allow seamless storage operations without downtime. Storage upgrades and maintenance can easily be achieved without interrupting the user's access to database files.

Nondisruptive operations offer the following benefits:

- Refresh hardware and software transparently without losing access to the customer's data. When it's time for an update, the administrator can simply move the Oracle Database volume to another node within the cluster nondisruptively to retire the old hardware from the cluster.
- Move data to a different node to redistribute the workload across a cluster. This task can be accomplished during normal business hours, enabling a more dynamic platform, without waiting for the next maintenance window.
- Conduct maintenance operations on specific hardware or software components transparently. For example, adding a NetApp Flash Cache™ acceleration card or redistributing data across controllers can be done nondisruptively.

## 4.4 NetApp Software Products Used in NetApp Cloning Plug-in for Oracle Multitenant Database

### NetApp Snapshot Technology

NetApp Snapshot™ software, the original and most functional point-in-time copy technology, enables you to protect your data without affecting performance and with minimal consumption of storage space:

- Make instant data copies while your applications run.
- Create Snapshot copies in under a second, for any volume size.
- Create up to 255 Snapshot copies per volume for online backup and recovery.

See the [NetApp Snapshot Technology](#) datasheet to learn more about Snapshot technology and how you can use it in your data protection solutions.

## NetApp FlexClone Technology

NetApp FlexClone software creates clones of data volumes and datasets without requiring additional storage space at the time of creation. Use FlexClone technology to:

- Replicate data volumes, files, and logical unit numbers (LUNs) as instant virtual copies
- Facilitate instant and scalable provisioning for virtual server and desktop environments
- Reduce space, power, and cooling costs through efficient storage utilization

NetApp and Oracle have collaborated to provide FlexClone integration with the Oracle Multitenant and PDB snapshot cloning introduced in Oracle Database12c. This integration supports both Data ONTAP operating in 7-Mode and clustered Data ONTAP.

To learn how NetApp FlexClone technology can help you get more out of your data, see the [FlexClone: Create Exact Disk Copies—Virtually](#) datasheet.

## 5 NetApp Cloning Plug-in for Oracle Multitenant Database

NetApp and Oracle collaborated to provide the ability to quickly clone an Oracle Multitenant PDB from the Oracle Database SQL command line. This integration leverages NetApp FlexClone technology to develop and test applications more quickly by creating instant, space-efficient clones of PDBs, which shortens the design cycle and lowers provisioning requirements, improving delivery service levels. The NetApp Cloning Plug-in works only with Oracle Multitenant and Oracle Database 12c.

### 5.1 PDB Features

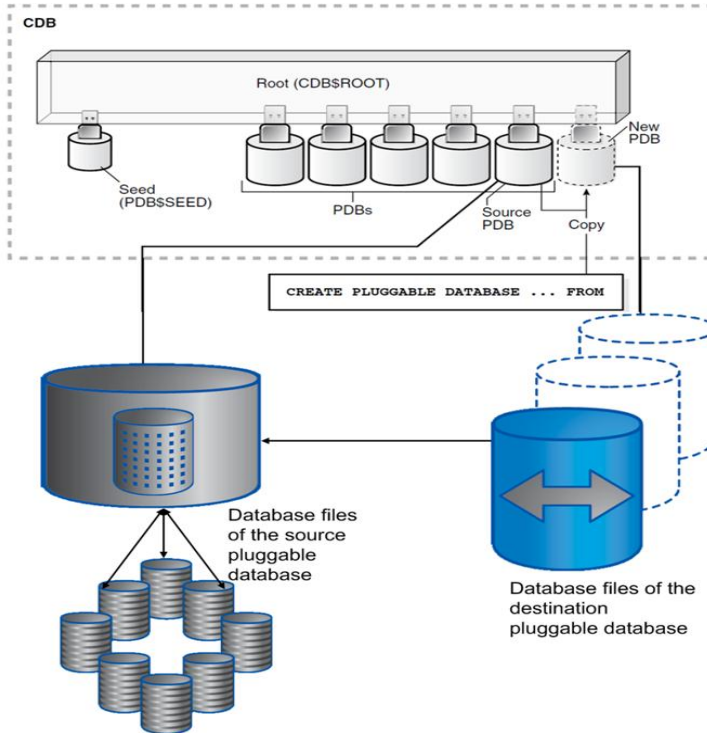
The cloned PDBs offer the following features:

- Support for role-based access control (RBAC)
- Support for rapid thin provisioning
- Persistent across Oracle Database12c after server restart
- Created within the CDB
- Flexible database migration through PDB unplug/plug operations
- Easy upgrades



## 5.2 CDB High-Level Architecture with Snapshot Copy

Figure 2) CDB high-level architecture with Snapshot copy.



When the source PDB resides in NetApp storage controllers, a Snapshot copy clause is required to clone a PDB. In this case, Oracle communicates with the NetApp binary to create the storage-level Snapshot copy of the source PDB volume and uses it to make the PDB clones. NetApp Snapshot technology makes the cloning instantaneous and space efficient.

The NetApp Cloning Plug-in for Oracle Multitenant Database receives the arguments from the Oracle binary, which selects the type of operation. See the [Oracle Database Documentation Library](#) to learn more about Oracle Database 12c.

## 5.3 Features in Plug-in Version 1.0

Version 1.0 of the plug-in supports:

- Cloning PDBs within a CDB
- Deleting a cloned PDB
- Data ONTAP operating in 7-Mode and clustered Data ONTAP

## 5.4 Minimum Requirements

Complete these steps before installing the NetApp Cloning Plug-in for Oracle Database:

1. Install SNMP packages.
2. Update the export option to `rw, anon=0` for `ORACLE_HOME` volume if it is mounted using the NetApp storage controller.
3. Verify that the permission for the `$ORACLE_HOME/bin/oradism` file is set to `setuid`.
4. Do not change the location for the default inventory pointer file.

5. In the NetApp storage system, verify that the `nfs.export.auto-update` parameter is set to `on`.
6. Verify that `snmp.access=all` and `snmp.enable=on` are set, so that the Oracle binaries can check the NetApp storage system.
7. If you want to specify the source and destination folder structures, you might have to install an Oracle patch.

Table 1 lists which source and destination folder structures require the Oracle patch.

**Table 1) Oracle patch for source and destination folders.**

Source PDB Folder	Destination PDB Folder	Oracle Patch Required
/pdb1data (single folder)	/pdb1data_ntap1 (single folder)	No
/pdb1lin2 (single folder)	/pdb1lin2_ntap2/oradata/lcdb/lpdb2/ (multiple folders)	Yes
/pdb1data/pdb/oradata/cdb (multiple folders)	/pdb1data_ntap1/pdb/oradata/cdb (multiple folders)	Yes
/pdb1data/pdb/oradata/cdb (multiple folders)	/pdb1data_ntap1 (single folder)	Yes

To learn which Oracle patch to install for your environment, see the following support available at [support.oracle.com](http://support.oracle.com):

- If you are using 12.1.0.1 on Linux<sup>®</sup> x86\_64, refer to MOS PATCH ID 16221044: DNFS NOT WORKING WITH SYMLINKS ON NON-NFS FILESYSTEM POINTING TO NFS FILES. This is corrected in 12.1.0.2.
- If you are using 12.1.0.1 on Solaris x86\_64, refer to MOS PATCH ID 17279778: COPY OF BUG 16221044 FOR SOLARIS X64 BACKPORT. This is corrected in 12.1.0.2.

For more information about the requirements for the NetApp Cloning Plug-in for Oracle Database, refer to the documentation on the [NetApp Community](http://netapp.com) site.

## 5.5 Download and Install

To download and install the NetApp Cloning Plug-in for Oracle Multitenant Database, complete the following steps:

1. Go to the NetApp Cloning Plug-in for Oracle Database page of the [NetApp Community](http://netapp.com) site to download the plug-in.
2. Select the file listed in Table 2 that corresponds to your operating system.

**Table 2) Download files for Linux and Solaris operating systems.**

Operating System	Download
Linux	ntap_vol_clone-Linux-x64-1.0.tar.gz
Solaris	ntap_vol_clone-Solaris-x64-1.0.tar.gz

3. Log in as the root user.
4. Extract the `plug-in.tar.gz` file by running the appropriate command:
  - For Linux: `tar -zxvf ntap_vol_clone-Linux-x64-1.0.tar.gz`
  - For Solaris: `gunzip ntap_vol_clone-solaris-x64-1.0.tar.gz` and `tar -xvf ntap_vol_clone-solaris-x64-1.0.tar`

5. Install the plug-in by running the appropriate command:

- For Linux: `bash install.sh`
- For Solaris: `./install.sh`

Refer to the [NetApp Cloning Plug-in for Oracle Database](#) main page for details about the following topics from the [plug-in documentation](#):

- Postinstallation
- Configuring direct NFS for the source PDB volume
- Creating storage credentials in Oracle
- Creating a PDB
- Deleting a PDB
- Troubleshooting

## 5.6 NetApp Cloning Plug-in for Oracle Database

Figure 3 shows the detailed workflow for the NetApp Cloning Plug-in PDB create and delete operations for Oracle Multitenant Database.

Figure 3) NetApp Cloning Plug-in for Oracle Database.

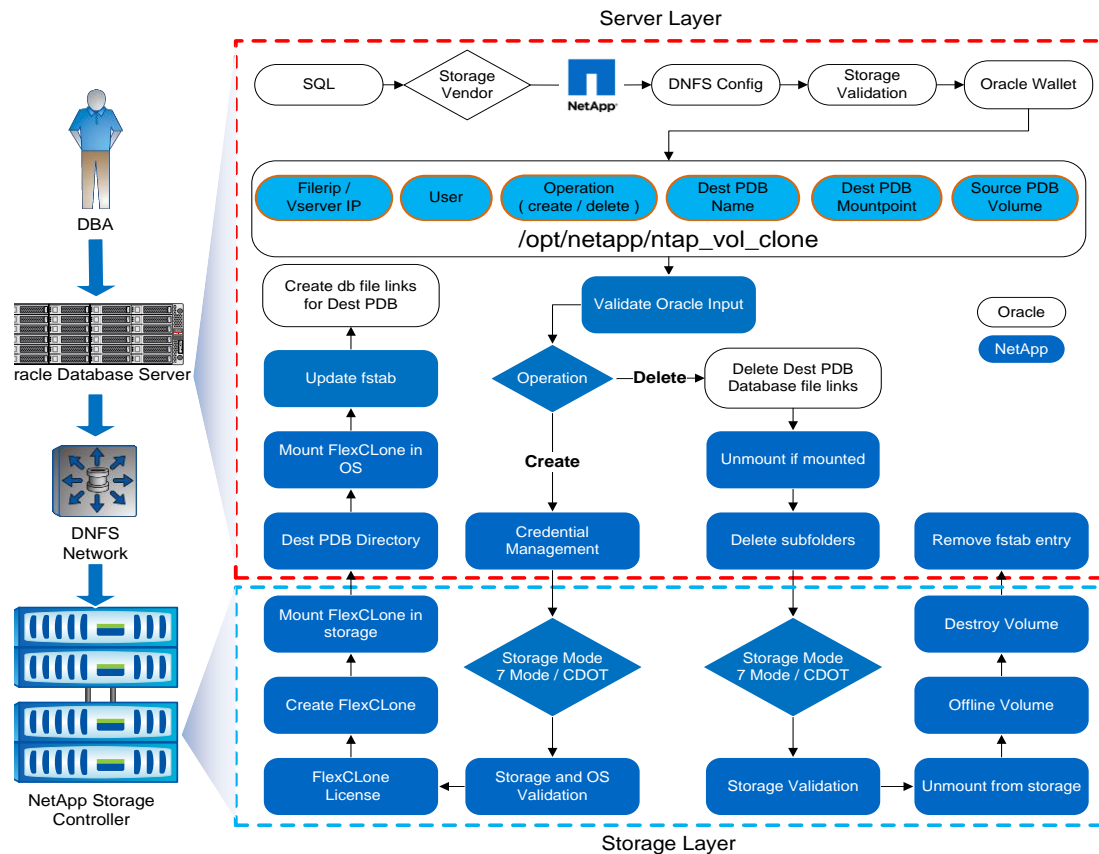


Figure 3 shows two operations: create destination PDB and delete PDB. The PDB can be created by using two different options specifying a specific directory or by using a string pattern that is passed to the `file_name_convert` clause in the `create pluggable database` from the SQL Command Line.

The workflow describing PDB create and delete operations for the NetApp Cloning Plug-in for Oracle Database is as follows:

1. The user (DBA) executes the command `create pluggable database. ...snapshot copy` on the SQL command line to create the pluggable database by using the storage vendor plug-in.
2. Oracle checks the storage vendor list to determine whether the source PDB volume resides in the NetApp storage controller.
3. The Oracle workflow collects the storage details from the DNFS configuration.
4. It checks the basic storage validation by using SNMP based on DNFS details.
5. It also collects the storage credentials from the Oracle Wallet Manager for storage communication.
6. It calls the NetApp binary with a set of arguments for the respective operations.
7. The NetApp Cloning Plug-in validates the arguments that are received from Oracle.
8. If the operation is to create a destination PDB, the NetApp Cloning Plug-in completes the following steps:
  - a. Collects the storage credentials from Oracle.
  - b. Determines whether the storage controller is using Data ONTAP operating in 7-Mode or clustered Data ONTAP.
  - c. Validates whether the FlexClone volume creation is possible from the source PDB volume at the storage and checks whether the operating system has the parent directory for the destination PDB in the directory pattern. If the string pattern method is used to create the destination PDB, then this step is not required.
  - d. Checks whether the FlexClone license is enabled for the NetApp storage controller.
  - e. Creates the FlexClone volume based on the destination PDB unique name, which is received as an argument from Oracle.
  - f. If clustered Data ONTAP is being used, then the junction path for the cloned volume is `<Clonename>`, and the volume is mounted in the storage controller. This step is not required for Data ONTAP operating in 7-Mode.
  - g. Creates subfolders in the parent folder to hold the database files for the destination PDB.
  - h. Mounts the cloned volume in the operating system.
  - i. Updates `/etc/fstab` (Linux) or `/etc/vfstab` (Solaris) to make the mount entry persistent across reboot for the destination PDB.
  - j. Oracle creates the destination PDB link files from the cloned volume of the source PDB volume.
9. If the operation is to delete a destination PDB, the NetApp Cloning Plug-in completes the following steps:
  - a. Oracle deletes the linked destination PDB files.
  - b. The plug-in unmounts the cloned volume from the operating system.
  - c. It deletes the subfolders, which are created during the create operation.
  - d. It determines whether the storage controller is using Data ONTAP operating in 7-Mode or clustered Data ONTAP.
  - e. It checks at the storage-controller level to determine whether the volume can be deleted from the controller.
  - f. If clustered Data ONTAP is being used, the plug-in unmounts the volume from the storage controller. This is not required for Data ONTAP operating in 7-Mode.
  - g. The volume is taken offline and destroyed.
  - h. The corresponding entry `/etc/fstab` (Linux) or `/etc/vfstab` (Solaris) is removed from the operating system.

## 6 Use Cases

### 6.1 Create PDB in Dedicated Cloud Infrastructure by Using Directory Structure

In the directory structure method, the `file_name_convert` clause needs a minimum of two strings:

```
file_name_convert=('string1','string2')
```

Where:

- `string1` is the absolute path for the directory that contains the PDB source files.
- `string2` is the absolute path for the directory that is used as a parent folder for the destination PDB files.

For example:

```
file_name_convert=('/sourcepdb_dbfiles_folder','/destpdb_dbfiles_folder')
```

Where:

- `/sourcepdb_dbfiles_folder` contains the source PDB files.
- `/destpdb_dbfiles_folder` contains the destination PDB files and has the same file name patterns as the file name for the source PDB.

### 6.2 Create PDB in Shared Infrastructure by Using String Pattern

In the string pattern method, `string1` is one of the file name patterns from the source PDB, `string2` is the replacement file name pattern for the destination PDB:

```
file_name_convert=('string1','string2')
```

For example:

```
file_name_convert=('01','01_destpdb')
```

Where the source PDB data files are:

- `/pdblin1/oradata/lcdb/lpdb1/system01.dbf`
- `/pdblin1/oradata/lcdb/lpdb1/sysaux01.dbf`
- `/pdblin1/oradata/lcdb/lpdb1/lpdb1_users01.dbf`

Where the destination PDB data files are:

- `/pdblin1/oradata/lcdb/lpdb1/system01_destpdb.dbf`
- `/pdblin1/oradata/lcdb/lpdb1/sysaux01_destpdb.dbf`
- `/pdblin1/oradata/lcdb/lpdb1/lpdb1_users01_destpdb.dbf`

For more information, refer to the [NetApp Cloning Plug-In 1.0 for Oracle Multitenant Database Installation and Administration Guide](#) on the [NetApp Community](#) site.

## 7 Troubleshooting

You might face some issues while installing the plug-in or while creating and deleting PDBs; for example:

- Storage credential is not set
- Parent directory is not created
- Parent directory does not have `oracle` user permission
- Unable to access the client secret, or the client secret is not opened

- Unable to delete PDB because not all instances of the PDB are closed
- Unable to delete PDB when you perform the delete operation from the same delete database
- Permission not set for the `oradism` file
- Unable to communicate to `ntap_vol_clone`
- Unable to start database
- Unable to delete PDB
- Unable to create PDB

For information about how to resolve these issues, refer to the [NetApp Cloning Plug-In 1.0 for Oracle Database Installation and Administration Guide](#) on the [NetApp Community](#) site.

## 8 Conclusion

The NetApp Cloning Plug-in for Oracle Database integrates with the Oracle Multitenant option for Oracle Database 12c to manage the rapid duplication of PDBs. This joint effort from Oracle and NetApp leverages NetApp FlexClone technology and uses the Oracle Multitenant CDB/PDB architecture to enable customers to easily consolidate multiple databases, accelerate development and testing of new applications, and support private cloud deployments. This report offers guidelines on how to implement the NetApp Cloning Plug-in for Oracle Database on a NetApp storage controller.

This report is not intended to be a definitive implementation or solutions guide. Additional expertise might be required to solve specific deployments. Contact your NetApp sales representative to speak with one of our Oracle Database solution experts.

Forward any errors, omissions, differences, new discoveries, or comments about this paper to the author by e-mail.

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- Margaret Susairaj, Principal Member Technical Staff, Oracle
- Mohit Singal, Consulting Member of Technical Staff, Oracle
- Patrick Wheeler, Senior Director, Oracle Multitenant Product Management, Oracle
- Sumanta Chatterjee, Vice President Database Virtual OS, Oracle

## References

This technical report uses the following references:

- Oracle Multitenant Datasheet  
<http://www.oracle.com/technetwork/database/multitenant-ds-12c-1951720.pdf>
- Oracle Enterprise Manager Cloud Control Documentation  
[http://docs.oracle.com/cd/E24628\\_01/index.htm](http://docs.oracle.com/cd/E24628_01/index.htm)

- TR-3712: Oracle VM and NetApp Storage Best Practices Guide  
<http://www.netapp.com/us/media/tr-3712.pdf>
- NetApp Cloning Plug-in 1.0 for Oracle Database Installation and Administration Guide  
<https://communities.netapp.com/docs/DOC-30115>

## Version History

Version	Date	Document Version History	Authors
Version 1.0	February 2014	Initial release	<a href="#">John P. McHugh</a> , <a href="#">Karthikeyan Nagalingam</a>

Refer to the [Interoperability Matrix Tool \(IMT\)](#) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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