

# Flashback Technology: Recovering from Human Errors

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## **EXECUTIVE OVERVIEW**

According to many studies, 40% of application outages are caused by operator or user errors. Part of being human is making mistakes. But these errors are extremely difficult to avoid and in can be particularly difficult to recover from without advance planning and the right technology. Such errors can result in “logical” data corruption or cause downtime of one or more components of the IT infrastructure. While it is relatively simple to rectify the failure of an individual component, detection and repair of logical data corruption, such as accidental deletion of valuable data, is a time consuming operation that causes enormous loss of business productivity. Typical user-errors may include accidental deletion of valuable data, deleting the wrong data, and dropping the wrong table. This paper focuses on the Oracle Database 10g architecture that leverages the unique technological advances in the area of database recovery due to human errors – Flashback Technology.

## **GUARDING AGAINST HUMAN ERRORS**

The best way to prevent errors is to restrict a user’s access to data and services they truly need to conduct their business. 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. In addition the security model of Oracle Database provides the ability to restrict data access at a row level, using the Virtual Private Database feature, further isolating users from data they do not need not access to.

When authorized people make mistakes you need the tools to correct these errors. The Oracle Database 10g provides a family of human error correction technology called Flashback. Flashback revolutionizes data recovery. In the past it might take minutes to damage a database but hours to recover it. With Flashback the time to correct errors equals the time it took to make the error. It is also extremely easy to use and a single short command can be used to recover the entire database instead of following some complex procedure. Flashback provides a SQL interface to quickly analyze and repair human errors.

## FLASHBACK TECHNOLOGY

Flashback technology is unique to the Oracle Database and supports recovery at all levels including the row, transaction, table, tablespace, and database wide.

In the past it might take minutes to damage a database but hours to repair it. In many cases the time to correct errors using Flashback equals the time it took to make the error. Flashback is also extremely easy to use and a single short command can be used to recover the entire database instead of performing complex media recovery. Flashback provides fine-grained surgical analysis and repair for localized damage -- like when the wrong customer order is deleted. Flashback also allows for correction of more widespread damage yet does it quickly to avoid long downtime -- like when all of this month's customer orders have been deleted. Flashback is unique to the Oracle Database 10g and supports recovery at any level of granularity including the row, transaction, table, and database wide.

- **Flashback Query** allows the user to query data at some point-in-time in the past to reconstruct lost data that may have been deleted or changed by accident
- **Flashback Version Query** provides a mechanism to view changes made to the database over time at the row level.
- **Flashback Transaction Query** provides a mechanism to view changes made to the database at the transaction level.
- **Flashback Database** is a new strategy for doing point-in-time recovery. It quickly rewinds an Oracle database to a previous time to correct any problems caused by logical data corruption or user error.
- **Flashback Table** provides the ability to recover a table, or a set of tables, to a specified point in time in the past very quickly and easily.
- **Flashback Drop** provides a safety net when dropping objects as you can very quickly and easily undrop a table and its dependent objects.

Let's take a more detailed look at each of the flashback features and how Oracle Database 10g provides fast recovery from logical corruption.

### Flashback Query

Oracle Flashback Query, a feature introduced in the Oracle9i Database, allows an administrator or user to query any data at some point-in-time in the past. This powerful feature can be used to view and reconstruct lost data that may have been deleted or changed by accident. For example:

```
Select * from EMPLOYEE as of '2:00 P.M.' where ...
```

**Oracle Flashback Query allows an administrator or user to query any data to some point-in-time in the past.**

This statement displays rows from the table EMPLOYEE from 2pm today. Developers can use this feature to build self-service error correction into their applications, empowering end-users to undo and correct their errors without delay, rather than burdening administrators to perform this task. Flashback Query is extremely simple to manage, as the database automatically keeps the necessary information to reconstruct data for a configurable time into the past.

The Flashback Query mechanism is most effective when you use Automatic Undo Management. The Oracle database treats undo as a first class database object. Undo is persistent and can survive database system crash or, shutdown. It also shares the database buffer cache with other database objects for better performance. The Oracle database uses undo beyond transaction commit to provide read consistency for long running queries and also, to recover from logical corruptions.

The Oracle database provides a means of explicitly specifying the amount of undo to retain. The system automatically recycles expired undo to make space for new transactions to generate undo. The choice of undo retention value depends upon the length of the long running queries and the logical corruption recovery requirements. Users can, however, choose not to specify the undo retention and allow the system to provide the best retention for the given undo space. This best retention allows for best possible coverage for the long running queries and also, to recover from logical corruptions. The default undo retention is not guaranteed. The system can use oldest un-expired undo if it runs out of expired undo to use for an ongoing transaction.

The following describes the steps required to ensure a database is enabled to use the Flashback Query and other flashback features that are dependent upon undo information. This includes

- Ensuring that the database is using an undo tablespace. The setting the UNDO\_MANAGEMENT initialization parameter to AUTO specifies this.
- Setting the UNDO\_RETENTION initialization parameter to a value that causes undo to be kept for a length of time that allows success of your longest query back in time or to recovery from human errors.
- To guarantee that unexpired undo will not be overwritten, set the RETENTION GUARANTEE clause for the undo tablespace.

The unique feature of Flashback Query allows you to see the data as it was in the past, then choose exactly how to process the information; you might do an analysis,

undoing the changes, or capture changed data for further processing. The Flashback Query mechanism is flexible enough to be used in many situations. You can:

- query data as it existed in the past.
- compare current data to past data. You can compare individual rows, or do more complex comparisons such as finding the intersection or union.
- recover deleted or changed data.
- refer to a point in time using a DATE or TIMESTAMP value, or record system change numbers.

Oracle Flashback Version Query provides a way to view changes made to the database at the row level. It is an extension to SQL and allows the retrieval of all the different versions of a row across a specified time interval.

### Flashback Version Query

Flashback Version Query provides a way to audit the rows of a table and retrieve information about the transactions that changed the rows. It retrieves all committed versions of the rows that exist or ever existed between the time the query was issued and a point in time in the past. It accomplishes this by utilizing Automatic Undo Management.

The Flashback Version Query is an extension to SQL that allows you to retrieve the different versions of rows in a given table that existed in a specific time interval. For any given table, a new row version is created every time the COMMIT statement is executed. The Flashback Version Query returns a row for each version of the row that existed in the time interval you specify.

```
SQL> select order_id, customer_id, order_status,
2         rawtohex(versions_xid) "XID",
3         versions_operation   "OPER",
4         versions_startscn    "START_SCN",
5         versions_endscn     "END_SCN"
6     from orders
7     VERSIONS BETWEEN SCN MINVALUE and MAXVALUE
8     where order_id = 2453;
```

ORD_ID	CUST_ID	ORD_STATUS	XID	OPER	START_SCN	END_SCN
2453	116		0 0001000A00003594	D	758952	
2453	116		0			758952

You invoke the Flashback Version Query functionality by using the `VERSIONS BETWEEN` clause of the `SELECT` statement, denoted in the example above in the box. This looks like any other SQL query except for a few additional columns. There are four new pseudo columns that provide transaction details on the row data that allows a DBA to pinpoint when and how data is changed in the Oracle database.

**The Flashback Version Query is a powerful tool for the DBA to run analysis and answer the question, “How did this happen?”**

- `VERSIONS_XID` – The transaction id the created this version of the row
- `VERSIONS_OPERATION` – The action that created this version of the row for example delete, insert, update.
- `VERSIONS_STARTSCN` – The SCN in which this row version first occurred.
- `VERSIONS_ENDSCN` -- The SCN in which this row version was changed.

From the resulting query two rows are returned, based on all of the undo data available, where `ORDER_ID = 2453`. The rows are returned in the order of most recent activity. The first row shows `ORDER ID 2453` was **DELETED** at SCN 758952 and the Oracle transaction id is 0001000A00003594. The second row has no transaction id or operation. That means there is no undo available for previous versions of this order.

The Flashback Version Query is a powerful tool for the DBA to run analysis and answer the question, ‘How did this happen?’ Using this a DBA can pinpoint when and how data is changed and trace it back to the user, application, or transaction. This allows the DBA to track down the source of a logical corruption in the database and correct it. It also enables the application developer to debug their code.

### **Flashback Transaction Query**

Flashback Transaction Query provides a way to view changes made to the database at the transaction level. It is an extension to SQL that allows you to see all changes made by a transaction.

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You may discover that somehow data in a table has been inappropriately changed. To research this change, you can use multiple flashback queries to view row data at specific points in time. More efficiently, you can use Flashback Version Query feature to view all changes to a row over a period of time. That feature allows you to append VERSIONS BETWEEN clause to a SELECT statement that specifies an SCN or timestamp range between which you want to view changes to row values.

Once you identify an erroneous transaction, you can then use the Flashback Transaction Query feature to identify other changes that were done by the transaction, and to request the undo SQL to reverse those changes. The FLASHBACK\_TRANSACTION\_QUERY view is the means through which you obtain transaction history and undo SQL.

```
XID          TABLE_NAME  OPERATION
-----
UNDO_SQL
-----
0001000A00003594 ORDERS      DELETE
insert into "SCOTT"."ORDERS"("ORDER_ID", "ORDER_MODE", "CUSTOMER_ID", "ORDER_STATUS",
"ORDER_TOTAL", "SALES_REP_ID", "PROMOTION_ID") values ('2453', 'direct', '116', '0',
'129', '153', NULL);
0001000A00003594 ORDER_ITEMS  DELETE
insert into "SCOTT"."ORDER_ITEMS"("ORDER_ID", "LINE_ITEM_ID", "PRODUCT_ID", "UNIT_P
RICE", "QUANTITY") values ('2453', '1', '2492', '43', '3');
```

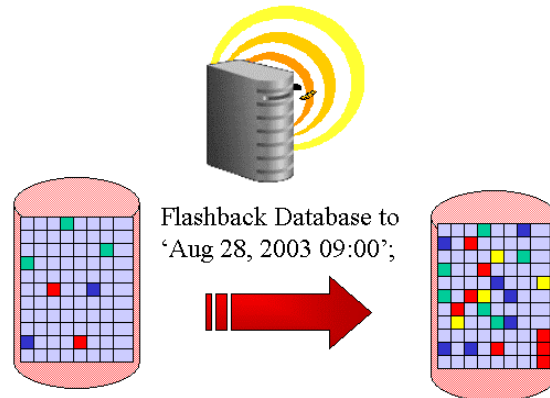
In the query above the transaction id was obtained from the previous Flashback Version Query. The resulting rows display all changes made within that transaction. In this particular case, ORDER 2453 and ORDER ITEMS belonging to ORDER 2453 have been deleted. If you need to repair the erroneous action, the SQL statements are supplied for you to manually execute.

Flashback Transaction Query provides a way for you to view all changes made to the database at the transaction level. When used in conjunction with Flashback Version Query, it allows you to easily recover from user or application errors. It increases online diagnosability of problems in your database and performs analysis and audits of transactions.

## Flashback Database

Flashback Database quickly rewinds an Oracle database to a previous time, to correct any problems caused by logical data corruptions or user errors. Flashback Database is like a 'rewind button' for your database.

It provides database point in time recovery without requiring a backup of the database to first be restored. When you eliminate the time it takes to restore a database backup from tape, database point in time recovery is fast. The Flashback Database capability, accessible from both RMAN and SQL\*Plus by using the FLASHBACK DATABASE command, is similar to conventional point in time recovery in its effects. It allows you to return a database to its state at a time in the recent past.



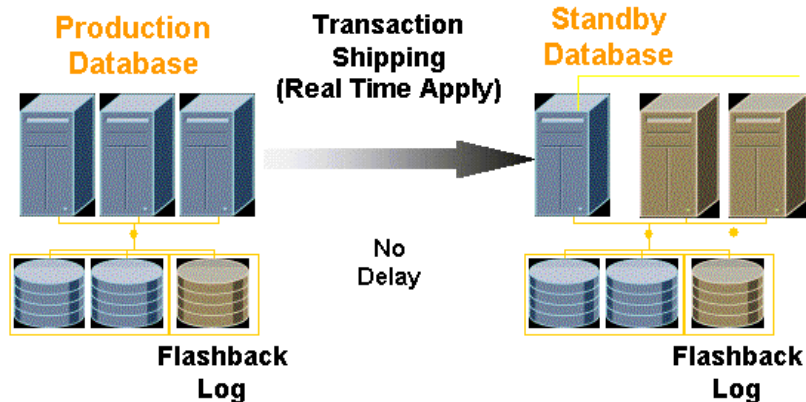
To enable the Flashback Database capability, a DBA configures the Flash Recovery Area. The Flash Recovery Area is a new feature in Oracle Database 10g that provides a unified storage location for all recovery related files and activities in an Oracle database. Besides Flashback Database logs, the recovery area contains redo archive logs and RMAN backups. For more information on the Flash Recovery Area, consult the Oracle Backup and Recovery Documentation.

**Oracle Flashback Database is like having a rewind button for your database.**

Oracle automatically creates and manages Flashback Logs within the Flash Recovery Area. Since the Flash Recovery Area is configured with a space quota, the Flashback Logs are subject to those disk space restrictions. The size of Flashback Logs can vary considerably, depending on the read/write ratio of database changes during a given flashback-logging interval. A copy of the block changes is written to the Flashback Log. If, over the course of a day, 10% of the database blocks are updated, then the size of Flashback Logs for 24 hours is 1/10<sup>th</sup> the size of your database. The DBA may change this disk quota dynamically if more disk space is required to recover the database to an earlier time in the past.

Data Guard provides several easy-to-use means to avoid user errors. Flashback Database can be used on both the primary and standby database to quickly revert the databases to an earlier point-in-time to back out user errors. Alternatively, if the

administrator decides to failover to a standby database, but those user-errors were already applied to the standby database (say, because Real Time Apply was enabled), the administrator may simply flashback the standby database to a safe point in time. Finally, the administrator has the added option not to use the Real Time Apply feature at one or more standby databases, and instead delay the application of redo data on those standby databases by a configurable amount of time, which provides a window of protection from such user errors or corruptions.



The performance overhead of enabling Flashback Database is less than 2%. While you may not be willing to sacrifice any performance overhead for your production database, think about the trade-off. If you could recover the database in minutes instead of hours, saving your company millions of dollars in lost revenue, would you then give 2% of the resources to Flashback Database?

Enabling Flashback Database functionality provides the following benefits.

- *Eliminate the time to restore a backup.* When a database is down because it runs into a catastrophic problem, millions of dollars in revenue is lost because they can no longer do business.
- *Eliminate standby database redo apply delay.* Flashback database is seamlessly integrated with Data Guard. A standby database can now be quickly and easily flashed back to an arbitrary point in time so a delay in the redo apply is not necessary.
- *Unanticipated Error Correction.* Flashback Database provides a continuous snapshot of the Oracle database. The database can be rewound back to a SCN or timestamp.

Oracle Flashback Database integrates with Oracle Data Guard to eliminate standby database redo apply delay.

## Flashback Table

When a human or application error occurs, you want to be able to restore the state of one or more tables to a point in time before the problem occurred. Flashback Table provides the DBA the ability to recover a table or a set of tables to a specified point in time quickly, easily, and online. Flashback Table restores the tables while automatically maintaining its associated attributes such as - the current indexes, triggers and constraints, not requiring the DBA to find and restore application specific properties. Flashback Table alleviates the need for you to perform more complicated point in time recovery operations. The following command flashes back the ORDERS and ORDER\_ITEMS tables to 2:33 PM on July 7<sup>th</sup>.

```
FLASHBACK TABLE orders, order_items TO TIMESTAMP (JUL-07-2003, 02:33:00);
```

**Oracle Flashback Table provides the DBA the ability to recover a table, or a set of tables, to a specified point in time in the past very quickly and easily.**

Like Flashback Query, Flashback Table also relies on the undo data to recover the tables. The undo data, therefore, must be available in order for a Flashback Table to be successful. The Automatic Undo Management feature allows you to specify how long they wish to retain the undo data using the UNDO\_RETENTION initialization parameter. By using this parameter and sizing the undo tablespace appropriately, DBAs can control how far back in time a table can be repaired using Flashback Table.

While a DBA can use the Flashback Table feature to quickly recover from human errors, it also serves as a self-service repair tool to recover from accidental modifications or deletions. An application developer can incorporate the Flashback Table functionality into their customized application. This tool provides significant benefits over media recovery in terms of ease of use, availability and faster restoration with point-in-time object based recovery.

### Flashback Table

- performs the restore operation online.
- restores all data in a specified table to a previous point in time described by a timestamp or SCN.
- automatically restores all of the table attributes, such as indexes, triggers, and the likes that are necessary for an application to function with the flashed back table.
- maintains any remote state in a distributed environment. For example, all of the table modifications required by replication are flashed back.

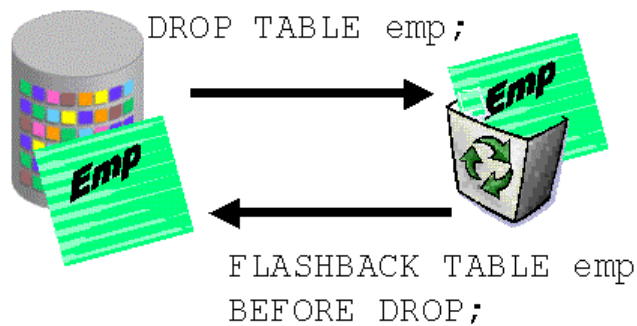
- maintains data integrity as specified by constraints. Oracle preserves all dependent objects and the referential integrity.
- provides the ability to revert it back to its original state even after a flashback operation.

## Flashback Drop

Dropping of objects by accident has always been a problem for users and DBAs alike. Users soon realize their mistake but then it's too late and historically there is no easy way to recover those dropped tables, indexes, constraints, triggers, etc. Flashback Drop provides a safety net when dropping objects in Oracle Database 10g. When a user drops a table, Oracle automatically places it into the Recycle Bin.

### What is the Recycle Bin?

The Recycle Bin is a virtual container where all dropped objects reside. Underneath the covers, the objects are occupying the same space as when they were created. If table EMP was created in the USERS tablespace, the dropped table EMP remains in the USERS tablespace. Dropped tables and any associated objects such as indexes, constraints, nested tables, and other dependant objects are not moved, they are simply renamed with a prefix of BIN\$\$\$. You can continue to access the data in a dropped table or even use Flashback Query against it.



**Oracle Flashback Drop provides a safety net when dropping objects in Oracle Database 10g. When a user drops a table, Oracle will place it in a Recycle Bin.**

Each user has the same rights and privileges on Recycle Bin objects before it was dropped. You can view your dropped tables by querying the new RECYCLEBIN view. Objects in the Recycle Bin will remain in the database until the owner of the dropped objects decides to permanently remove them using the new PURGE command. The Recycle Bin objects are counted against a user's quota. But Flashback Drop is a non-intrusive feature. Objects in the Recycle Bin will be automatically purged by the space reclamation process if

- a user creates a new table or adds data that causes their quota to be exceeded.
- the tablespace needs to extend its file size to accommodate create/insert operations.

Flashback Drop is just like having an undrop button for a table, and its dependent objects.

## **CONCLUSION**

Human errors are one of the predominant causes of system failure. These errors are extremely difficult to avoid and can be particularly difficult to recover from without advance planning and the right technology. The 'right' technology is here – Oracle Database 10g. Why should an error that takes seconds to execute take hours or days to recovery from? It shouldn't and now it doesn't. Flashback revolutionizes recovery by operating on just the changed data. A single command surgically repairs corruptions from human errors. Flashback technology removes the complexity of recovery while decreasing the time it takes to recover from unpredictable human errors.



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