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Oracle Database 11g Release 2 High Availability

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Introduction

Enterprises use Information Technology (IT) to gain competitive advantages, reduce operating costs, enhance communication with customers, and increase management insight into their business processes. As the use of IT-enabled Services becomes prevalent, modern enterprises become increasingly dependent on their IT infrastructure and its continuous availability. Application downtime and unavailability of data directly translate into lost productivity and revenue, dissatisfied customers, and tarnished corporate image.

The traditional approach to building a high availability (HA) infrastructure requires widespread use of redundant and often idle hardware and software resources supplied by disparate vendors. Besides being very expensive, that approach falls short of service level expectations due to loose integration of components, technological limitations, and administrative complexities. Oracle addresses these challenges by providing customers with a comprehensive set of industry-leading high availability technologies that are pre-integrated and can be implemented at a minimal cost.

In this paper, we review the common causes of application downtime and discuss how technologies available in the Oracle Database can help avoid costly downtime and enable rapid recovery from unplanned failures and also minimize impact from planned outages. We also highlight new technologies introduced in Oracle Database 11g Release 2 that enable businesses to make their IT infrastructure even more robust and fault tolerant, maximize their return on investment on high availability infrastructure, and provide better quality of service to users.

Oracle's High Availability Vision

When architecting a highly available IT infrastructure, it is important to first understand the causes of downtime. In the diagram below we categorize downtime as either unplanned or planned. Unplanned outages are generally caused by computer failures and any other failures that may cause the data to be unavailable (e.g. storage corruption, site failure, etc.). Planned downtime includes maintenance activities such as hardware, software, application, and/or data change.

The Traditional Way to High Availability

Adding basic fault tolerance to an IT infrastructure is not hard. You can add a few redundant components, and you can claim fault tolerance, or high availability. If you have some failure in your IT stack, there are redundant components available to which you can failover. Following this basic principle, some customers have built an HA framework consisting of:

- An N+1 active-passive server clustering model (e.g., clustering integrated with the OS)
- Mirroring of the bits in the storage array to some other remote storage array
- A tape backup product which ensures that periodic backups are taken and stored offsite
- A separate volume management product to ease the management of the underlying storage

This type of configuration works, but with important limitations, as follows:

- Typically, the solutions mentioned above come from different vendors. Stitching together and managing these disparate solutions require a non-trivial effort.
- Because the overall architecture is based on disparate point solutions, it is difficult to scale the configuration to increase throughput. Scaling effectively is critical from an HA standpoint.
- While hardware-centric HA solutions (e.g., mirroring) offer simple data protection methods, their byte-level approach makes it very difficult to build application-optimized capabilities.¹
- A related factor is return on investment (ROI) on the HA systems. If a server is configured in a cold-cluster N+1 environment as the failover target, it cannot support production workload, and computing resources are wasted. If a remote storage array is receiving bits through storage mirroring technology, no applications or databases can be mounted on that storage array – more waste.

¹ With hardware-centric solutions alone, it is almost impossible to reduce downtime related to upgrades and patches, to prevent human errors, to detect and recover from physical corruptions, and to ensure application clients also failover in the event of an outage.

The Oracle Way to High Availability

Given these problems, Oracle has taken the approach of building a set of tightly integrated HA features within the database kernel. The three guiding principles of Oracle's HA vision follow.

Leverage enhanced Oracle-optimized data protection

Oracle understands Oracle block structure better than anyone, allowing for native solutions with intelligent capabilities. Because Oracle can detect whether an Oracle block is physically corrupted at the earliest opportunity, Oracle's data protection solution, Oracle Data Guard, will detect and stop propagation of corrupted blocks to target systems.² Similarly, Oracle's backup and recovery solution (RMAN), can do fine-grained, efficient recovery of individual blocks instead of entire data files. RMAN can also optimally keep track of changed blocks, ensuring that only changed blocks get backed up, thus providing a powerful implicit deduplication capability. Active Data Guard allows physical standby databases to be open for read access even while being kept synchronized with the production database through media recovery.³

Deliver application-integrated High Availability

Providing HA and data protection at the bits and bytes level is not enough, as outages ultimately strike the application, and hence impact the users. Oracle's innovative Flashback technologies operate at the business object level – e.g., repairing tables or recovering specific transactions. The solutions are very granular and thus very efficient and cause no disruption to the rest of the database. Also, through the Online Redefinition feature, Oracle allows making structural changes to a table while others are accessing and updating it. Similarly, when there is a failover at the database level, Oracle's solutions ensure that the application / middle-tier connections are also failed over automatically, improving availability and quality of service by preventing users from being affected by unresponsive connections or the experience of manually reconnecting to the database.

Provide an integrated, automated and open architecture

Since Oracle's HA solutions are available as built-in features of the database, there is no separate integration required with third-party technologies. No separate installs are required, and upgrades to new versions are greatly simplified, eliminating the painful and time-consuming process of release certification across multiple vendors' technologies. Also, all the

² Storage mirroring technologies cannot provide the same level of protection from corruption because they do not benefit from Oracle validation before changes are applied to remote volumes.

³ Tasks such as real-time reporting or fast incremental backups can now be offloaded to the physical standby, for better utilization of resources compared to mirroring, which requires that target storage arrays be kept offline.

features can be managed via the unified Oracle Enterprise Manager Grid Control management interface. Oracle also builds automation into every step, preventing common mistakes typical in manual configurations. Customers can easily choose to automatically failover to a standby database if the production database becomes offline; backups can be automatically archived and removed for effective space management; and physical block corruptions can be automatically repaired. Finally, Oracle's HA solution set is open: it does not restrict customers to use only Oracle-native solutions. For instance, customers can use Oracle's native replication technology, but choose a third party backup product. They can use Oracle's clustering technology, but choose third party storage mirroring if they prefer to leverage previous investments in storage mirroring technology and operational practices.

Oracle's HA vision is embodied in Oracle's HA solution set and the Oracle Maximum Availability Architecture (MAA), which is Oracle's HA Best Practices blueprint. The following diagram shows an overview of Oracle Database's integrated HA solution set. For more information see Oracle's [High Availability web resources](#).

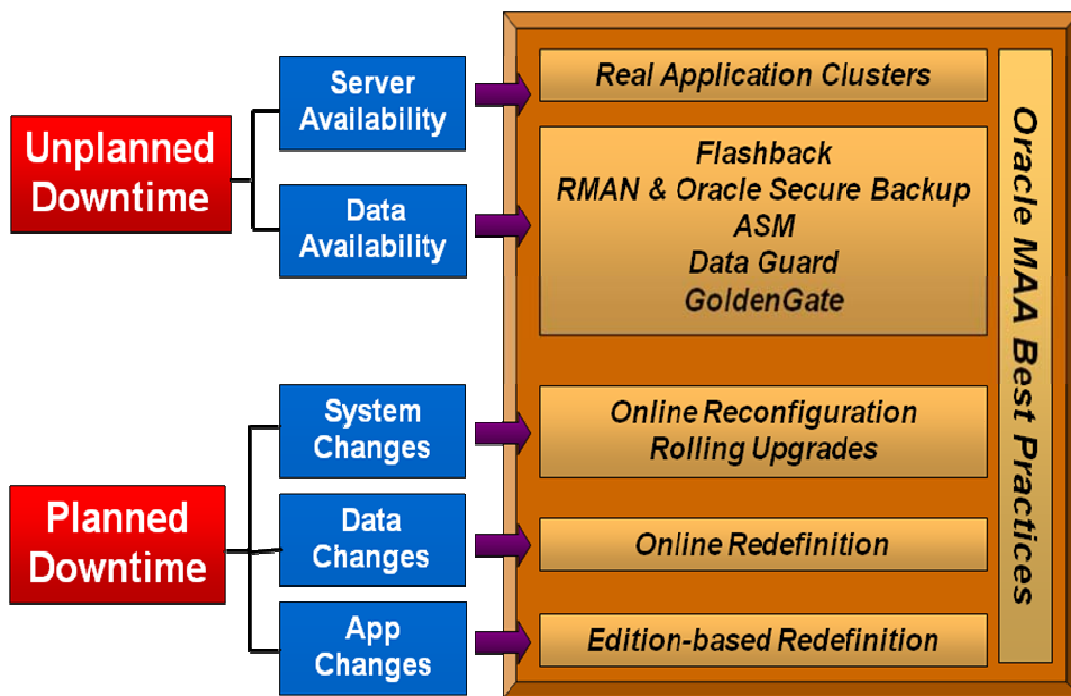


Figure 1: Oracle Database's Integrated HA Solution Set

The next sections in this paper describe the key Oracle HA solutions corresponding to specific outage categories, along with a summary of the new capabilities available with these solutions in Oracle Database 11g Release 2.

"High availability is absolutely essential for us...we now use Oracle RAC for instance failover, Data Guard for site failover, ASM to manage our storage, and Oracle clusterware to hang the whole thing together."

Jon Waldron, Executive Architect, Commonwealth Bank of Australia

Reducing Unplanned Downtime

Hardware faults, which cause server failure, are essentially unpredictable, and result in application downtime when they eventually occur. Likewise, a range of data availability failures, including storage corruption, site outage and human error, also cause unplanned downtime. In this section we discuss how Oracle's HA solutions address these fundamental categories of failures in order to prevent and mitigate unplanned downtime.

Server Availability

Server availability is related to ensuring uninterrupted access to database services despite the unexpected failure of one or more machines hosting the database server, which could happen due to hardware or software fault. Oracle Real Application Clusters, the foundation of Oracle's Private Cloud Computing architecture, can provide the most effective protection against such failures.

Oracle Real Application Clusters

Oracle Real Application Clusters (RAC) is the premier database clustering technology that allows two or more computers ("nodes") in a Server Pool to concurrently access a single shared database. This database system spans multiple hardware systems, yet appears to the application as a single unified database. This architecture extends availability and scalability benefits to all applications, specifically:

- Fault tolerance within the server pool, especially computer failures.
- Flexibility and cost effectiveness in capacity planning, so that a system can scale to any desired capacity on demand and as business needs change.

A key advantage of RAC is the inherent fault tolerance provided by multiple nodes. Since the physical nodes run independently, the failure of one or more nodes does not affect other nodes. This architecture also allows a group of nodes to be transparently put online or taken offline, while the rest of the server pool continues to provide database service. Additionally, RAC provides built-in integration with Oracle Fusion Middleware and Oracle clients for failing over connections.

Oracle RAC also gives users the flexibility to add nodes to the server pool as the demands for capacity increase, reducing costs by avoiding the more expensive and disruptive upgrade path of replacing an existing system with a new one having more capacity. The Cache Fusion technology implemented in Oracle RAC and the support for InfiniBand networking enable capacity to be scaled near linearly without any changes to your application.

"Oracle Real Application Clusters on Linux has given us continuous availability for about 65% less than what a traditional implementation would have cost. This improved availability for our patient care systems also positions us to have zero-downtime upgrades for system maintenance."

Kay Carr, Chief Information Officer, St. Luke's Episcopal Health System

With its unique capabilities described above, Oracle RAC enables enterprise Private Clouds. Enterprise Private Clouds are built out of large configurations of standardized, commodity-priced components: processors, servers, network, and storage. In addition, Oracle Real Application Clusters is completely transparent to the application accessing the Oracle RAC database, thereby allowing existing applications to be deployed on Oracle RAC without requiring any modifications.

Oracle RAC 11g Release 2 Enhancements

With Oracle Database 11g Release 2, managing applications under the control of Oracle Clusterware is made easier through the graphical interface provided by Oracle Enterprise Manager. Oracle Database 11g Release 2 also introduces the grid infrastructure, a new Oracle Home which includes the binaries for both Oracle Clusterware and Automatic Storage Management, easing deployment and management of HA infrastructure software.

Another enhancement is that applications never have to modify their connections as you add or remove nodes in the server pool. Single client access name (SCAN) allows clients to connect to the Oracle RAC database with a single address for both failover and load balancing purposes.

Server pools are logical entities to allocate resources to specific applications; servers are allocated to the pool per a declarative specification of your scalability requirements that the server pool administers automatically within the existing resources. Grid Plug and Play further automates server pool management. You can delegate a network sub-domain to the server pool and the Grid Naming Service (GNS) will use DHCP to automatically allocate all virtual internet protocol addresses (VIPs) for the server pool. Adding an instance to an Oracle RAC database is automatically done when the server pool size is increased; no manual steps are required of the DBA other than ensuring the software is provisioned.

For more information see Oracle's [Real Application Clusters web resources](#).

Oracle Clusterware

Oracle Database 11g includes Oracle Clusterware, a complete, integrated clusterware management solution available on all Oracle Database 11g platforms. This clusterware functionality includes mechanisms for server pool messaging, locking, failure detection, and recovery. Oracle Clusterware 11g adds server pool time management to ensure that the clocks on all nodes in the server pool are synchronized. For most platforms, no third party clusterware management software need be purchased. Oracle will, however, continue to support select third party clusterware products on specified platforms.

Oracle Clusterware includes a High Availability API to make applications highly available. Oracle Clusterware can be used to monitor, relocate, and restart your applications.

Data Availability

Data availability concerns itself with avoiding and mitigating data failures: the loss, damage, or corruption of business-critical data. The causes of data failure are multifaceted and often difficult to identify. Generally, data failure is due to one or a combination of these causes: storage subsystem failure, site failure, human error, and corruption. Oracle Database has several technologies to address these causes and help diagnose, mitigate, and recover from data failure.

Human Error Protection

Human errors are a leading cause of downtime, hence good risk management must include measures to prevent human error and also to remediate it when it happens. For example, an incorrect `WHERE` clause may cause an `UPDATE` to affect many more rows than intended. The Oracle Database provides a set of powerful capabilities that help administrators prevent, diagnose and recover from such errors. It also includes features that allow end-users to recover from problems without administrator intervention, speeding recovery of the lost and damaged data.

Preventing Human Errors

A good way to prevent costly human errors is to restrict users' access scope to just the data and services they need. The Oracle Database provides a wide range of security tools to control user access to application data by authenticating users and then allowing administrators to grant users only those privileges required to perform their duties. The Oracle Database security model allows fine-grained access control, down to the row, via Oracle's Virtual Private Database (VPD) feature. For more information see [Virtual Private Database web resources](#).

Oracle Flashback Technologies

Despite preventive measures, human errors do happen. Oracle Database Flashback Technologies are a unique and rich set of data recovery solutions that enable reversing human errors by selectively and efficiently undoing the effects of a mistake. Before Flashback, it might take minutes to damage a database but hours to recover it. With Flashback, correcting an error takes about as long as it took to make it. In addition, the time required to recover from this error is not dependent on the database size, a capability unique to the Oracle Database. Flashback supports recovery at all levels including the row, transaction, table, and the entire database.

Flashback is easy to use: the entire database can be recovered with a single short command, instead of following a complex procedure. Flashback provides fine-grained analysis and repair for localized damage, e.g., when the wrong customer order is deleted. Flashback also supports repairing more widespread damage while still avoiding long downtimes, e.g., when all yesterday's customer orders have been deleted.

"By using Flashback Query, we've extended our reporting and troubleshooting capability providing to the minute data research options which is a big time saver and management tool."

Greg Penk, VP of Data Administration, Banknorth Group

Flashback Query

Using Oracle Flashback Query, administrators are able to query any data at some point-in-time in the past. This powerful feature can be used to view and logically reconstruct corrupted data that may have been deleted or changed inadvertently. For example, a simple query like:

```
SELECT * FROM emp AS OF TIMESTAMP time WHERE...
```

displays rows from the `emp` table as of the specified *time* (a timestamp, obtained for example via a `TO_TIMESTAMP` conversion). Administrators can use Flashback Query to quickly identify and resolve logical data corruption. This functionality could also be built into an application to provide its users with a quick and easy mechanism to undo erroneous changes to data without contacting their database administrator.

Flashback Versions Query

Flashback Versions Query enables administrators to retrieve different versions of a row across a specified time interval instead of a single point-in-time. For instance, a query like:

```
SELECT * FROM emp VERSIONS BETWEEN TIMESTAMP time1 AND time2 WHERE...
```

displays each version of the row between the specified timestamps. This mechanism gives the administrator the ability to pinpoint exactly when and how data has changed, providing great utility in both data repair and application debugging.

Flashback Transaction Query

Logical corruption may also result from an erroneous transaction that changed data in multiple rows or tables. Flashback Transaction Query allows an administrator to see all the changes made by a specific transaction. For instance, a query like:

```
SELECT * FROM FLASHBACK_TRANSACTION_QUERY WHERE XID = transactionID
```

shows the changes made by this transaction and it also produces the SQL statements necessary to flashback or undo the transaction. This precision tool empowers the administrator to efficiently pinpoint and resolve logical corruptions in the database.

Flashback Transaction

Often, data failures take time to be identified, and additional transactions may have executed on logically corrupted data. In the event of a 'bad' transaction, the DBA must analyze changes made by the transaction and any dependencies (e.g., transactions that modified the same data after the bad transaction), to ensure that undoing the transaction preserves the original, correct state of the data. Performing this analysis can be laborious, especially for very complex applications.

With Flashback Transaction, a single transaction, and optionally, all of its dependent transactions, can be flashed back with a single PL/SQL operation or by using an EM wizard to identify and

flashback the problem transactions. Flashback Transaction relies on undo data and archived redo logs to back out the changes.

Flashback Table

Sometimes logical corruption is limited to one or a set of tables instead of the entire database. Flashback Table allows the administrator to easily recover tables to a specific point-in-time. A query like the following:

```
FLASHBACK TABLE orders, order_items TIMESTAMP time
```

will rewind the `orders` and `order_items` tables, undoing any updates made to these tables between the current time and the specified *time*.

Flashback Drop

Accidentally dropped tables are a DBA's nightmare, typically requiring restore, recovery, export/import, and re-creation of all associated table attributes. With the Flashback Drop feature, dropped tables can be easily recovered, with a simple `FLASHBACK TABLE <table> TO BEFORE DROP` statement. This restores the dropped table, and all of its indexes, constraints, and triggers, from the Recycle Bin. (The Recycle Bin is a logical container for all dropped objects.)

Flashback Database

To restore an entire database to a previous point-in-time, the traditional method is to restore the database from a RMAN backup and recover to the point-in-time prior to the error. With the size of databases growing, it can take hours or even days to restore an entire database.

In contrast, Flashback Database, using Oracle-optimized flashback logs, can easily restore an entire database to a specific point-in-time. Flashback Database is extremely fast as it only restores blocks that have changed. Flashback Database can restore a whole database in a matter of minutes using a simple command like:

```
FLASHBACK DATABASE TO TIMESTAMP time
```

No complicated recovery procedures are required and there is no need to restore backups from tape. Flashback Database drastically reduces the amount of downtime required for scenarios where logical point-in-time recovery of the database is required.

Flashback 11g Release 2 Enhancements

Oracle Database 11g Release 2 includes enhancements to Flashback Database and to Flashback Transaction. Flashback Database can now be enabled while the database is open; it also offers improved logging performance for direct loads and enhanced progress monitoring. Flashback Transaction now supports tracking of foreign key dependency. For more details, see Oracle's [Flashback web resources](#).

Protection from Data Corruption

Physical data corruption is created by faults in any of the components making up the Input/Output (I/O) stack. When Oracle issues a write operation this database I/O operation is passed to the operating system's code. The write goes through the I/O stack: from file system to volume manager to device driver to Host-Bus Adapter to the storage controller and finally to the disk drive where the data is written. Hardware failures or bugs in any of these components can result in invalid or corrupt data being written to disk. This corruption could damage internal Oracle control information or application/user data – either of which could be catastrophic to the functioning or availability of the database. In this section, we discuss Oracle's comprehensive set of solutions to protect data from corruption.

Corruption Detection in the Database

Oracle provides superior corruption detection and prevention. The simplest way to achieve the highest level of protection is to set the `DB_ULTRA_SAFE` initialization parameter (`DB_ULTRA_SAFE=DATA_AND_INDEX`) on both a primary and standby database in a Data Guard configuration. This single setting automatically configures several additional parameters that enable critical corruption checks, including block header checks, full-block checksums, and lost-write verification that includes both primary and standby databases as appropriate.

Oracle Backup and Recovery

In addition to the prevention and recovery technologies discussed thus far, every IT organization must implement a comprehensive data backup procedure. Multiple-failure scenarios are rare but do occur, and the IT organization must be able to recover business-critical data from backup. Oracle provides industry standard tools to efficiently backup data, to restore data from previous backups, and to recover data up to the time just before a failure occurred. As shown in the diagram, Oracle backup and recovery include backups to disk, to tape, and to cloud storage.

Oracle's wide range of backup options allows users to deploy the optimal solution for their particular environment. While traditional disk and tape backups may be de facto standards in the user's environment, they can be complemented with backups to low-cost cloud storage, managed by Amazon Simple Storage Services (S3). Backups to the cloud can reduce in-house backup costs and at the same time provide offsite, geographically diverse redundancy.

Besides providing extensive backup capabilities, Oracle also offers intelligent database problem identification and recovery capabilities with the Data Recovery Advisor (DRA). With DRA, the administrator is relieved of having to spend time identifying database failure conditions, gathering supporting information, and planning appropriate recovery steps, thereby reducing overall system downtime. The following sections discuss Oracle's disk, tape, and cloud backup technologies, in addition to Data Recovery Advisor.

"RMAN has greatly improved reliability of backups and database copies for our customers. We can now consistently deliver QA and development environments to our customers to meet their project needs. With automated database duplication, RMAN allows us to perform trouble-free cloning"

Rich Bernat, Sr DBA/SAP Basis Administrator, ChevronTexaco

Recovery Manager (RMAN)

Large databases can be composed of hundreds of files, making backup extremely challenging. Missing even one critical file can render the entire database backup useless. Worse, incomplete backups go undetected until they are needed in an emergency. Oracle Recovery Manager (RMAN) is the core Oracle Database software component that manages database backup, restore, and recovery processes. RMAN maintains configurable backup and recovery policies and keeps historical records of all database backup and recovery activities. RMAN ensures that all files required to successfully restore and recover a database are included in complete database backups. Furthermore, as part of RMAN backup operations, all data blocks are verified to ensure that corrupt blocks are not propagated into the backup files.

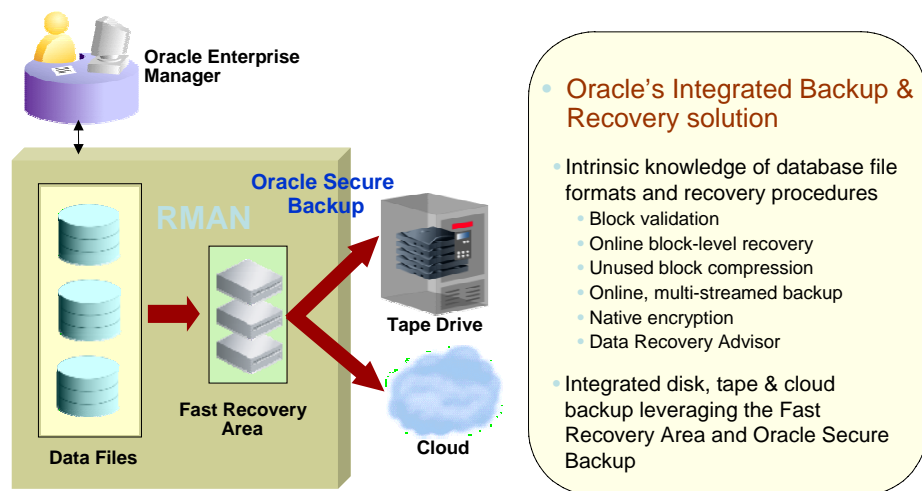


Figure 2: Integrated Disk, Tape, and Cloud Backup & Recovery from Oracle

RMAN 11g Release 2 Enhancements

RMAN has been enhanced in Oracle Database 11g Release 2 in several areas. For example, RMAN now offers a choice of compression levels. Compression set to `MEDIUM` is suitable to most environments, whereas `HIGH` is suitable for backups where network speed is the bottleneck,

and LOW has the least CPU impact. Among other enhancements to DUPLICATE, you can clone a database without connecting to the source database (i.e., the target database in RMAN terminology). For more information see Oracle's [RMAN web resources](#).

Fast Recovery Area

A key component of the Oracle disk backup strategy is the Fast Recovery Area (FRA), a storage location on a filesystem or Automatic Storage Management (ASM) disk group that organizes all recovery-related files and activities for an Oracle database. All files that are required to fully recover a database from media failure can reside in the Fast Recovery Area, including control files, archived logs, data file copies, and RMAN backups.

What differentiates the FRA from simply keeping your backups on disk is the FRA's proactive space management. In addition to a location, the FRA is also assigned a quota, which represents the maximum amount of disk space that it can use at any time. For example, when new backups are created in the FRA and there is insufficient space (per the assigned quota) to hold them, backups and archived logs that are not needed to satisfy the RMAN retention policy (or that have already been backed up to tape), are automatically deleted, to reclaim space. The Fast Recovery Area will also notify the administrator via the alert log, when disk space consumption is nearing its quota and there are no additional files that can be deleted. The administrator can then take action to add more disk space, backup files to tape, or change the retention policy.

Oracle Secure Backup

Oracle Secure Backup (OSB) is Oracle's enterprise-grade tape backup management solution for both database and filesystem data. Corporate data are vital business assets but their protection is challenging because they reside within databases or file systems on various servers and storage distributed across data centers, branches and remote offices. With a highly scalable client-server architecture, Oracle Secure Backup delivers centralized tape backup management for distributed, heterogeneous environments for your entire IT environment, by providing:

- Oracle Database integration with Recovery Manager (RMAN) supporting versions Oracle9i to Oracle Database 11g. Optimized RMAN integration can increase backup performance by 25 – 40% over comparable products.
- File system data protection for UNIX, Windows, and Linux servers, as well as Network Attached Storage (NAS) protection via the Network Data Management Protocol (NDMP).

Oracle Secure Backup supports policy-based fine-grained control over the backup domain and media including: backup encryption and key management, tape duplication and tape vaulting (rotating tapes between multiple locations).

The Oracle Secure Backup environment may be managed using command line, the OSB web tool or Oracle Enterprise Manager. For further details see Oracle's [OSB web resources](#).

"Oracle ST-IT has saved over \$300,000 in license renewal and annual maintenance costs by replacing our tape backup software with Oracle Secure Backup!"

Tom Guillot, Senior Manager, ST Development Systems, Oracle

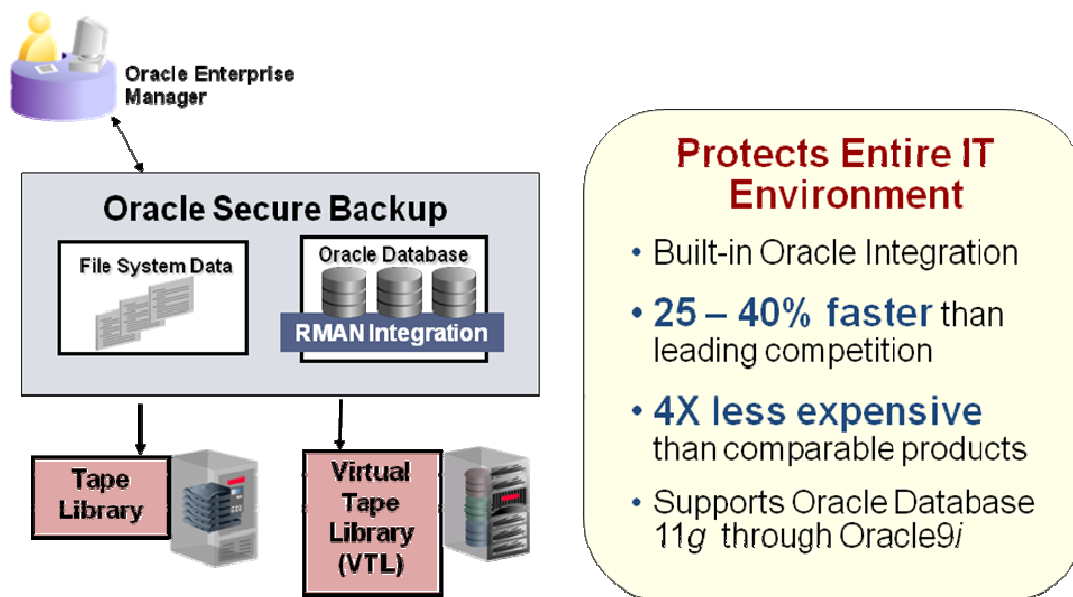


Figure 3: Oracle Secure Backup – Oracle's Enterprise-grade Tape and Cloud Backup Product

Oracle Secure Backup 10.3 Enhancements

Oracle Secure Backup 10.3 provides increased tape device utilization for duplication and encryption, which improves the performance of those operations and reduces server overhead. While these operations are independent of one another, with both, OSB 10.3 provides the option of offloading the server in favor of leveraging tape device resources:

- Server-less tape duplication eliminates the transport of backup data through the media server. Instead, only OSB control messages flow through the media server whereas backup data to duplicate are sent directly from the Virtual Tape Library (VTL) to the tape drive.
- Hardware (LTO-4) backup encryption offloads the encryption process from the host to the tape drive. OSB generates and manages the encryption keys seamlessly whether native or LTO-4 encryption is used. LTO-4 drive encryption allows encryption of NAS backups.

Oracle Secure Backup delivers comprehensive data protection management with enterprise-class features and Oracle database integration in one, complete solution. Advanced capabilities, which comparable products license separately, are included in the Oracle Secure Backup low-cost, per tape drive license simplifying licensing without compromising functionality.

Oracle Secure Backup Cloud Module

The advent of low-cost Cloud storage (such as Amazon's S3) presents new opportunities to make offsite backups more accessible and reliable. With RMAN and the Oracle Secure Backup Cloud module it is now possible to send local disk backups directly to Amazon S3 for offsite storage. The Oracle Secure Backup Cloud module can also be used to stream backups directly to the Cloud. This is particularly useful when the database is running in the Cloud, using services such as Amazon Elastic Compute Cloud (EC2).

The Oracle Secure Backup Cloud module can be used to back up all supported versions of Oracle Database, i.e., Oracle Database 9i Release 2 or higher.⁴ Database administrators can continue to use their existing backup tools – Enterprise Manager, RMAN scripts, etc. – to perform Cloud backups. For more information see Oracle's [Cloud Computing web resources](#).

Data Recovery Advisor

When critical business data become jeopardized, recovery and repair options need to be quickly and thoroughly evaluated to ensure a safe and fast recovery. These situations can be very stressful and often occur in the middle of the night. Research shows that administrators spend a majority of repair time investigating what, why, and how data has become compromised. Administrators need to comb through volumes of information to identify and inspect the relevant errors, alerts, and trace files.

The Oracle Data Recovery Advisor reduces the uncertainty and confusion during an outage. Because it is tightly integrated with other Oracle High Availability features such as Data Guard and RMAN, the Data Recovery Advisor is able to identify which recovery options are feasible given the specific conditions. The possible recovery options are presented to the administrator, ranked based on potential data loss. The Data Recovery Advisor can also automatically implement the best recovery options, reducing reliance on the administrator.

Many disaster scenarios can be mitigated based on accurate analysis of errors and trace files that are presented prior to an outage. Therefore, a set of database health checks can be proactively run to verify physical integrity. Based on the health checks results, the advisor can identify symptoms that could be precursors to a database outage, and alert the administrator. The administrator then can choose to obtain recovery advice and perform preventive actions to fix the problem before it results in system downtime. See also [Data Recovery Advisor web resources](#).

⁴ The OSB Cloud module uses the RMAN media management interface, which seamlessly integrates external backup libraries with RMAN for all database backup and recovery operations.

ORACLE Enterprise Manager 10g Grid Control

Home | **Targets** | Deployments | Alerts | Compliance | Jobs | Reports

Hosts | Databases | Middleware | Web Applications | Services | Systems | Groups | **All Targets**

Database Instance: [NewYork.us.oracle.com](#) >

Information

- Database Failures - 1
- Current Status - MOUNTED

Perform Recovery

Oracle Advised Recovery

The Data Recovery Advisor has detected failures. Click on "Advise and Recover" to have Oracle analyze and produce recovery advice. **Advise and Recover**

Failures Detected **Critical: 0 High: 1 Low: 0**
 Failure Description **One or more non-system datafiles are missing**

User Directed Recovery

Recovery Scope: **Whole Database** **Recover**

Operation Type: Recover to the current time or a previous point-in-time
Datafiles will be restored from the latest usable backup as required.

Restore all datafiles
Specify Time, SCN or log sequence. The backup taken at or prior to that time will be used. No recovery will be performed in this operation.

Recover from previously restored datafiles

Decrypt Backups

Host Credentials

To perform recovery, supply operating system login credentials to access the target database.

* Username:
 * Password:
 Save as Preferred Credential

Overview

- Recover database failures as advised by Oracle
- Restore and/or recover the entire database or selected objects
- Restore files to a new location
- Recover tablespaces to a point-in-time based on a timestamp, system change number (SCN), or log sequence number
- Recover datafile data blocks that are marked as corrupted, or based on datafile block IDs or tablespace block addresses
- Flashback database or tables to a specific system change number (SCN) or timestamp

Figure 4: Using Data Recovery Advisor through Enterprise Manager

Storage Failure Protection

Oracle Database 10g introduced Automatic Storage Management (ASM), a breakthrough storage technology that integrates file system and volume manager capabilities specifically designed for Oracle database files. Through its low cost, ease of administration and high performance characteristics ASM quickly became the storage technology of choice for IT administrators managing both stand-alone and Oracle RAC databases. Oracle Database 11g Release 2 extends ASM functionality to manage *all* data: Oracle database files, Oracle Clusterware files and non-structured data such as binaries, external files and text files.

For performance and high availability, ASM follows the principle of stripe and mirror everything. Intelligent mirroring capabilities allow administrators to define 2- or 3-way mirrors to protect vital data. When disk failures occur, system downtime is avoided by using the data available on the mirrored disks. If the failed disk is permanently removed from ASM, the underlying data is striped or rebalanced across the remaining disks to continue delivering high performance.

ASM Block Repair

Oracle Database 11g introduces new functionality to increase the reliability and availability of ASM. The first of these features is the capability to recover corrupt blocks on a disk by

leveraging the valid blocks available on the mirrored disk(s). When a read operation identifies that a corrupt block exists on disk, ASM automatically relocates the valid block from the mirrored copy to an uncorrupted portion of the disk. In addition, administrators can use the ASMCMD utility to manually relocate specific blocks due to underlying corruption of the disk.

Rolling Upgrades of ASM

ASM in Oracle Database 11g enhances the availability of the entire server pool environment with the capability to perform Rolling Upgrades of the ASM software. ASM Rolling Upgrades permit administrators to keep their applications online while they upgrade ASM on individual nodes by keeping the other nodes in the server pool available during the migration. The ASM instances can run at different software versions until all nodes in the server pool have been upgraded. Any functionality introduced in the newer version of the ASM software would not be enabled until all nodes in the server pool are upgraded.

ASM 11g Release 2 Enhancements

The ASM Cluster File System (ACFS) is a general-purpose scalable storage management technology that extends the ASM functionality to support all non-Oracle database files for Linux and Windows platforms. For example, ACFS supports Oracle binaries, application executables, trace files, alert logs, BFILEs, audio/video/image files and any other general-purpose files. ACFS Snapshot is a read-only space efficient point-in-time snapshot technology for ACFS file systems.

The ASM Dynamic Volume Manager (ADVM) is loadable kernel module that provides a general purpose volume management platform not only for ACFS file systems but also for third party file systems such as ext3 for Linux. ADVMS are managed by the ASM instance and benefit from ASM's storage provisioning, rebalancing, redundancy and automation. ASM Dynamic Volumes leverage all the powerful ASM features such as storage provisioning, rebalancing, redundancy and automation and are managed by the ASM instance. In addition, the Oracle Cluster Registry (OCR) and Voting files can now be automatically created by ASM and managed with high integrity and availability. For more information, see Oracle's [ASM web resources](#).

Site Protection

Enterprises need to protect their critical data and applications against events that can take an entire data center offline. Natural disasters, power outages, and communications outages are all examples of site failures, by making a datacenter completely unavailable. The Oracle Database offers a variety of data protection solutions that can safeguard an enterprise from costly downtimes due to complete site failures. Frequently updated and tested local and remote backups constitute the foundation of an overall HA strategy. However, restoring backups in a site-wide disaster can take more time than the enterprise can afford and the backups may not contain the most up to date versions of data. For that reason enterprises often keep one or more duplicate copies of the production database in physically separate data centers. We discuss next how you can achieve replication with one or both of Oracle Data Guard and Oracle GoldenGate.

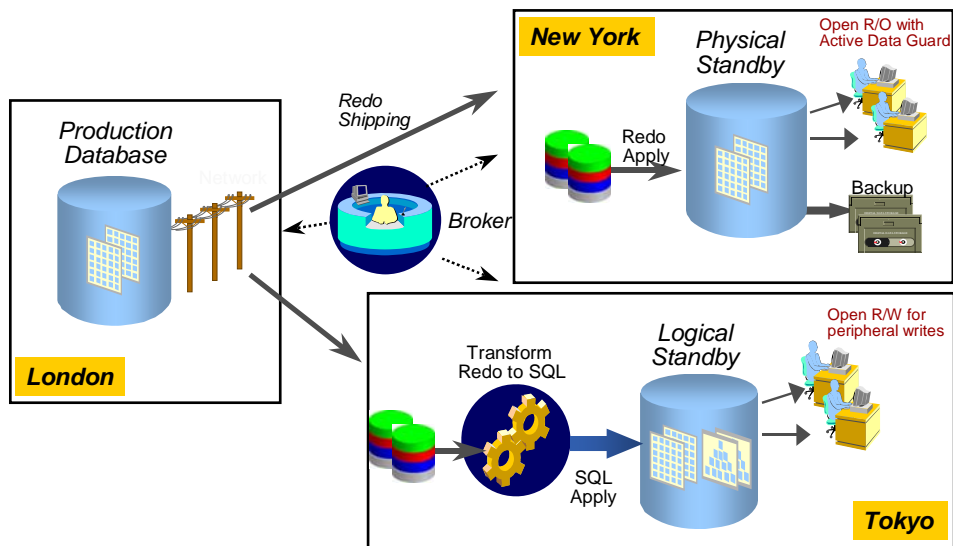


Figure 5: Oracle Data Guard – Ensuring Data Protection and Data Availability

Data Guard

Oracle Data Guard is Oracle's recommended data availability and data protection solution. It provides the management, monitoring, and automation software infrastructure to create and maintain one or more standby databases to protect enterprise data from failures, disasters, errors, and data corruptions. With Data Guard you can deploy and manage one or more standby copies of a production database either in the local data center or in a remote data center. Data Guard also works transparently across Private Cloud Server Pools as the servers can be added dynamically to the standby database in the event a failover is required.

Data Guard contributes to your ROI beyond disaster protection, as standby databases can be used for reporting, ad-hoc queries, backups, and test activity. Specifically:

- The Active Data Guard option, first available with Oracle Database 11g, enables a physical standby database to be open read-only while redo transport and standby apply are both active. Queries executed on active standby databases return up-to-date results.
- Snapshot Standby enables a physical standby database to be open read-write for any activity that requires a read-write replica of production data (e.g., testing). A Snapshot Standby continues to receive, but not apply, redo generated by the primary. Redo is applied automatically when the Snapshot Standby is converted back to a physical standby database.
- A logical standby database has the additional flexibility of being open read-write. While data maintained by SQL Apply cannot be modified, you can add additional local tables, create local index structures to optimize reporting, use the standby database as a data warehouse, or use it to transform information used to load data marts.

"Active Data Guard 11g is a quick win! We easily dual-purposed our ten terabyte standby database for both disaster protection and secure read-only access for our public-facing eCommerce applications. We were happy to discover after much effort evaluating other alternatives, that utilizing our existing Data Guard standby database was the simplest solution to provide customers with continuous access to current information"

Sue Merrigan, Intermap Technologies

- You can use Standby databases to perform planned maintenance in a rolling fashion. This reduces downtime and risk when performing hardware or O.S. maintenance, site maintenance, or when upgrading to new database patchsets, full database releases, or implementing other significant database changes.
- You can also offload backups from a primary to a physical standby database.

Data Guard 11g Release 2 New Features

Data Guard in Oracle Database 11g Release 2 is available with new or enhanced capabilities in many areas. Active Data Guard now automatically enforces service level objectives for maximum data delay when querying an active standby, and it automatically repairs corrupt blocks online using an active standby. Redo Transport now supports up to 30 standby databases and also offers compression for both Synchronous and Asynchronous transport. Synchronous Redo Transports enhancements reduce overhead on the primary database. Un-sent redo in asynchronous configurations using Maximum Performance may be flushed to a standby before failover to achieve zero data loss, enhancing data protection. Redo Apply switchovers no longer require any standby instances to be shut down, among other enhancements to role transitions. Data Type support now includes support for SecureFiles, basic table compression, OLTP table compression; and support for SQL Apply for replication of column objects, VARRAY, and Oracle-supplied Spatial type SDO_GEOMETRY.

Finally, manageability is improved by these 11g Release 2 enhancements:

- Increased performance for very large transactions (greater than 8 million rows) when using SQL Apply.
- Triggers can be defined on a logical standby to perform local processing independent of the primary.
- Data Guard Broker has improved status and error reporting.
- Data Recovery Advisor uses available standby database for intelligent data repair.

For more information, and the full list of new enhancements, see Oracle's [Data Guard web resources](#).

Oracle GoldenGate

Oracle GoldenGate is Oracle's information distribution solution. It provides a set of elements designed to facilitate the capture, staging, and delivery of changes from and to the Oracle database.

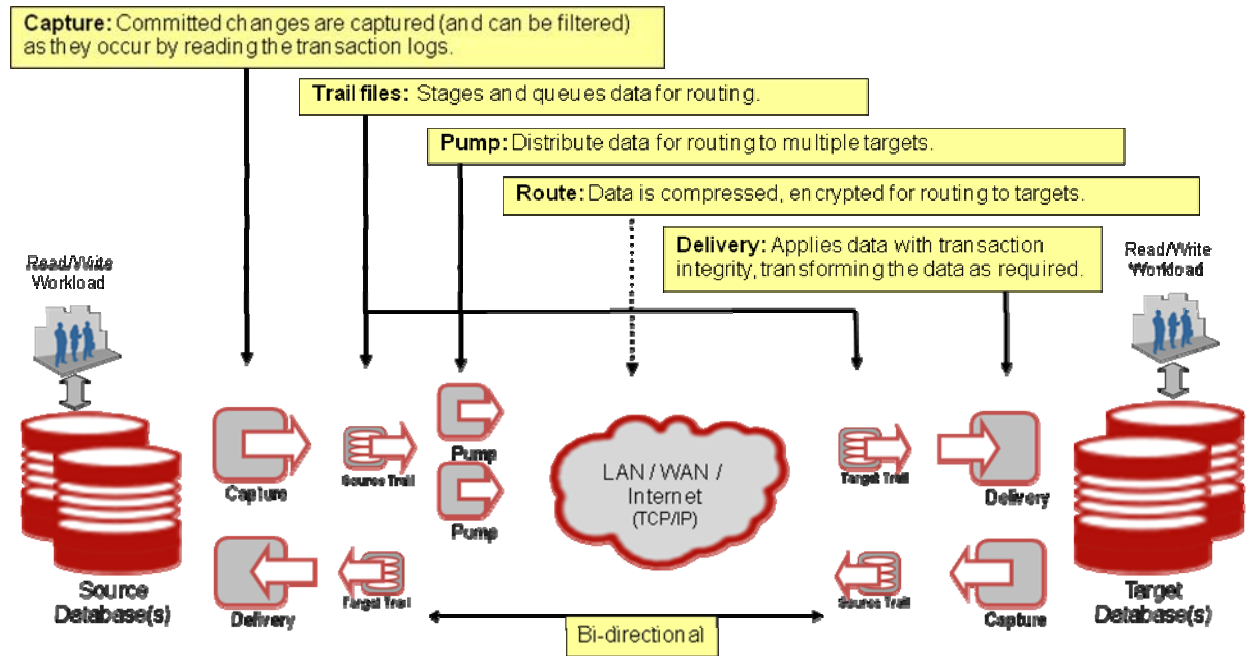


Figure 6: Oracle GoldenGate – Ensuring Active-Active Information Sharing

Existing applications can use Oracle GoldenGate with minimal modification or special handling. Oracle GoldenGate can be easily configured, for example, to capture of changes for an entire database, or a set of schemas, or individual tables. Databases using Oracle GoldenGate technology can be heterogeneous – e.g. a mix of Oracle, DB2, SQL Server, etc. These databases may be hosted in different platforms – e.g. Linux, Solaris, Windows, etc. Participating databases can also maintain different data structures using GoldenGate to transform the data into the appropriate format. All of these capabilities provide a strong foundation for GoldenGate to be adopted as the standard replication technology within large enterprises.

Active – Active Databases

In a GoldenGate replication configuration, both the source and destination databases are fully available to end-users for reading and writing, yielding a distributed, active-active configuration. Because users can update different copies of the same table anywhere, changes made at different database sites to the same data element may result in an update conflict. Oracle GoldenGate provides a wide variety of options for avoiding, detecting, and resolving conflicts. These options

can be implemented globally, on an object-by-object basis, based on data values and filters, or through event-driven criteria including database error messages.

Oracle GoldenGate and Oracle Streams – Strategic Direction

Oracle databases offers a built-in replication capability, called Oracle Streams. It relies on internal database mechanisms to capture, propagate, and apply logical change records (LCRs) between Oracle databases. Unlike GoldenGate, Streams does not support replication between Oracle and non-Oracle databases. Oracle Streams continues to be a supported database feature, but it will not be enhanced beyond Oracle Database 11g Release 2. In subsequent releases, Oracle GoldenGate, as Oracle's recommended replication solution for the enterprise, will be enhanced with the best of Streams technology as well as additional capabilities..

For more information see Oracle's [GoldenGate web resources](#).

Reducing Planned Downtime

Planned downtime is typically scheduled to provide administrators with a window to perform system and/or application maintenance. Throughout these maintenance windows, administrators take backups, repair or add hardware components, upgrade or patch software packages, and modify application components including data, code, and database structures. Oracle has recognized the need of IT administrators to continue traditional system and maintenance activities, while avoiding system and application downtime, and provides several key solutions to ensure HA during planned maintenance.

Online System Reconfiguration

Oracle supports dynamic online system reconfiguration for all components of your Oracle hardware stack. Oracle's Automatic Storage Management (ASM) has built-in capabilities that allow the online addition or removal of ASM disks. When disks are added or removed from an ASM Diskgroup – Oracle automatically rebalances the data across the new storage configuration while the storage, database, and application remain online. Real Application Clusters provide extraordinary online reconfiguration capabilities. Administrators can dynamically add and remove clustered nodes without any disruption to the database or the application. Oracle supports the dynamic addition or removal of CPUs on SMP servers that have this online capability. Finally, Oracle's dynamic shared memory tuning capabilities allow administrators to grow and shrink the shared memory and database cache online. With automatic memory tuning capabilities, administrators can let Oracle automate the sizing and distribution of shared memory per Oracle's analysis of memory usage characteristics. Oracle's extensive online reconfiguration capabilities support administrators' ability to not only minimize system downtime due to maintenance activities – but to also enable enterprises to scale their capacity on demand.

Online Upgrades

Enterprises with high availability demands can leverage Oracle technology to patch and upgrade their systems -even entire data centers- with minimal user interruption. With the strategic use of Real Application Clusters and Oracle Data Guard, administrators can more adeptly support the demands of the business.

Database Patching with Minimal Downtime

One-off patches may be applied to an Oracle database using two techniques: one is using the Online Patching feature introduced in Oracle Database 11g, and the other is using Oracle RAC in a rolling manner. Both are described below.

Online Patching

Beginning with Oracle Database 11g there is support for online patching for some qualified interim patches. Online patching, which is integrated with OPatch, provides the ability to patch the processes in an Oracle instance without bringing the instance down. Each process associated with the instance checks for patched code at a safe execution point, and then copies the code into its process space.

Online patching is the preferred solution for debug patches and interim patches where the scope of the fix is small. For more information on Online Patching, [see this paper \(PDF\)](#).

In Oracle Database 11g Release 2, Online Patching is available in these additional platforms:

- Windows 32-bit and Windows 64-bit
- AIX v6.1 [TL2 SP1]

Rolling Patch Upgrades using Oracle RAC

Oracle supports the application of patches to the nodes of a Real Application Cluster (RAC) system in a rolling fashion permitting availability of the database throughout the patching process. To perform the rolling upgrade, one of the instances is quiesced and patched while the other instance(s) in the server pool continue to service the end users. This process continues while all instances are patched. The rolling upgrade methodology can be used for emergency one-off database and diagnostic patches using OPATCH, operating system upgrades, and hardware upgrades. With Oracle Database 11g Release 2, the OPATCH utility has been updated to streamline the application of patches in a server pool.

Rolling Database Upgrade

Utilizing Oracle's Data Guard SQL Apply technology, administrators can apply database patchsets, major release upgrades, and server pool upgrades with near-zero downtime to the end users. The process begins with instantiating a logical standby database and configuring Data Guard to keep the standby synchronized with the production database. Once the Data Guard

configuration is complete, the administrator will pause the synchronization and all redo data will be queued. The standby database is upgraded, brought back online, and Data Guard is re-activated. All queued redo data will be propagated to and applied on the standby to ensure no data loss occurs between the two databases. The standby and production databases can remain in mixed-mode until testing on the logical standby database confirms that the upgrade completed successfully. At this point, the switchover can occur resulting in a database role reversal – the standby database is now servicing the production workload and the production database is ready to be upgraded. While the old production database is upgraded, the new primary database is queuing the redo data. Once the old production database is upgraded and the redo data is applied, a second switchover can be initiated and the original production system resumes accepting production traffic.

The capability of rolling database upgrades using Data Guard has been available since Oracle Database 10g Release 1. Oracle Database 11g further improves the rolling upgrade process by introducing Transient Logical Standby. This feature allows to temporarily convert a physical standby to a logical standby database to effect a rolling database upgrade, and then revert to a physical standby once the upgrade is complete (using the `KEEP IDENTITY` clause). This benefits physical standby users who wish to execute a rolling database upgrade without investing in redundant storage otherwise needed to create a logical standby database.

Data Center Migration

Data Guard is a popular approach to reducing downtime and risk when relocating a data center or when introducing other significant changes to a production environment. In the case of a data center move, a physical standby database for the database to be moved is first instantiated in the new data center. A Data Guard switchover operation can then rapidly transition production users to the database at the new data center with the guarantee of zero data loss. Following the switchover, the database at the original primary location can function as a synchronized standby database for the new location, providing a zero data loss fallback option should unforeseen difficulties necessitate a switch back to the original site. Systems at the original data center can be decommissioned as soon as there is confidence that the migration has been successful.

For example, a major US airline leveraged a Data Guard switchover to effect a complete data center migration to a new bunker site. First, they set up a physical standby in the destination data center (in North Carolina, USA) to their then-primary database (in Texas, USA). Once their standby in NC was caught up, they switched over to it. With the production database now in North Carolina, they were able to start migrating data center facilities there, all with minimal impact on production end users.

Online Data and Application Change

Online data and schema reorganization improves the overall database availability and reduces planned downtime by allowing users full access to the database throughout the reorganization

process. Starting with Oracle Database 11g, support of online reorganization functionality is available to additional object types including: advanced queuing (AQ) tables, materialized view logs, tables with Abstract Data Types (ADT), and Clustered Tables. Adding columns with a default value has been improved so that such additions have no effect on database availability or performance. Many data definition language (DDL) maintenance operations allow administrators to specify timeouts on lock waits, allowing administrators to maintain a highly available environment while performing maintenance operations and schema upgrades. Also, indexes can be created with the `INVISIBLE` attribute causing the Cost-Based Optimizer (CBO) to ignore them although they are still maintained by DML operations. When an index is ready for production availability, a simple `ALTER INDEX` statement will make it visible to the CBO.

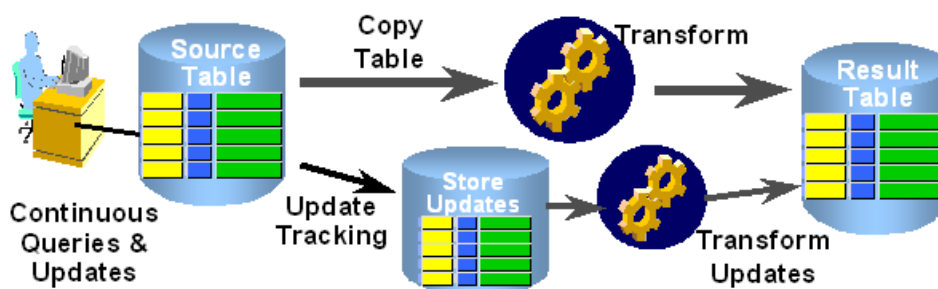


Figure 7: Maintaining a Table without Downtime using Online Table Redefinition

Online Table Redefinition

As business requirements evolve, so too do the applications and databases supporting the business. Through the strategic use of the `DBMS_REDEFINITION` package (also available in Enterprise Manager) – administrators can reduce downtime in database maintenance by allowing changes to a table structure while continuing to support an online production system. Administrators using this API enable end users to access the original table, including insert/update/delete operations, while the maintenance process modifies an interim copy of the table. The interim table is routinely synchronized with the original table and once the maintenance procedures are complete, the administrator performs the final synchronization and activates the newly structured table.

Online Application Upgrades

Oracle Database 11g Release 2 introduces new capabilities that allow online application upgrade with uninterrupted availability of the application. When the installation of the upgrade is complete, the pre-upgrade application and the post-upgrade application can be used at the same time. Therefore an existing session can continue to use the pre-upgrade application until its user decides to end it; and all new sessions can use the post-upgrade application. As soon as no sessions are any longer using the pre-upgrade application, it can be retired. Thus the application as a whole enjoys hot rollover from the pre-upgrade version to the post-upgrade version.

The new Oracle Database 11g Release 2 feature that enables this is called Edition-based Redefinition. It comprises the following functional components:

- Code changes are installed in the privacy of a new edition.
- Data changes are made safely, by writing only to new columns or new tables not seen by the old edition. An editioning view exposes a different projection of a table into each edition to allow each to see just its own columns.
- A crossedition trigger propagates data changes made by the old edition into the new edition's columns, or (in hot-rollover) vice-versa.

Managing Oracle Database High Availability Solutions

Oracle Enterprise Manager 10g Grid Control (Oracle Grid Control) is the recommended management interface for an Oracle environment. Oracle Grid Control delivers centralized management functionality for the complete Oracle IT infrastructure, including systems running Oracle and non-Oracle technologies. With a broad set of administration, configuration management, provisioning, end-to-end monitoring, and security capabilities, Oracle Grid Control reduces the cost and complexity of managing grid computing environments, while helping customers maintain their IT infrastructure service levels.

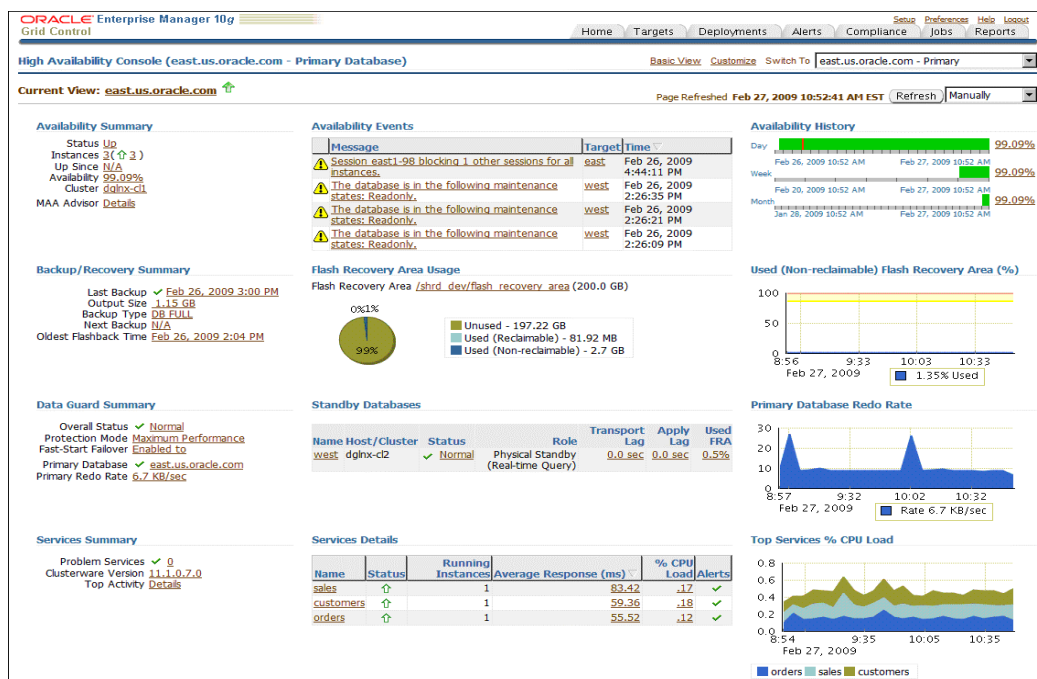


Figure 8: Grid Control HA Console

Oracle Enterprise Manager 10g Release 5 has been augmented with several key HA focused capabilities, as follows:

- It offers a new HA Console that integrates monitoring of various HA areas (e.g. clustering, backup & recovery, replication, disaster recovery), provides overall HA configuration status and initiates appropriate operations (see figure 8).
- The Maximum Availability Architecture Configuration Advisor page allows you to evaluate the configuration and identify solutions for protection from server, site, storage, human and data corruption failures, enabling workflows to implement Oracle recommended solutions.
- It enables further MAA automation by enabling migration of databases to ASM and conversion of single instance databases to Oracle RAC with minimum downtime.

- It has dramatically improved the management and monitoring of Oracle Streams configurations. Administrators now have complete end-to-end topology views of Streams configurations with integrated health-check metrics, through which any bottleneck in the topology (e.g. because of network bandwidth issues) can be quickly identified and resolved.
- It supports management of Oracle Secure Backup administrative server as a target and Oracle Secure Backup File System backup/restore and reporting.

Oracle Maximum Availability Architecture

Operational best practices are essential to the success of an IT infrastructure. Oracle Maximum Availability Architecture (MAA) is Oracle's best practices blueprint based on the integrated suite of Oracle's best-of-breed High Availability (HA) technologies. MAA integrates Oracle Database features for high availability including RAC, Data Guard, Streams, ASM, RMAN, Enterprise Manager, etc. MAA includes best practice recommendations for critical infrastructure components including servers, storage and network. Beyond the technology, the MAA blueprint encompasses specific design and configuration recommendations that have been tested to ensure optimum system availability and reliability. Enterprises that leverage MAA in their IT infrastructure find they can quickly and efficiently deploy applications that meet their business requirements for high availability.

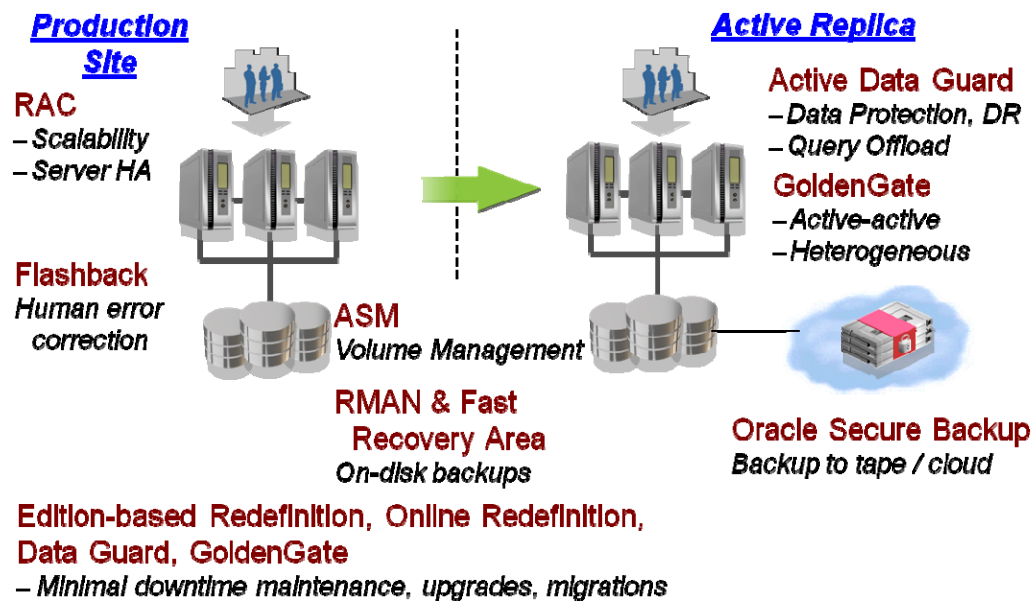


Figure 9: Maximum Availability Architecture: Integrated Deployment of Oracle HA

Oracle's Maximum Availability Architecture, through the right combination of technology and operational best practices, enables enterprises to deploy unbreakable IT solutions. The MAA best practices are continually being extended. See also Oracle's [MAA web resources](#).

Oracle's High Availability Customers

Oracle's HA solutions have shown remarkable customer adoption and market success, and continue to be a critical differentiator when prospective customers must choose a database technology that can support the 24x7 uptime requirements of today's businesses.

A long list of customers from all industries benefiting from Oracle Database's availability, performance, reliability, manageability, and security capabilities is available on the web. More focused [lists of customers who have implemented various Oracle high availability solutions](#), along with detailed implementation case studies, are also available on the web. These success stories about Oracle High Availability in action at some of the best names in various industry verticals across the world is a glowing tribute to Oracle's unparalleled technical superiority in the area of high availability.

Conclusion

Successful enterprises understand the vital importance of maintaining highly available technology infrastructures to protect critical data and information systems. At the core of many mission critical information systems is the Oracle database, responsible for the availability, security, and reliability of the technology infrastructure. Building on decades of innovation, Oracle Database 11g offers revolutionary new availability and data protection solutions to provide customers with highly effective ways to maximize their data and application availability, in the event of both planned maintenance activities and of unexpected failures. Working in tandem with Oracle Database's HA features, the Private Cloud capabilities make certain that the cost to deploy your database environment, and adapt to changing business needs, is significantly less than what you had to spend in the past to achieve equivalent results.



Oracle Database 11g Release 2 High Availability
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Author: Cris Pedregal
Contributing Authors: Ashish Ray, Database HA
Product Management Team

Oracle Corporation
World Headquarters
500 Oracle Parkway
Redwood Shores, CA 94065
U.S.A.

Worldwide Inquiries:
Phone: +1.650.506.7000
Fax: +1.650.506.7200
oracle.com



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