Edition-Based Redefinition

an Oracle Database capability to support online application upgrade

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Executive Overview

Large, mission critical applications designed for Oracle Database 11*g* Release 1, or earlier versions, are often unavailable for tens of hours, or even longer, while the application's database backend is patched or upgraded. Oracle Database 11*g* Release 2 introduced edition-based redefinition—hereinafter EBR—a revolutionary capability that allows 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. In other words, the application as a whole enjoys hot rollover from the pre-upgrade version to the post-upgrade version.

To take advantage of the capability, the application's database backend must be EBR-readied by making some one-time schema changes; and the script that install a patch or an upgrade must be written in a new way to use EBR's features. Therefore, EBR adoption and subsequent use is the perogative the development shop.

Oracle Database 12*c* Release 1 and Oracle Database 12*c* Release 2 brought significant improvements to EBR that make it easier to EBR-ready an application's database backend.

This whitepaper explains how EBR works, how to adopt it, and how to write online application upgrade scripts using this capability, at the level of detail needed by the engineers who will plan and do the implementation.

Introduction

To achieve online application upgrade[1], the following challenges must be met:

» The installation of the changed database objects into the production database must not perturb live users of the pre-upgrade application.

» Transactions done by the users of the pre-upgrade application must be reflected in the post-upgrade application.

» For hot rollover, transactions done by the users of the post-upgrade application must be reflected in the pre-upgrade application.

Oracle Database 11g meets these challenges by making some evolutionary improvements to existing capabilities in both Release 1 in Release 2 and, more significantly, by introducing a revolutionary new capability in Release 2.

The revolutionary new capability is *edition-based redefinition*—herinafter EBR:

» 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.

This whitepaper explains EBR in detail by treating the concepts that underpin it and by illustrating the basic operations with minimal code samples. Then it presents a series of realistic use cases in order of increasing complexity. The discussion of these use cases should prepare the user for designing and implementing scripts for the online upgrade of the database component of real world applications.

This whitepaper does not attempt to be a reference manual. The relevant SQL syntax and PL/SQL APIs are documented in the Oracle Database SQL Language Reference book, the Oracle Database PL/SQL Language Reference book, and the Oracle Database PL/SQL Packages and Types Reference book; and the catalog views that expose facts about the relevant objects are documented in the Oracle Database Reference book. Rather, it aims to explain the concepts and the use of EBR at a depth that is not practical in the Oracle Database Documentation Library. In this way, it complements and extends the treatment in the Oracle Database Advanced Application Developer's Guide book and the Oracle Database Administrator's Guide book.

1. The term *upgrade* will be used in this whitepaper to denote both that and *patch*. The term *patch* is conventionally used to denote changes that are made to a system to *correct* behavior which deviates from its current functional specification; and the term *upgrade* is conventionally used to denote changes that are made to *enhance* behavior so that it conforms to a new version of the functional specification. However, this distinction in intention has no consequence for the nature of the changes that are made to an application's database objects. A change, for example, to a PL/SQL unit, to table data, or to table structure requires the same steps and has the same consequences whether the intention is to patch or to upgrade.

Customer Goals and Oracle Database Capabilities

Businesses rely on applications, some of which are used by their employees and others of which are used directly by their customers. Increasingly commonly, both the employees and the customers may be located anywhere around the world. For such applications, then, there is no common notion of the working day, the working week, or of public holidays. Therefore, not only is randomly occurring unavailability in the face of some kind of electrical or mechanical breakdown unacceptable, but so also is even planned unavailability to perform predictable software maintenance tasks. The customer's *high availability* goal is quite simply *zero downtime* stretching into the indefinite future.

Oracle Database has for some time had various capabilities to allow customers to maintain availability in the face of a spectrum of hardware problems ranging from disk or CPU failure through to demolition of the whole site.

With respect to deliberately undertaken software changes, it is useful further to break down this class into changes to the database system itself, as supplied by Oracle Corporation, and changes to the database objects that constitute the back end of the application, as supplied by developers employed by the customer organization or by an ISV.

Changes to the database itself are affected by running programs[2] supplied by Oracle Corporation. These changes are engineered to have no effect on the semantics of the database component of an extant application[3]. This fact has allowed capabilities which were designed to maintain availability the face of hardware problems to be used to maintain availability the face of planned changes to the database system. Both Logical Standby and Streams may be used in this way. Briefly, a new database is established as true copy of the extant database on a second hardware system dedicated to that purpose. For a period, the new database tracks the old database. Then the new database is taken off line, noting the moment at which this is done[4]. The new database's system software is upgraded as required and then it is put back on line and tracking of the old database is turned on again so that it "catches up" with the changes to customer objects that were made in the old database while the new database was not tracking it. Finally, the new database is declared to be the canonical one and end user sessions start to use it. (This requires a brief period of downtime to ensure that no end-user sessions use the new database until the old one has been formally closed for such sessions.) Then the hardware that supported the old database can be returned to the pool of available hardware to restore the *status quo* of hardware use by the application. This approach is viable also when it is required to upgrade the operating system software; it is viable, too, even if the goal is to migrate the database to brand new hardware which possibly has a different operating system.

The approach just described relies on the fact that the customer's database objects are identical in the old and the new databases. When the aim is to upgrade these objects, a different approach is needed. Such an approach is supported by EBR and is the subject of this whitepaper.

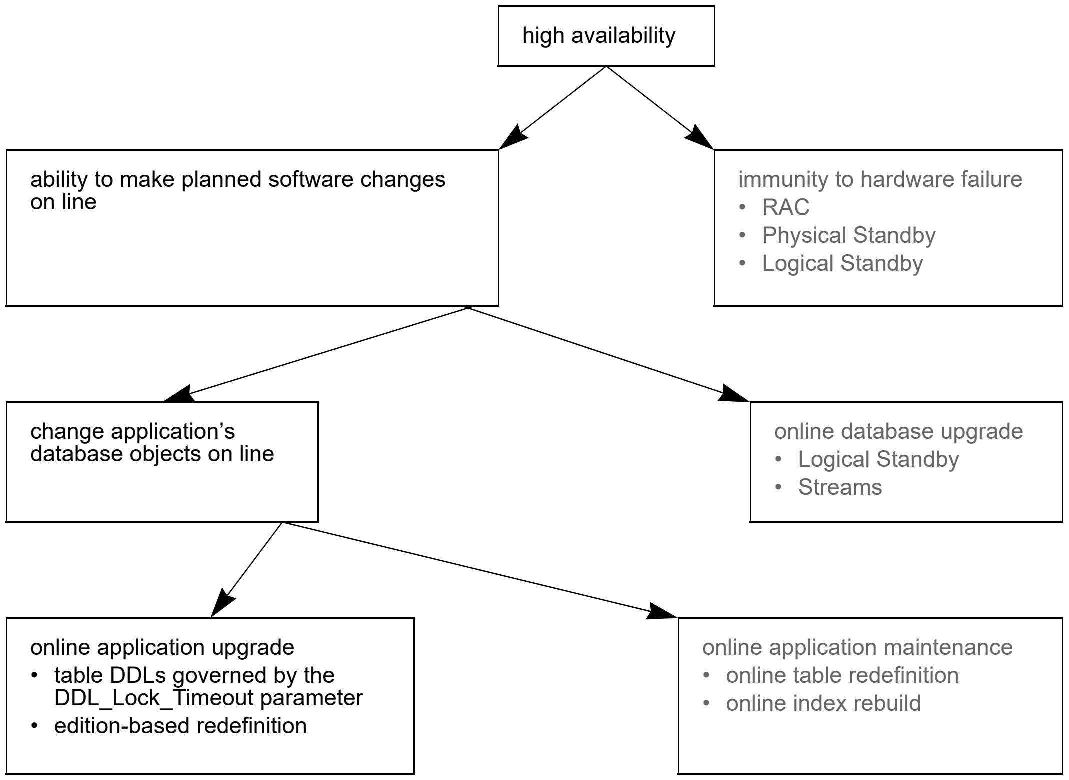
It is useful, finally, to distinguish between these two goals: online application upgrade and online application maintenance. In the former, changes are made to the *logical* aspects of an application's database objects; and in the latter, changes are made to their *physical* aspects. Examples of online application maintenance goals are the desire to tidy up a table by coalescing chained rows, by reclaiming the space taken up by a column that has been set unused, or by moving it to a different tablespace; and by the desire to rebuild an index. *Figure 1.*

2. Here, the term *program* is used generically to mean a set of machine-readable files whose contents determine the outcome when processed by various operating system utilities and utility components of the Oracle Database software installation.

3. Of course, a bug fix intentionally causes a behavior change. But such benign changes are insignificant in the present discussion.

4. This "moment" is recorded as a System Change Number.

summarizes the preceding discussion and shows illustrative capabilities of Oracle Database that support the various depicted customer goals.



high availability
ability to make planned software changes on line
immunity to hardware failure
• RAC
• Physical Standby
• Logical Standby
change application's database objects on line
online database upgrade
• Logical Standby
• Streams
online application upgrade
• table DDLs governed by the DDL_Lock_Timeout parameter
• edition-based redefinition
online application maintenance
• online table redefinition
• online index rebuild

Figure 1. Taxonomy of high availability goals and illustrative capabilities of Oracle Database that support them

It is self-evident that the new Oracle Database capabilities that support the customer's online application upgrade goal must be fully interoperable with, and must not compromise the reliability of, the Oracle Database capabilities that support other aspects of the customer's overall high availability goal. This whitepaper will show that this is the case.

Edition-Based Redefinition

EBR depends upon three new kinds of object: the *edition*, the *editioning view*, and the *crossedition trigger*.

» If the application upgrade will change only views, synonyms, and PL/SQL objects, then the edition alone is sufficient to allow these changes to be made while the application remains on line. This type of change is common when, for example, new presentations of data or new workflows are required.

» If changes to table data or structure are restricted to only those tables that are not changed via the ordinary end-user interfaces, then the edition together with the editioning view are sufficient to allow these changes to be made while the application remains on line. Tables whose data parameterizes the user interface layout or workflows meet this condition. So do tables that hold the catalog of wares for a shopping application.

» If changes to table data or structure are required for those tables that are changed routinely by the end-user, then the edition, the editioning view, and the crossedition trigger must be used in concert to allow these changes to be made while the application remains on line.

This understanding determines the natural order of exposition of the following topics.

The edition

This section first explains, at the next level of detail the challenge that presents when several mutually referring database objects are to be changed in the environment of others that, to implement the current upgrade, will not be changed.

It then explains, at a conceptual level, what an edition is and how it solves the problem at hand. This explanation brings with it some important terms of art that are not reflected directly in SQL syntax or in the names of catalog views, their columns, or the values that these contain.

It then presents code that illustrates the minimal self-contained illustration of a complete EBR exercise.

The challenge

Suppose that an application has 1,000 mutually dependent tables, views, PL/SQL units, and triggers, that these are owned by more than one user, and that the source code of these objects makes references to other of these objects, often by schema-qualified name[5]. Suppose that the upgrade needs to change only 10 of these. *Figure 2.* illustrates this.

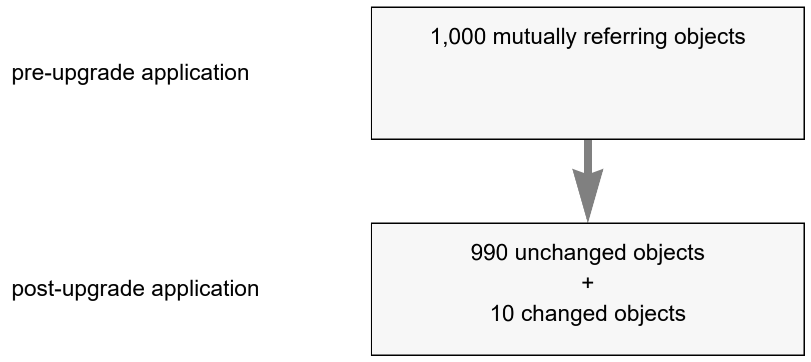


Figure 2. The challenge of online application upgrade

5. There is no getting away from schema-qualified names when an application's database objects span two or more schemas. The best that can be done is to isolate the schema-qualification in the definition of synonyms.

Of course, the 10 objects cannot be changed in place because many of the other 990 refer to them and doing so would change the meaning of the pre-upgrade application. Through Oracle Database 11*g* Release 1, the only dimensions that identify the intended object when one object refers to another, are its name and its owner: these naming mechanisms are not rich enough to support online application upgrade.

A short digression on the viability of an approach that uses schemas and synonyms to explicitly to enrich the naming mechanisms manually will be useful. It would be possible for a customer to impose a discipline where every reference from an object to another "primary" object in a different schema is made via a "secondary" private synonym in the referring object's schema. In such a regime, it might seem that online application upgrade could be achieved by installing the complete upgraded application in a new set of schemas with appropriately redefined private synonyms. This would, at least, allow the source text of the 900 "primary" objects for which no change was intended to remain unchanged in the source control system. There would, however, be some effort in redefining the synonyms in the source control system, but this could, presumably be done automatically. This approach suffers from a number of disadvantages with respect to using EBR:

» It requires specific design by the customer.

» Every "primary" object needs to be duplicated. This costs both space and the time it takes to run the DDL statements.

» While a scheme to handle changes to table data and structure might, just, be feasible using a hand-crafted equivalent of the editioning view, the effort to design and implement a scheme to reflect changes made by the pre-upgrade application into the representation that the post-upgrade application uses, and *vice versa*, would be dauntingly complex and, because of that, subject to an appreciable risk of error.

» Some applications issue DDL statements as part of their normal response to ordinary end-user interaction. The effort to design and implement a scheme to reflect such changes forwards and backwards between the pre-upgrade and the post-upgrade applications would be huge.

With applications of sufficient size and complexity, various issues arise (too complicated to describe in this whitepaper) that defeat the scheme. It is, quite simply, not generally viable "in the large".

As shall be seen, EBR supports the high-level philosophy of the manual approach just described but overcomes all its disadvantages.

Conceptual explanation of the edition

The understanding of how the edition enriches the naming mechanism is best gained by first appreciating the following new, seemingly dry, facts about EBR.

editions

» An edition is a new, nonschema object type, uniquely identified, therefore, by just its name. Editions are listed in the *DBA_Objects* catalog view family where, just like the nonschema object type *directory*, they appear to by owned by *Sys*[6].

» Every database from *11.2* onwards, whether brand new or the result of an upgrade from an earlier version, non-negotiably has at least one edition. Immediately on creation or upgrade to *11.2*, there is exactly one edition with the name *Ora$Base*.

» A new edition must be created as the child of an existing one; the syntax of the *create edition* statement allows that the parent edition be identified using the *as child of* clause.

6. A nonschema object, just as the name implies, is not owned by a schema and is potentially visible to all users, identified by just its name. The fact that *DBA_Objects* shows the owner of an edition or directory to be *Sys* is an artefact of the implementation and has no practical significance.

- An edition may have no more than one child[7].
- The *create edition* statement allows that the *as child of* clause be omitted to mean that the new edition is created as the child of the *leaf edition*[8].
- Every foreground database session, at every moment throughout its lifetime, non-negotiably *uses* a particular edition[9]. This is reflected as the value of the new parameter *Current_Edition_Name* in the *Userenv* namespace for the *Sys_Context()* builtin.
- A new *not null* database property, *Default_Edition*, listed in *Database_Properties*, specifies the edition that a session will use immediately on connection if the connect syntax does not nominate an explicit edition[10]. *Code_1* shows the SQL statement to set this.

  ```
  -- Code_1
  alter database default edition = Some_Edition
  ```

  A side effect of making an edition the default is to grant *Use* on it to *public*.
- When a new connection is made, it is possible to specify to edition the session should (initially) use.
- A new *alter session* command allows the edition that a session is using to be changed. However, this command is legal only as a top-level server call; an attempt to issue it using PL/SQL's dynamic SQL will cause an error[11]. Further, an attempt to change the edition that a session is using will fail if there is any uncommitted DML[12].

editionable object types, editions-enabled users, and editioned objects

- Views (and therefore editioning views), synonyms, and all the kinds of PL/SQL objects type[13] (and therefore crossedition triggers) are *editionable* object types. There are no other editionable object types. For example, *table* is not an editionable object type; nor is *java class*[14].
- The nonschema object type *user* has a new *Y/N* property, shown in *DBA_Users.Editions_Enabled*. This can be set with the *create user* command or changed with the *alter user* command, but only from *N* to *Y*.

7. This restriction may be relaxed in a later version of Oracle Database. The reader will see that the conceptual design accommodates this.

8. As long as the restriction holds that an edition may have no more than one child, there will always be exactly one *leaf edition*. Until this restriction is lifted, Oracle recommends thatthe plain *create edition* command be used without the *as child of* clause.

9. Some background sessions, most notably *MMON*, also always use exactly one edition.

10. The OCI and JDBC programmatic interfaces have been enhanced to allow an edition to be specified at session-creation time; and tools like SQL*Plus expose this new optional degree of freedom with appropriate syntax. However, in *11.2*, the connect string specification (*i.e.* the item for which an alias can be established in *tnsnames.ora*) does not allow the edition to be specified. This means that a database link always connects to the target database's default edition.

11. A new overload for *DBMS_Sql_Parse()* allows a single SQL statement to be executed in a specifically nominated edition. See *"Using DBMS_Sql_Parse() to execute SQL outside of the current edition"* on page 17. And a new procedure *DBMS_Session.Set_Edition_Deferred()* causes the nominated edition to be made current as the last action of the top-level server call that issues it.

12. The attempt causes *ORA-38814: Alter session set edition must be first statement of transaction*.

13. All the PL/SQL object types are potentially listed in the *DBA_PLSQL_Object_Settings* catalog view family. This includes *library*.

14. Objects of some types are purely metadata (represented just by rows in tables in the data dictionary) and consume no quota. It is convenient to call these *code objects*. Objects of other types, like tables and indexes, not only have metadata but also contain quota consuming substantive data. It is convenient to call these *data objects*. Later releases of Oracle Database might grow the list of editionable by adding more code object types. But for reasons that will become clear in *"The editioning view"* on page 18, the list will never include data object types.

However, certain users (*Sys*, *System*, and any user listed in the *DBA_Registry* catalog view family) cannot be *editions-enabled*; the attempt will cause an error.

» An object of an editionable object type that is owned by an editions-enabled user is *editioned*. An object that is not of an editionable object type can never be editioned. An object of an editionable object type that is owned by a user that is not editions-enabled is not editioned, but it will irrevocably become so when its owner is altered to become editions-enabled.

» An object that is not editioned is uniquely identified, just as it was through *11.1*, by just its owner, name and namespace. The context of reference defines the namespace so that references mention only the owner and name as explicit references. For example, a *package* is in the namespace *1*, and a *package body* is in the namespace *2*[15]. The *create package* statement establishes the namespace as *1*; the *create package body* statement establishes the namespace as *2*; and the invocation of *DBMS_Output.Put_Line()* in a PL/SQL unit establishes that the identifier *DBMS_Output* is in namespace *1*.

» An editioned object is uniquely identified by its owner, name, namespace *and* the value of current edition that issued the SQL statement that created or changed it[16]. This fact is the *sine qua non* of EBR; it lets two or several occurrences of the "same" object, as identified by owner, name, namespace, exist in the same database.

» The *DBA_Objects* catalog view family has a new column, *Edition_Name*[17]. It is always *null* for an object that is not editioned; for an editioned object, it is always *not null* and shows the name of the edition where the object was created or changed.

actual objects, inherited objects, and name resolution

» There is no edition-extended syntax. When an editioned object is to be identified, the name of the edition is always supplied implicitly by the context of the reference. For a DDL statement, the current edition provides the value; and for a reference from the source code of an editioned object, the referring object's edition provides the value.

» Therefore, the source code of an object that is not editioned may not refer to an editioned object; such an attempt will cause a compilation error. As a corollary, an attempt to editions-enable a user will sometimes fail[18].

» When the source code of an editioned object refers to another editioned object, then this reference is resolved to that occurrence whose *Edition_Name* is that of the edition which is the closest ancestor to the one denoted by the *Edition_Name* of the referring object. When the *Edition_Name* of the referenced object is the same as that of the referring object, then the referenced object is said to be *actual* from the point of view of the referring object; and when the *Edition_Name* of the referenced object denotes an ancestor to that of

15. Starting in *11.1*, the *DBA_Objects* catalog view family gained the column *Namespace* to advertise this property that, hitherto, had been somewhat obscure.

16. As will be seen, "change" includes not only the effect of the *create or replace* or *alter* statements but also statements like *grant* and *revoke*.

17. This column was in fact introduced in *11.1*, but there it was always *null*. It first becomes useful in *11.2*.

18. *First example:* Suppose that the users *u1* and *u2* are both not editions-enabled and are not among those supplied by Oracle Corporation that cannot be editions-enabled. Suppose that procedure *u2.p* depends on procedure *u1.p*. An attempt to editions-enable *u1* will fail unless *u2* is editions-enabled first.

Second example: Suppose that table *u1.Tabl* has a column whose datatype is the user-defined type *u1.Typ*. An attempt to editions-enable *u1* will fail until *u1.Tabl*, or the column in question, is dropped.

This is discussed further in "EBR-readying an application" on page 31.

the referring object, then the referenced object is said to be *inherited* from the point of view of the referring object.

» This same distinction between actual and inherited holds between editioned objects listed in the *DBA_Objects* catalog view family and varies according to the current edition. When *DBA_Objects.Edition_Name* is the same as the current edition, then the object is said to be actual in that edition; and when *DBA_Objects.Edition_Name* is that of an ancestor edition to the current edition, then the object is said to be inherited in that edition.

» All the catalog views that show properties about objects whose type is editionable share the behavior of showing only those editioned objects that are visible in the current edition. However, only the *DBA_Objects* and the *DBA_Objects_AE*[20] catalog view families have an *Edition_Name* column[19].

» A DDL statement that changes an existing inherited editioned object (for example *create or replace* or *alter*) causes that object to become actual in the current edition of the session that issued the DDL, in other words, it *actualizes* a new occurrence of the target object. This means that the changes are not seen in ancestor editions.

» The effect of the *drop* command on an inherited object is to make it vanish from the point of view of the current edition[20]. Again, the effect of this is not seen in ancestor editions. The *rename* command is supported for views and synonyms but not for PL/SQL objects. Rename behaves as if the target had been dropped and recreated with the new name: the target object is visible with its old name in ancestor editions and with its new name in the edition where the DDL statement was executed[21].

» If the owner and name of the target of the *create* command collide with an existing editioned object, then the attempt causes an error. This is the case both when the collision is with an actual object and when it is with an inherited object. Of course, *drop* followed by *create*, using the same owner and name, can have the result that the identified editioned object is of different types in different editions[22].

» An editioned object, then, is visible in its own edition and in descendants of its own edition until, in such a descendant, there exists a new actual occurrence.

» If an editioned object is the target of a DDL statement in particular edition (including *drop*), if that edition has descendants, and if the object in question is not actual in any of these descendants, then the effect of the change is visible in the descendants. If the object in question *is* actual in one of these descendants, then the change is visible in the intervening descendants up to, but not including, the descendant where it is actual.

Retiring an edition

When an EBR exercise is complete, it is useful to ensure that no new sessions will start to use the pre-upgrade edition. This is simply achieve by revoking the *Use* privilege on the to-be-retired edition from every user and role in the database. Notice that *Sys*, being beyond the normal notions of privilege, can still use the retired

19. *To do...* Some other views like *DBA_Errors_AE* also have an *Edition_Name* column. List them here.

20. The *DBA_Objects* catalog view family is supplemented by the *DBA_Objects_AE* catalog view family. “AE” stands for “all editions”; these views have the same columns as their non-AE counterparts; but for each editioned object, they show each actual occurrence it has. *DBA_Objects_AE* shows an object that was the target of the *drop* command with the type *non-existent* in the edition where it suffered that DDL. This fact is an overt part of the user’s conceptual model; it lets the user understand how, even after dropping an object in a particular edition, it is still visible in that edition’s ancestors (but not visible in any descendent editions).

21. The *DBA_Objects_AE* shows an object that was the target of the *rename* command with the type *non-existent* in the edition where it suffered that DDL.

22. The *create* that follows a *drop* for a particular owner and name will re-use the *non-existent* object caused by the *drop*. (Here, re-use refers to the value of *Object_ID*.) Most users will never notice this; but users who want to develop a complete mental model might feel pleased when they appreciate that this is an inevitable consequence of the axioms of the conceptual model.

edition. Advantage can be taken of this to drop objects that are actual in such retired editions and that are not visible in any non-retired edition because they are actual in a descendant of the retired edition.

Dropping an edition

It is useful to drop the new child edition that was used for an EBR exercise should the exercise for some reason fail, or should the result be deemed unsatisfactory. For this use case, use the *drop edition... cascade* command to drop all objects the are actual in the to-be-dropped edition.

While it is never necessary to drop the *root edition*, this may be done when the conditions given below are met. The current *root edition* may be dropped, and then the new *root edition* may be dropped, until the database has only a single edition: the *leaf edition* as was when these successive drops of the *root edition* were started. Customers may occasionally like to do this in pursuit of a feeling of hygiene. But doing this has no practical benefit except to remove mental clutter.

The *drop edition... cascade* command. just like the *drop user... cascade* command, is not atomic. This means that if the instance is shut down while the command is in progress, some of the edition's actual objects will have been dropped but others, and the edition itself, will remain. However, unlike is the case if the instance is shut down while a *drop user... cascade* command is in progress (where connecting as the to-be-dropped user is still safe), it is *not* now safe to use the to-be-dropped edition. For this reason, such an edition is marked unusable. This status is reflected in the *Usable* column in the *DBA_Editions* catalog view family. If a session attempts to make an unusable edition its current edition, either with the *alter session* command or at connect time, then an error occurs[23].

An edition can be dropped only when the following conditions are met:

» The edition is not the only one in the database

› *and either* it has no child edition (*i.e.* is the *leaf edition*)

› *or both* it has no parent edition (*i.e.* is the *root edition*) *and* it has no editioned objects that are inherited by its child edition[24].

» No session is using the edition.

» The edition is not the database default edition.

Notice that the *MMON* background process, just as the foreground processes do, always use an edition. This is because, unlike other "primitive" background processes like *SMON* or *PMON*, it issues SQL. Some other background processes also issue SQL. *MMON* and other such SQL-issuing background processes use the database default edition. Therefore, before attempting to drop, for example, edition *Pre_Upgrade*, it must be ensured that the default edition is something else, for example, *Post_Upgrade*[25].

The EBR lifecycle

Most EBR exercises will follow this simple pattern:

» Before starting, the database will have only one non-retired edition, say *Pre_Upgrade*.

23. An error also occurs if the overload of *DBMS_Sql_Parse()* that has an *Edition* formal is used to attempt to execute a SQL statement in an unusable edition.

24. Notice that crossedition triggers (see *"The crossedition trigger"* on page 22) are of an editionable object type. Moreover, every crossedition trigger must be editioned. However, as will be seen, a crossedition trigger is visible only in the edition where it is actual. Therefore, the presence of crossedition triggers in an edition does not affect whether that edition can be dropped.

25. *MMON* and other SQL-issuing background processes run in a continuous loop and poll the identity of the default edition on each iteration. Should this be changed, then they issue an *alter session* command to use the new default. This switch usually happens with very little delay. But if the attempt to drop the former default edition is made before the switch has happened, then *ORA-38805: edition is in use* will occur.

» During the EBR exercise, the database will have two non-retired editions, *Pre_Upgrade* and its child, say *Post_Upgrade*.

» When no sessions any longer need to use *Pre_Upgrade*, then this will be retired and the starting state for the next exercise will be restored: the database has only one non-retired edition.

As long as the *Pre_Upgrade* edition is still available for ordinary use, then *Post_Upgrade* can be simply dropped[26]. This might be done if it were realized that the upgrade install script is irrevocably incompatible with some customizations that have be made at the particular deployed site. With possibly some manual follow-up steps, all traces of the aborted upgrade attempt can be removed without interrupting the availability of the pre-upgrade application. The use-case for dropping the ultimate child edition, then, is clear.

The use-case for dropping the ultimate parent edition is far less clear and is expected to be a rare occurrence. The idea of returning to the "ground state" after each EBR exercise, where the database has just one edition, seems initially to be intuitively appealing. However, this is unnecessary and resource-intensive.

The key question is this: what is the practical difference between using an edition where every editioned object is actual and one where just a few are actual and most are inherited from many retired editions stretching back over a lengthy ancestor chain? It might seem that, in principle, name resolution in the many-edition regime would be appreciably slower than in the single-edition regime because most lookups would involve a recursive search backwards in the edition ancestor chain. However, the implementation, which faithfully preserves the conceptual model, transparently uses a denormalization to avoid the recursive search. Moreover, name resolution takes place at compile time and not at run-time[27]. It turns out, therefore, that there is no noticeable difference between using a database where the only non-retired edition is that database's only edition and using one where the only non-retired edition has an ancestor chain of, say, several hundred retired editions.

26. As soon as the post-upgrade application is used to record end-user transactions that cannot be represented by the pre-upgrade application, then the possibility for a simple return to the pre-upgrade application vanishes. This is determined by ordinary logic and not by any restrictions imposed by EBR.

27. The compilation of a stored PL/SQL unit is very visible, because it requires a separate step. The compilation of a SQL statement, often referred to as *parsing*, is less visible to users because interfaces like PL/SQL's embedded SQL disguise the distinction between SQL compilation and SQL execution; nevertheless, the distinction is clear—and the famous so-called soft-parse skips the SQL compilation and goes straight to the execution.

Diagramatically illustrated example

Figure 3. shows the kind of situation that might exist after a few distinct EBR exercises have been undertaken.

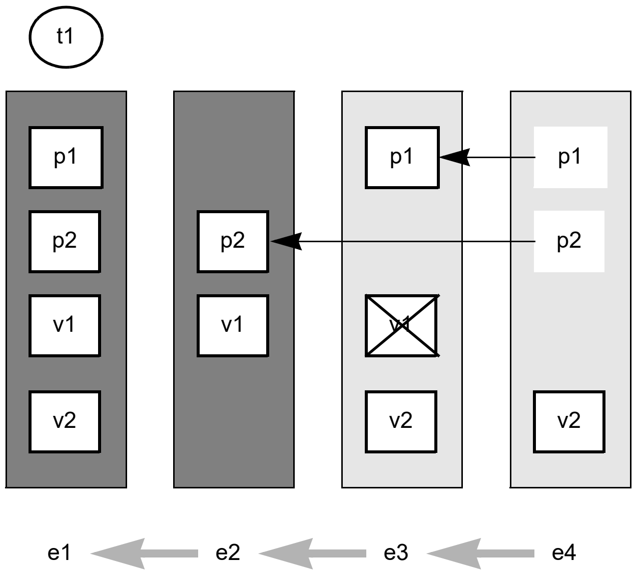


Figure 3. The situation after three EBR exercises. Actual editioned objects are shown as squares with a solid border; inherited editioned objects are shown as squares with no border; objects that are not editioned are shown as circles with a solid border; active editions are shown with a light gray fill; and retired editions are shown with a dark gray fill.

» The starting point is that the database has exactly one edition, *e1*[28]. The procedures *p1* and *p2* and the views *v1* and *v2* are editioned objects and are actual, as they must be, in *e1*. The table *t1*, because it is not an editioned object, is drawn outside of the containing box that represents *e1*.

» Then *e2* is created as the child of *e1*.

» Then a session that uses *e2* does *create or replace* on *p2* and *v1*, causing them to be actualized in *e2*. A session using *e2* sees *p2* and *v1* as actual and *p1* and *v2* as inherited; sessions using respectively *e1* and *e2* see the same occurrence of *p1* and *v2*; each sees its own distinct occurrence of *p2* and *v1*, each with its own defining source code; and, of course, each sees the same *t1* because there can never be more than one occurrence of an object that is not editioned. When no sessions any longer need to use *e1*, it is retired.

» Then *e3* is created as the child of *e2*.

» Then a session that uses *e3* does *create or replace* on *p1* and *v2*, causing them to be actualized in *e3*; and it drops *v1*. A session using *e3* sees *p1* and *v2* as actual and *p2* as inherited. Of course, it cannot see the dropped *v1*; and it sees the one-and-only occurrence of *t1*. Though *v1* is dropped in *e3*, it is still visible in *e1* and in *e2*. When no sessions any longer need to use *e2*, it is retired.

» Then *e4* is created as the child of *e3*.

» Then a session that uses *e4* does *create or replace* on *v2*, causing it to be actualized in *e4*. A session using *e4* sees *v2* as actual and *p1* and *p2* as inherited. Of course, it too, like *e3*, cannot see the dropped *v1*; and it, too, sees the one-and-only occurrence of *t1*. When no sessions any longer need to use *e3*, it is retired.

28. This is very easy to achieve. A freshly created, or newly upgraded, *11.2* database has no editions-enable users and therefore no editioned objects. It is trivial to create edition *e1* as the child of *Ora$Base*, to set the database default edition to *e1*, and then (when no sessions are using it) drop *Ora$Base*. This succeeds because *Ora$Base* has no actual editioned objects. There is no reason to do this in a production environment; the name *Ora$Base* is as good as any other name. But in a test database, and especially in connection with developing code examples for teaching purposes, it is nice to choose the name of the starting edition.

Figure 4. shows the situation that might exist after the next EBR exercise.

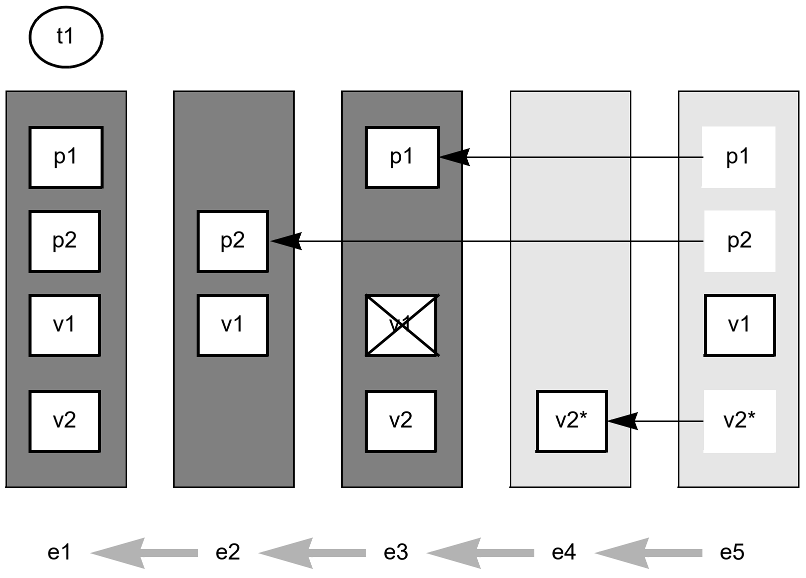


Figure 4. The situation after four EBR exercises

- *e5* is created as the child of *e4*.
- Then a session that uses *e4* does *create or replace* on *v2*; this change is denoted by the asterisk in *Figure 4.*. A session using *e5* sees the same modified *v2* because it sees *v2* it as inherited.
- Then a session that uses *e5* creates package *v1*. Because, just before it does this, *e5* sees no object called *v1*, there is no reason why this name cannot now be used for an editioned object of a different type from that which the name denotes in *e1* and *e2*. Notice that had an attempt been made to create an object called *v1* that was not editioned (for example a table called *v1*), then this would have failed because of name collisions in *e1* and *e2*.

A minimal, complete EBR exercise code example

The starting point is a database that has exactly one edition, *Pre_Upgrade*. The application architect has worked out that objects whose type is editionable and that are owned by *App_Owner* should be editioned. Therefore, the DBA has executed the SQL statement shown in *Code_2*.

```
-- Code_2
alter user App_Owner enable editions
```

App_Owner connects and inevitably uses edition *Pre_Upgrade*. The query shown in *Code_3* is then executed.

```
-- Code_3
select    Text
from      User_Source
where     Name = 'HELLO' and Type = 'PROCEDURE'
order by  Line
```

The output is as shown in *Code_4*.

```
-- Code_4
procedure Hello is
begin
  DBMS_Output.Put_Line('Hello from Pre_Upgrade');
end Hello;
```

Of course, when *Hello* is executed, it shows "*Hello from Pre_Upgrade*".

In preparation for the EBR exercise, a user who has the *Create Any Edition* system privilege creates *Post_Upgrade*, and allows *App_Owner* to use it, using the SQL*Plus script shown in *Code_5*.

```
-- Code_5
create edition Post_Upgrade as child of Pre_Upgrade
/
grant use on edition Post_Upgrade to App_Owner
/
```

App_Owner is now able to execute the SQL statement shown in *Code_6*.

```
-- Code_6
alter session set Edition = Post_Upgrade
```

If *Hello* is executed, it still shows "*Hello from Pre_Upgrade*". Now *App_Owner* executes exactly the same DDL statement that would have been used to modify *Hello* in versions of Oracle Database prior to *11.2* as shown in *Code_7*.

```
-- Code_7
create or replace procedure Hello is
begin
  DBMS_Output.Put_Line('Hello from Post_Upgrade');
end Hello;
```

App_Owner now executes the SQL*Plus script shown in *Code_8*.

```
-- Code_8
begin Hello(); end;
/
select    Text
from      User_Source
where     Name = 'HELLO' and Type = 'PROCEDURE'
order by  Line
/

alter session set edition = Pre_Upgrade
/
select   Sys_Context('Userenv', 'Current_Edition_Name')
from     Dual
/

-- Notice that the spelling that follows is identical
-- to that used before the current edition was changed
begin Hello(); end;
/
select    Text
from      User_Source
where     Name = 'HELLO' and Type = 'PROCEDURE'
order by  Line
/
```

While *App_Owner* is using *Post_Upgrade*, the output of *Hello* is "*Hello from Post_Upgrade*" and the code shown in *User_Source* is that of the new, modified occurrence; and while *App_Owner* is using *Pre_Upgrade*, the output of *Hello* is "*Hello from Pre_Upgrade*" and the code shown in *User_Source* is that of the old, original occurrence.

When all are satisfied that the application as represented in *Post_Upgrade* is an improvement on the one represented in *Pre_Upgrade*, and no sessions any longer are using *Pre_Upgrade*, then a suitably privileged user will retire the *Pre_Upgrade* edition[29]. In this trivial example, *Pre_Upgrade* now has no actual editioned objects that are inherited by its child (and has no parent); there is no reason, therefore, not to drop it. However, in the general case, it is very likely that *Pre_Upgrade* would have editioned objects that are inherited by *Post_Upgrade* and it would not be cost-beneficial to actualize all of these in *Post_Upgrade*. Therefore, in the general case, *Pre_Upgrade* would be retired but not dropped.

29. See *"Retiring an edition"* on page 9.

If, for some reason, it is decided to abandon the changes made in *Post_Upgrade*, then a user who has the *Drop Any Edition* system privileges ensures that no session is using *Post_Upgrade* and then executes the SQL*Plus script shown in *Code_9*[30].

```
-- Code_9
drop edition Post_Upgrade cascade
/
```

Consequential actualization of dependants and fine-grained dependency tracking

When an editioned object refers to, and therefore depends upon, another editioned object, then, of course, the referenced editioned object[31] must be visible in the edition where the dependant is actual. The referenced object might be actual in the same edition as the dependant, or might be actual in an ancestor edition to the dependant's and therefore seen as inherited in the dependant's edition. This rule implies that when a referenced object is first actualized in a particular edition, then all its direct and recursive dependants, that are not yet actual in that edition, will be consequentially actualized in that same edition[32].

Oracle Database 11*g* Release 1 brought a new, fine-grained dependency tracking model. In earlier releases, *any* change to a referenced object caused all objects that depended on it to become invalid. This was because only coarse-grained dependency information (object *p* depends on object *q*) was recorded. The fine-grained model records dependency information at the level of the *element* within the referenced object. For example:

» If procedure *p* depends only on procedure *x* in the package *Pkg* and if *Pkg* also exposes other subprograms, variables, type declarations, and so on, then the dependency information records that p depends on *Pkg.x*[33].

» If view *v* mentions only columns *c1*, *c2* and *c3* in table *t*, then the dependency information records exactly this[34].

This means that when a referenced object is changed without changing the elements that an object that depends on it refer to, then the dependant remains valid.

This understanding needs to be extended when the referenced object, and therefore the dependant too, are editioned. If the dependant is already actual in the same edition as the referenced object (after this has suffered the DDL), or in a descendant of that edition, then the full benefit of fine-grained dependency tracking is available and invalidation that is not logically required is avoided. However, if on completion of the DDL to the referenced object, it is now in a younger edition than the dependant, then the dependant is actualized into the referenced object's edition in an invalid state[35].

30. See *"Dropping an edition"* on page 10

31. The term *referenced object* reflects the names of the columns in the *DBA_Dependencies* catalog view family: *Referenced_Owner*, *Referenced_Name*, and so on.

32. The rule is a consequence of logic: an object cannot depend on another that it cannot see.

33. The fine-grained dependency information also records the signature of *Pkg.x* (the names and datatypes of its formals).

34. The datatypes of the columns are recorded too.

35. It turns out that, because of various internal optimizations, an invalid object that is the result of consequential invalidation does not show up immediately in the *DBA_Objects* and *DBA_Objects_AE* catalog view families. However, it will show up after a call to *DBMS_Utility.Compile_Schema()* or to one of the *Utl_Recomp* APIs. It will show up, too, after an attempt to reference it (in either a compilation or an execution context).

Deliberate invalidation and revalidation of editioned objects

In an ordinarily installed Oracle Database, any user can invoke *DBMS_Utility.Validate()* or *DBMS_Utility.Compile_Schema()*[36] but only the owner, *Sys*, can invoke the *Utl_Recomp* APIs.

DBMS_Utility.Validate() has two overloads. One takes *Object_ID* and the other takes *Owner*, *ObjName*, *Namespace*, and *Edition*. (*Edition* is defaulted to the current edition.) If the target object is not actual in the current edition, then it is not actualized into this but remains actual in the edition where it was found. Notice that this is different from how *alter... compile* behaves; here, the target object is actualized into the current edition.

DBMS_Utility.Compile_Schema() and the *Utl_Recomp* APIs can be understood as wrappers that apply *DBMS_Utility.Validate()* to all the invalid objects in all editions in the specified schema or database-wide. As a consequence, using these APIs never causes actualization.

It is likely that an EBR exercise will make changes to editioned objects where at least some of these will have dependent objects. This will cause the dependent objects to be actualized into the new edition in an invalid state[37]. It would be sensible to revalidate such objects as soon as all the intended DDLs have been done in the new edition and before proceeding to the next steps[38]. *Utl_Recomp.Recomp_Parallel()* is the natural choice. There are no privilege concerns; implicit validation of invalid objects in the closure of dependency parents of an invalid object that is referenced for compilation or execution will anyway take place with no special privileges.

DBMS_Utility.Invalidate() has only one overload; this identifies the target object using *Object_ID*. Its only use in an EBR exercise would be to enable the values of the PL/SQL compilation parameters for a large number of units to be changed in the new edition with optimal efficiency. For example, an upgrade script might intend to compile each of the application's PL/SQL objects *native*. This is done efficiently by first invoking *DBMS_Utility.Invalidate()* for each object, using an appropriate actual for *p_plsql_object_settings*, and then invoking *Utl_Recomp.Recomp_Parallel()*.

Oracle recommends against invoking *DBMS_Utility.Invalidate()* on an object that is not actual in the current edition.

The effect of DDL in an edition with a child

Suppose that a database has exactly *N* editions, e_1 through e_N, where e_2 is the child of e_1 and so on. Let $x[e_1]$ denote an editioned object *x* that is actual in e_1 and that has no dependencies on any editioned objects. As long as no DDL has been done on *x*, while using edition e_2 or one of its descendants, then $x[e_1]$ will be visible in e_2 and its descendants because no actual occurrence of *x* exists in these editions. Notice that if $x[e_1]$ does have a dependency on an editioned object, *y*, then it will be actualized as $x[e_M]$ in edition e_M should *y* be actualized there as $y[e_M]$.

In other words, when an editioned object suffers DDL using a particular edition, then the change is visible in all descendent editions up to, but not including, the closest descendent edition where another actual occurrence exists. (This actual occurrence might have *Object_Type = non-existent* if a DDL had been issued in the descendent edition to drop the object in question[39].)

36. The *Execute* privilege on *DBMS_Utility* is granted to *public* and the package has a public synonym.

37. This is explained in *"Consequential actualization of dependants and fine-grained dependency tracking"* on page 15.

38. The next steps begin with enabling all crossedition triggers and batch transforming all data from the old representation to the new one.

It can be seen, therefore, that in general, the effect of DDL in any descendent editions it might have, depends on specific circumstances and history: it might well happen that the effect “shines through” to all descendent editions; but this result is not guaranteed.

Using *DBMS_Sql_Parse()* to execute SQL outside of the current edition

DBMS_Sql_Parse() has some new overloads in *11.2*. Some support working with crossedition triggers; these will be described in *“The crossedition trigger”* on page 22. One new overload is provided to execute a single SQL statement in a specifically nominated edition. This allows a PL/SQL unit to execute SQL in two or more different editions and can be useful for automating DBA tasks[40]. In *11.2*, the remote session that supports access via a database link can use only the remote database’s default edition. See *“Database links”* on page 33. By using the remote database’s *DBMS_Sql* package, then at least single SQL statements can be executed in the chosen edition in the remote database.

Package state when the same package is instantiated in more than one edition

Suppose that the database has two editions, *Pre_Upgrade* and *Post_Upgrade* and that the editioned package *Pkg,* with the source shown in *Code_10*[41], is actual in *Pre_Upgrade* and inherited in *Post_Upgrade*.

```
-- Code_10
package Pkg authid Current_User is
  State simple_integer := 0;
end Pkg;
```

The SQL*Plus script shown in *Code_11* runs without error.

```
-- Code_11
alter session set Edition = Pre_Upgrade
/
begin Pkg.State := 1; end;
/
alter session set Edition = Post_Upgrade
/
begin
  if Pkg.State <> 0 then
    Raise_Application_Error(-20000,
     'Unexpected Pkg.State: '||Pkg.State);
  end if;
end;
/
alter session set Edition = Pre_Upgrade
/
begin
  if Pkg.State <> 1 then
    Raise_Application_Error(-20000,
     'Unexpected Pkg.State: '||Pkg.State);
  end if;
end;
/
```

This shows that the same editioned package is instantiated distinctly in each distinct edition from which it is referenced during the lifetime of a session and that its state for each edition’s instantiation is preserved independently. It is important to understand this when a forward crossedition trigger references an editioned package that is referenced also by ordinary application code.

39. Objects with *Object_Type = non-existent* can be seen in the *DBA_Objects_AE* catalog view family but not in the *DBA_Objects* catalog view family. This is a deliberate design. The latter view shows a world which, if a user uses only a single edition, reflects the same mental model as held for databases before *11.2*. The former view enables the user to understand the bigger picture and to predict what objects will be visible in any edition.

40. Recall that *alter session* cannot be used to change the current edition from a database PL/SQL unit.

41. The datatype *simple_integer*, new in *11.1*, has a *not null* constraint.

Notice that the opposite is the case for a noneditioned package. This has just a single instantiation. This can be seen by re-running *Code_11* when the owner of *Pkg* is not editions-enabled. Now, the value of *Pkg.State* that was set in *Pre_Upgrade* is visible in *Post_Upgrade*[42].

The editioning view

Only some object types are editionable. Those that, in *11.2* and onwards, are not can be split into two classes: those that might become so in a later release of Oracle Database; and those that will never be editionable. Objects of the types in the first class do not consume quota—they are represented entirely by metadata (rows in various tables in the *Sys* schema) and cannot contain data. It is convenient to refer to these as *code objects*. Objects of the types in the second class *do* consume quota. In addition to the metadata that describes them, they contain substantive data. It is convenient to refer to these as *data objects*. The obvious examples of data objects are *tables* and *indexes*. These days, it is not uncommon for tables to contain terabytes of data.

It is practical for a given editioned object to have many occurrences in different editions, and to rely on a name-resolution scheme that supplies the *Edition_Name* implicitly because, as code objects, they are small enough to allow many distinct, but similar, occurrences to exist without using a scheme that represents differences. However, the potential enormous size of data objects makes such an approach impractical; and any approach that attempted to represent only differences would have to use a fixed scheme in order not to harm the performance of DML and queries. The obvious scheme is physical: to use the database block as the quantum of differencing. But while this might allow a very compact representation of several occurrences of a table that differed only in a tiny number of rows, it is easy to see that an unfortunate pattern of differences could lead to such a large number of blocks that differed between the various occurrences that the explosion in data volume would be unacceptable.

The only practical approach, then, is to let the user control the differencing explicitly. If the aim is to change a column, for example by widening it, then the original column is left in place and a new wider *replacement column* (or columns) is *added* to the table.

A further practical reason drives this design. Typical table changes during an application upgrade are incremental: the pre-upgrade and post-upgrade applications see most of the table's data in common. Therefore, during an EBR exercise, it is natural and efficient to share this common data explicitly rather than to use mechanisms to keep tow separate copies of nominally the same data synchronized.

How, then, can such a table be presented to editioned code objects so that these see only the logical intention of the table at each new version and are not troubled by physical details? A view provides exactly the right mechanism; but an ordinary view is too general in its power of expression, and because of this forbids it being treated like a table with respect to some application requirements. For example, it is not allowed to create table-style triggers[43] on an ordinary view.

EBR brings a new kind of view, the editioning view. It is created using special syntax and its defining *select* statement must satisfy strict restrictions if the creation is to succeed.

42. A happy consequence of this is that you can still use *DBMS_Output* to trace code that does DML that causes a crossedition trigger to fire. The messages that are written by the application code that causes the DML, running for example in the pre-upgrade edition, and those that are written by the forward crossedition trigger, running therefore in the post-upgrade edition, are interleaved in the chronological order in which they are written and are displayed ordinarily in a tool like SQL*Plus when the server call completes.

43. A table-style trigger is one whose timing point is *before statement*, *before each row*, *after each row*, or *after statement*. An ordinary view allows only *instead of* triggers.

An editioning view, as a special kind of view, is editionable. It might help to think that while the physical table cannot be editioned, the editioning view allows different occurrences of its logical projection to be presented in different editions.

Indexes and constraints remain in the physical domain at the table level.

The conditions that an editioning view must satisfy

An editioning view's defining select statement must obey several restrictions[44]. The following list is not intended to be complete; rather, it is intended to make the spirit of the design clearer. The restrictions reflect the intention that an editioning view must simply return every row from a single table (and only those rows), without explicit ordering, and project, and maybe rename, a subset of the columns.

Because a successfully created editioning view has been confirmed to have satisfied all the restrictions, various operations on an editioning view can be supported that cannot be supported on an ordinary view. In particular, all memory of the fact that an editioning view stands in front of a table is lost during SQL compilation. The resulting execution plan is identical to the one for a query with the same meaning that targets the table(s) directly. In other words, the use of an editioning view is guaranteed to bring no performance penalty.

An editioning view must be owned by an editions-enabled user

This restriction emphasizes the fact that an editioning view's specific and only purpose is to provide an editioned API to a projection of the data that is stored it the table it covers.

An editioning view must be owned by its table's owner

This implies that the table for an editioning view cannot be in a different database denoted by a database link.

There can be no more than one visible editioning view for a particular table in a particular edition

This follows from the basic intent of the editioning view. Its purpose is to present different logical projections of the data stored in a particular table in different editions. It is meaningless, in the basic conceptual model, to have more than one logical projection of the same table data in the same edition[45].

The subquery factoring clause is not allowed

Because of the other restrictions, the subquery factoring clause could anyway have no practical usability benefit.

The subquery must be a single query block

This implies that the keywords *union [all]*, *minus*, and *intersect* are not allowed.

44. An attempted *create editioning view* statement that fails to satisfy the restrictions will cause an error and the view will not be created. The error message may seem obscure. For example, inclusion of a *where clause* causes *ORA-00933: SQL command not properly ended*; and inclusion of the *distinct* keyword causes *ORA-00936: missing expression*. If the statement succeeds without the *editioning* keyword but fails with it, then the reason is that the defining statement does not respect the restrictions. This suggests an approach to debugging a failed *create editioning view* statement: try it again without the *editioning* keyword.

45. There are also situations where it is useful uniquely to identify, starting with a table, how it is projected in a particular edition. For example, the intention to create an index on a list of logical columns is easily translated into the corresponding *create index* statement at the physical level. And the presence of an index on physical columns that are projected in a particular way in one edition suggests that a logically corresponding index, on possibly different columns, will be needed to support access from a different edition. Customer-written utilities can take advantage of the fact that the editioning view that presents a table into a particular edition is uniquely determined.

The *for update* clause is not allowed

The *for update* clause *is* always allowed in a query that targets an editioning view. (This is an instance of the more general rule that the *for update* clause is allowed in a query that targets an updatable view.)

The query block must identify exactly one table

The *from list* must have just one item and the must be a *table*. A self-join is not permitted[46]. The item cannot be a view or a synonym.

The *select list* must mention only column names and optional aliases

No column can be mentioned more than once. No kind of expression is allowed in the *select list*. For example, columns cannot be arithmetically combined; SQL and PL/SQL functions are prohibited.

The *where clause*, *group by* clause, and *having* clause are not allowed

This is consistent with the basic intention to provide a logical cover for a physical table. Application upgrades typically change the structure of tables and apply corrections, for every row, to values in particular columns. It is rare that they need to add or remove rows in a table. For such scenarios, different occurrences of the editioning view must denote different physical tables in different editions[47].

The *order by* clause is not allowed

This, too, is consistent with the basic intention. In particular, without this restriction the requirement could not be met that the execution plan for a query that targets an editioning view must be identical to the one for a query with the same meaning that targets the table directly.

Other restrictions

The *distinct*, *unique*, and *all* keywords are not allowed before the *select list*. The *hierarchical query clause* and the *model* clause are not allowed. The *flashback query* clause is not allowed.

Allowed freedoms when defining an editioning view

The following semantics are allowed in addition to the basic rule that an editioning view merely projects a single table, maps the names of its columns, and does no restriction.

The *with read only* clause is allowed

Sometimes the amount of data in a table that needs to be changed in an application upgrade is small. This is typically the case for lists of values and for data that configures the behavior of the application. Moreover, such data is normally not modifiable by ordinary end-user actions but, rather, is changed only by an administrator. In such cases, a very straightforward approach to online application upgrade is possible. A new table is defined and populated ordinarily and is then exposed using an editioning view with the same name and logical meaning in the new edition as the one that exposed the old table into the old edition. By setting these editioning views *with read only*, the intention that the table content is not changed by end-users is formally enforced[48].

46. ANSI join syntax is therefore disallowed.

47. It hardly needs pointing out that rows come and go, and are changed, as part of the routine operation of every application. The capability to do this comfortably in a multiuser environment is well-established. It would be appropriate to use EBR to stage the visibility of such ordinary changes only when the content of the tables in some way defines the behavior and meaning of the application, and, of course, especially when both the context and the structure of such configuration tables needs to be changed.

48. The *DBA_Views* catalog view family has *Y/N* columns called *Read_Only* and *Editioning_View*.

Of course, the *alter view* command can be used to make an editioning view either read-only or read/write. Notice that there is no special *alter editioning view* syntax.

Primary key constraints are allowed but foreign key constraints are disallowed

Primary key and foreign key constraints can be created on an ordinary view, but the keywords *disable novalidate* must be used. The benefit is mainly that tools can generate diagrammatic representations of the logical database design. However, an editioning view must be editioned and an editioned object cannot be the source or the target of a foreign key constraint. Therefore, an editioning view cannot be the source or the target of a foreign key constraint. An editioning view can have a *disable novalidate* primary key constraint.

Operations supported by an editioning view that are not supported by an ordinary view

The fact that the following operations are allowed on an editioning view reflects the intention that, once an editioning view is in place in front of every table, then the rest of the application design and implementation can treat these editioning views as if they were tables and will never, therefore, need to refer to a table explicitly.

The following are examples. However, rather than listing every single property that distinguishes an editioning view from an ordinary view, it is more useful to state the overall principle:

» Any *select*, *insert*, *update*, *delete*, *merge*, *lock table* or *explain plan* SQL statement[49] that will run without error on a table will run without error on an editioning view that covers that table.

An editioning view allows table-style triggers

Following the approach described in *"EBR-readying an application"* on page 31 will leave triggers that had been defined on renamed tables still attached to those table but possibly invalid[50]. However, to honor the principle that application code should not refer explicitly to tables, the triggers should be recreated on the editioning view that now has the table's former name. This trivially achieved by dropping the triggers and then re-running the DDL that created them[51].

Notice that when DML is done using an editioning view, then not only will triggers defined on the editioning view fire, but also ones defined on its base table will fire. However, when DML is done using a table, then only the triggers defined on the table will fire—and triggers defined on the editioning view will not fire. The paradigm requires that all regular application DML be done using editioning views; as shall be seen (see *"The crossedition trigger"* on page 22) only crossedition triggers are allowed to do DML using tables.

A hint in a SQL statement that targets an editioning view can identify an index by listing the names of its columns.

This, again, allows extant application code to remain correct after the introduction of an editioning view to cover a table.

49. For example, *select Rowid, ev.* from ev* is legal when *ev* is an editioning view.

50. When a table is renamed, the opening part of the source text of a trigger on the table is automatically updated to reflect the new name. The same happens when columns are renamed and the they are mentioned in the *when clause*. However, the source text of the PL/SQL that implements the trigger action is not updated. This will leave the trigger in an invalid state when the text refers to other tables that have been renamed.

51. The DDL will run without error because the new editioning view exposes exactly the same identifiers as the table it covers. This holds also for compound triggers that may been defined on the renamed table.

Queries against an editioning view allow partition extended syntax

When an editioning view's base table is partitioned, then the same query extended syntax that can be used against the table can be used against the editioning view. The SQL*Plus script shown in *Code_12* illustrates this.

```
-- Code_12
create table t(PK integer primary key, Info varchar2(10))
  partition by range(PK)
  (partition p1 values less than (10),
   partition p2 values less than (maxvalue) )
/
begin
  insert into t(PK, Info) values ( 5, 'in p1');
  insert into t(PK, Info) values (15, 'in p2');
  commit;
end;
/

create view v as select a.PK, a.Info from t a
/
-- Causes ORA-14109
select * from v partition(p1)
/

create editioning view ev as select a.PK, a.Info from t a
/
-- Runs without error
select * from ev partition(p1)
/
```

EBR using only editions and editioning views

If an application upgrade will change only those tables whose data is not changed via the ordinary end-user interfaces, then the edition together with the editioning view are sufficient to allow these changes to be made while the application remains on line. The most obvious example is configuration data—data that determines the behavior of the application and that is changed only as part of an upgrade. Such data is typically not voluminous and so it would be natural to create a replacement table for the upgrade so that an editioning view with a particular owner and name selects from one table in the pre-upgrade edition and from a different table in the post-upgrade edition. The upgrade installation script can simply populate the replacement table as required. According to the requirements of the upgrade, the editioning view that covers the post-upgrade table may, or may not, have the same shape as the editioning view that covers the pre-upgrade table.

The crossedition trigger

Sometimes, an application upgrade has to change one or more tables whose content is queried and changed by ordinary end-user interaction. The use case described in *Xref to be filled in*[52] provides such an example: a single column that represents a telephone number as it would be used when dialling within the USA is to be split into two columns, one for the country code and one for the within-country number. A bulk transformation of the data is not, by itself, sufficient to ensure correctness of the transformed data. A mechanism is needed to keep pace with changes that end-users of the pre-upgrade application make to the old representation of the data, transforming it into the new representation, both during the bulk transformation and after it is complete as some users continue to use the pre-upgrade application while others start to use the post-upgrade application.

Moreover, changes that end-users of the post-upgrade application make to the new representation of the data must be transformed back into the old representation for the benefit of end-users of the pre-upgrade application.

52. An account of this use case will be added in a later version of this whitepaper.

Triggers have exactly the right properties to effect the proper responses to the changes that end-users make during the bulk forward transformation of data and during the hot rollover period. Moreover, the use of a trigger for this purpose meets the high level requirement that application code *itself* can be written to implement only what is needed for its ordinary pre- and post-upgrade operation and need not implement special logic to accommodate the period when an EBR exercise is in progress. Special triggers, understood to be distinct from the application code, can be deployed during the EBR exercise and dropped when it is complete.

A crossedition trigger is a special kind of trigger; and a trigger is an editionable object type. However, unlike other objects whose type is editionable, a crossedition trigger *must* be owned by an editions-enabled user; in other words, a crossedition trigger is always editioned[53]. The reason for this restriction is that the firing rules for a crossedition trigger are defined with respect to the relationship between the edition in which it is actual and the current edition of the session that issues the DML. Further, a crossedition trigger is visible only in the edition in which it is actual. As a consequence, the SQL*Plus script shown in *Code_13* runs without error.

```
-- Code_13
alter session set edition = e2
/
create trigger x
  before insert or update or delete on t
  for each row
  forward crossedition
  disable
begin
  ...
end x;
/
-- e3 is the child of e2
alter session set edition = e3
/
-- Notice that we don't need "or replace"
create trigger x
  before insert or update or delete on t
  for each row
  forward crossedition
  disable
begin
  ...
end x;
/
```

It is unimportant with respect to the firing rules that a crossedition trigger is visible only in the edition in which it is actual because these rules are explicitly defined; but this has the consequence that dependencies between crossedition triggers (by virtue of *follows* or *precedes* relationships) can exist only between sets of crossedition triggers that are actual in the same edition[54]. If the clause is *follows*, then the target must be a forward crossedition trigger; and if the clause is *precedes*, then the target must be a reverse crossedition trigger[55].

The compilation of a crossedition trigger follows the normal rules for the compilation of any editioned object: names are resolved to objects that are visible in the edition in which it is actual. But in contrast to other

53. If a user that is not editions-enabled attempts to create a crossedition trigger, this causes *ORA-25030*.

54. This restriction ensures that no contradictions about firing order can be expressed. As will be seen, the firing order of crossedition triggers in a particular edition cannot be interleaved with that of crossedition triggers in a different edition.

55. The *follows* and *precedes* clauses were introduced in *11.1*. A regular trigger may use only the *follows* clause and its target must be a regular trigger on the same table. An ordering relationship may be established only between triggers with the same timing point (*before statement*, *before each row*, *after each row*, or *after statement*). An attempt to violate this rule causes *ORA-25022: cannot reference a trigger of a different type*. An ordering relationship may be established between compound triggers; however, the ordinary ordering of the timing points (*before statement* fires before *before each row*, and so on) is always respected. It might appear, therefore, that when a compound trigger with only a *before statement* section is defined using *follows* with respect to one with only a *before each row* section, the ordering specification is not respected. However, the ordering can be seen to make sense when many compound triggers are mutually ordered and different ones of them have sections for different subsets of timing points.

editioned objects, a crossedition trigger and all code it calls always *runs* using the edition in which it is actual. *Code_20* is a SQL*Plus script that shows this.

A crossedition trigger may be created only directly on a table—and not on either a regular view or an editioning view[56]. This implies that only the *before statement*, *before each row*, *after each row*, and *after statement* variants may be specified; the *instead of* variant is not legal for a crossedition trigger. A crossedition trigger may be a compound trigger.

Basic firing rules for crossedition triggers

The firing rules were designed on the assumption that the crossedition triggers required to implement a particular upgrade are all installed in the post-upgrade edition. This is consistent with the overall paradigm that (in order that the pre-upgrade application will be unperturbed) *all* DDL to editioned objects is done in the post-upgrade edition. The rules assume that pre-upgrade columns are changed (by ordinary application code) only by sessions using the pre-upgrade edition and that post-upgrade columns are changed (again by ordinary application code) only by sessions using the post-upgrade edition. There are therefore two kinds of crossedition trigger:

» A *forward crossedition trigger* is fired by application DML issued by sessions using the pre-upgrade edition. Such a trigger is used to implement transformations from the old representation forwards into the new representation.

» A *reverse crossedition trigger* is fired by application DML issued by sessions using the post-upgrade edition. Such a trigger is used to implement transformations from the new representation backwards into the old representation.

The following is a more careful statement of the rules, acknowledging the fact that three or more editions might be active during an EBR exercise:

» A forward crossedition trigger is fired by application DML issued by a session using any ancestor edition to that in which the trigger is actual.

» A reverse crossedition trigger is fired by application DML issued by a session using the edition in which the trigger is actual or any descendant of that edition.

The following demonstration illustrates these basic firing rules for crossedition triggers. The database has five editions, *e1*, *e2* (child of *e1*), and so on through to *e5* (child of *e4*).

The procedure *Trace*[57], shown in *Code_15*, is owned by *Sys* and is therefore not editioned.

```
-- Code_14
procedure Trace(
  t1 in varchar2, t2 in varchar2 := null)
  authid Definer
is
  f Utl_File.File_Type := Utl_File.Fopen(
    Location   => 'MY_DIR',
    Filename   => 't.txt',
    Open_Mode  => 'a',
    Max_Linesize => 32767);
begin
  if t2 is null then
    Utl_File.Put_Line(f, t1);
  else
    Utl_File.Put_Line(f, Rpad(t1, 30, '.')||' '||t2);
  end if;
  Utl_File.Fclose(f);
end Trace;
```

There is a public synonym for *Sys.Trace*, and *Execute* on *Sys.Trace* is granted to public.

56. The attempt causes *ORA-42306: a crossedition trigger may not be created on an editioning view*.

The user *Usr* is editions-enabled and is granted only *Create Session*, *Resource*, and *Use* on each of *e1* through *e5*.

The function *Usr.Curr_Edn*, shown in *Code_15*, is actual in edition *e1*.

```
-- Code_15
function Curr_Edn return varchar2 authid Definer is
  e constant varchar2(30) not null :=
    Sys_Context('Userenv', 'Current_Edition_Name');
begin
  return e;
end Curr_Edn;
```

The table *Usr.t* has a column *n* of datatype *number*; the editioning view *Usr.ev* covers it and selects *n*. The regular trigger *Usr.Regular*, shown *Code_16*, is actual in edition *e2*.

```
-- Code_16
trigger Regular
  after update on ev
begin
  Trace('From Regular', Curr_Edn());
end Regular;
```

The forward crossedition trigger *Usr.Fwd_Xed*, shown in *Code_17*, is actual in edition *e3*.

```
-- Code_17
trigger Fwd_Xed
  after update on t
  forward crossedition
begin
  Trace('From Fwd_Xed. Expect E3', Curr_Edn());
end Fwd_Xed;
```

The reverse crossedition trigger *Usr.Rev_Xed*, shown in *Code_19*, is actual in edition *e4*.

```
-- Code_18
trigger Rev_Xed
  after update on t
  reverse crossedition
begin
  Trace('From Rev_Xed. Expect E4', Curr_Edn());
end Rev_Xed;
```

Finally, the procedure *Usr.Do_Update*[58], shown in *Code_19*, is actual in edition *e1*.

```
-- Code_19
Do_Update authid Definer is
begin
  Trace('From Do_Update', Curr_Edn());
  update ev set n = n + 1;
  commit;
end Do_Update;
```

57. It is typically not possible to trace the behavior of a crossedition trigger using *DBMS_Output.Put_Line()*. This is because the procedure accumulates the lines in a *DBMS_Output* package global collection so that, when the server call terminates, SQL*Plus can traverse the collection to print out the lines. However, as has been explained (see *"Package state when the same package is instantiated in more than one edition"* on page 17), when a session uses different editions during its lifetime, then a particular package is separately instantiated in each edition from which a reference to the package is made. It is for this reason that the more cumbersome approach, using *Utl_File*, is used. This method of tracing, using *Utl_File* to open the trace file in append mode, write one line, and then to close the file is very inefficient. However, in a test such as this, the inefficiency is undetectable.

58. Notice that the procedure *Usr.Do_Update* issues a *commit*. This allows the scripts shown in *Code_20* to run without error. It is illegal to change the current edition during a transaction. (See *"Conceptual explanation of the edition"* on page 6.)

The SQL*Plus script shown in *Code_20*

```
-- Code_20
alter session set edition = e1
/
begin
  Trace(Chr(10)||'App using e1');
  Do_Update();
end;
/

alter session set edition = e2
/
begin
  Trace(Chr(10)||'App using e2');
  Do_Update();
end;
/

alter session set edition = e3
/
begin
  Trace(Chr(10)||'App using e3');
  Do_Update();
end;
/

alter session set edition = e4
/
begin
  Trace(Chr(10)||'App using e4');
  Do_Update();
end;
/

alter session set edition = e5
/
begin
  Trace(Chr(10)||'App using e5');
  Do_Update();
end;
/
```

will then produce this output to the trace file *t.txt*:

```
-- Code_21
App using e1
From Do_Update................ E1
From Fwd_Xed. Expect E3....... E3

App using e2
From Do_Update................ E2
From Regular.................. E2
From Fwd_Xed. Expect E3....... E3

App using e3
From Do_Update................ E3
From Regular.................. E3

App using e4
From Do_Update................ E4
From Regular.................. E4
From Rev_Xed. Expect E4....... E4

App using e5
From Do_Update................ E5
From Regular.................. E5
From Rev_Xed. Expect E4....... E4
```

When a database has no more than two active editions during an EBR exercise and when no crossedition trigger issues DML[59], then it is sufficient just to understand these basic firing rules.

59. This situation is expected to be common.

Advanced firing rules for crossedition triggers

We will use the term *crossedition trigger DML* for DML issued directly, using embedded SQL or native dynamic SQL, from the PL/SQL unit that is a crossedition trigger; and we will use the term *regular DML* for DML issued from *any other site*. Notice that this definition means that DML that is issued from a PL/SQL unit that is invoked by a crossedition trigger is *regular DML*. In particular, DML issued by using the *DBMS_Sql* API is by default regular DML, even when the invocation of these subprograms is made directly from the implementation of a crossedition trigger. However, if the name of the crossedition trigger that invokes the *DBMS_Sql* API is provide for the actual of the *Applying_Crossedition_Trigger()* formal parameter to *DBMS_Sql_Parse()*, then the DML that the *DBMS_Sql* API issues will be crossedition trigger DML.

» Regular DML always fires both visible regular triggers and appropriately selected crossedition triggers.

» The firing order of crossedition triggers in a particular edition is never interleaved with that of crossedition triggers in a different edition. All forward crossedition triggers in edition *e* will fire before any in a descendent edition of edition *e*. And all reverse crossedition triggers in edition *e* will fire after any in an ancestor edition of edition *e*.

» Crossedition trigger DML from a forward crossedition trigger actual in edition *e* will fire forward crossedition triggers that are actual in descendents of edition *e* but will never fire reverse crossedition triggers or regular triggers.

» Correspondingly, crossedition trigger DML from a reverse crossedition trigger actual in edition *e* will fire reverse crossedition triggers that are actual in ancestors of edition *e* but will never fire forward crossedition triggers or regular triggers.

» Recall the fact that DML done to a table does not fire triggers on an editioning view that covers the table (see *"An editioning view allows table-style triggers"* on page 21). This means that, in practice, even DML to tables that a crossedition trigger issues using the *DBMS_Sql* API or a helper PL/SQL unit that in turn does the DML (which is therefore regular DML) will not fire regular triggers because these, following the paradigm, will not be created on tables but will be created only on editioning views.

» Crossedition trigger DML from a unit that is actual in edition *e* does not, unless special programming steps (described in the next two bullet points) are taken, fire crossedition triggers that are actual in edition *e*.

» If forward crossedition trigger *Fwd_Xed_1*, on table *t1*, issues crossedition trigger DML to table *t2*, then forward crossedition trigger *Fwd_Xed_2*, on table *t2*, will fire if and only if there is an ordering relationship between *Fwd_Xed_2* and *Fwd_Xed_1*. Either *Fwd_Xed_2* may be defined using the *follows Fwd_Xed_1* syntax; or the ordering relationship between *Fwd_Xed_1* and *Fwd_Xed_2* may be established transitively (through one or several intervening crossedition triggers).

» Correspondingly, if reverse crossedition trigger *Rev_Xed_1*, on table *t1*, issues crossedition trigger DML to table *t2*, then reverse crossedition trigger *Rev_Xed_2*, on table *t2*, will fire if and only if there is an ordering relationship between *Rev_Xed_2* and *Rev_Xed_1*. Again, the ordering may be direct or transitive[60].

The *apply* step: systematically visiting every row to transform the pre-upgrade representation to the post-upgrade representation

While forward crossedition triggers are necessary in order to propagate changes that happen to be made to the pre-upgrade representation by user activity, just having them in place is, of course, not sufficient to ensure that every row will be transformed. The simplest way to ensure that every row is transformed is to use a batch process to force each forward crossedition trigger to fire. This is trivially achieved by updating each forward

60. Of course, neither the use of the *precedes* clause nor the use of the *follows* must specify circularity. The attempt causes *ORA-25023: Cyclic trigger dependency is not allowed*.

crossedition trigger's base table to set a column that fires the trigger on update to itself. There is, however, a little more to this than you might at first think.

Using *DBMS_Sql_Parse()* to apply a forward crossedition trigger

The firing rules for crossedition triggers dictate that regular DML issued by a session using edition *e* will not fire forward crossedition triggers that are actual in edition *e*. But the paradigm for EBR requires that a session that is installing the upgrade should use the post-upgrade edition. How, then, can such a session make a relevant forward crossedition trigger fire?

New in *11.2*, *DBMS_Sql_Parse()* has overloads with the formal parameter *Apply_Crossedition_Trigger*. These overloads also have the formal parameters *Edition* and *Fire_Apply_Trigger*. *Apply_Crossedition_Trigger* has no default value, *Edition* has the default value *null*, and *Fire_Apply_Trigger* has the default value *true*. (Other overloads have just the formal parameter *Edition*; in these, it has no default value.) *Code_22* shows the simple use of the overload with *Apply_Crossedition_Trigger* to fire the forward crossedition trigger *Fwd_Xed*, on table *t*, for each of its rows.

```
-- Code_22
DBMS_Sql.Parse(
  c                          => The_Cursor,
  Language_Flag              => DBMS_Sql.Native,
  Statement                  => 'update t set c1 = c1',
  Apply_Crossedition_Trigger => 'Fwd_Xed');
```

When *Edition* is *null*, then names are resolved in the current edition of the session that invokes *DBMS_Sql_Parse()*. The significance of *Fire_Apply_Trigger* is explained in *"Using explicit SQL for the apply step"* on page 29.

Forward crossedition triggers are the only triggers that you can *apply* (cause to fire on every row of the table on which they are defined).

Crossedition triggers must be idempotent

It is impossible to predict whether a particular row that is to be transformed by a forward crossedition trigger will be visited first by ordinary end-user activity or by the *apply* step. Therefore, it is possible that, when the *apply* step happens second, the same transform will be applied twice to the same row. The action of a forward crossedition trigger must therefore, by explicit design, be *idempotent*. (Similar rationale holds for the design of a reverse crossedition trigger—even though these are never the subject of an *apply* step.)

When a replacement table is used, then every row in the original table needs to be reflected in the replacement. If the source row is visited first by ordinary end-user activity, then when the same row is visited by the *apply* step, no further cation is needed. (This is because the current state of the source row is already reflected in the target replacement table.) The *Ignore_Row_On_Dupkey_Index*[61] is provided to allow the rule to be simply implemented. It is, however, necessary to detect that the *apply* step is in progress if this is implemented simply by causing the forward crossedition trigger that implements the transform to fire for every row. The boolean function *Applying_Crossedition_Trigger()* in the package *DBMS_Standard* is provided for this purpose.

It is possible, of course, that when the forward crossedition trigger fires in response to ordinary end-user activity, the source row is already reflected in the target table. If this is the case, then the functional equivalent of a *merge* must be done. The *Change_Dupkey_Error_Index* hint is provided to allow this functionality to be programmed conveniently[62].

61. The *Ignore_Row_On_Dupkey_Index*, *Change_Dupkey_Error_Index*, and *Retry_On_Row_Change* hints are new in *11.2*.

62. *To do...* explain the circumstances when the *Retry_On_Row_Change* hint is useful.

When to enable crossedition triggers—*DBMS_Utility.Wait_On_Pending_DML()*

In order that there be no “lost updates” during the *apply* step, the following logic must be used.

» Enable the forward crossedition triggers that are mutually related by the *follows* relationship.

» Invoke *DBMS_Utility.Wait_On_Pending_DML()*. This waits until all transactions (other than the caller’s own) that have locks on the listed tables and that began prior to the invocation of this function have either committed or been rolled back.

» Start the *apply* step.

Using the *DBMS_Parallel_Execute* API

If the table which will suffer the *apply* step has very many rows, then should the operation be done as a single transaction, ordinary users attempting to change rows in the same table would be very likely to suffer unacceptable waits. Therefore, the availability of the pre-upgrade application will be improved if the *apply* step is conducted in separately committed chunks of reasonable size. (Because the transform is required to be idempotent, there is no requirement to complete the *apply* step in a single commit unit and no requirement to keep the wall clock time between the commit of the separate chunks short.) The *DBMS_Parallel_Execute* package[63] provides a convenient way to achieve this. It exposes just the same degrees of freedom as does the *DBMS_Sql_Parse()* overload shown in *Code_22* on page 28.

Using explicit SQL for the *apply* step

While it takes least effort on behalf of the developers of the EBR exercise to implement the *apply* step simply by causing the forward crossedition trigger(s) that implement the transform for each row of the table, this is not always the approach that produces the most performant result. This is especially the case when a replacement table is used. A SQL statement that has the same effect (if one can be written) will use less computational resource than the row-by-row approach (with associated per row SQL to PL/SQL to SQL context switches) that reusing the forward crossedition trigger(s) implies. *Code_23* shows how, to achieve this, *DBMS_Sql_Parse()* is used with *Fire_Apply_Trigger* set to *false* to indicate that rather than firing the forward crossedition trigger designated by *Apply_Crossedition_Trigger*, the real SQL statement designated by *Statement* will be used.

```
-- Code_23
DBMS_Sql.Parse(
  c                          => The_Cursor,
  Language_Flag              => DBMS_Sql.Native,
  Statement                  => The_Real_SQL_Statement,
  Apply_Crossedition_Trigger => 'Fwd_Xed',
  Fire_Apply_Trigger         => false);
```

It is necessary to specify the name of the forward crossedition trigger, *Fwd_Xed*, that implements the same transform so that the closure of other forward crossedition triggers in *follows* relationship the *Fwd_Xed* will fire. Of course, the *DBMS_Parallel_Execute* approach may be used for this approach to the *apply* step.

Combining several bug fixes in a single EBR exercise

Real applications are often very large and complex; they may be developed and maintained by a large team; and, sadly but realistically, they suffer from many independent bugs. Each bug fix might be implemented independently of others by a different developer. There are two ways to implement a set of fixes at a deployed site.

» *Either*, a single patch script is developed to make the transformation corresponding to *N* distinct bug fixes, going from the start state to the end state in an optimal fashion

63. The *DBMS_Parallel_Execute* is new in *11.2*. It is implemented ordinarily in PL/SQL as wrapper for calls to the *DBMS_Scheduler* API. It manages the state of progress of a task by using *Sys*-owned tables exposed via catalog views.

» *or N* separate patch scripts are developed, each to implement the fix for one bug, and these *N* scripts are run in succession in an order that has been designed to be appropriate.

The first approach is potentially more efficient; but the second approach is likely to require less effort from the team that develops and maintains the application. Moreover, especially when the application is delivered by an ISV[64], different sites where the same application is deployed might need to apply different bug fixes; in such cases, the second approach offers more flexibility.

When the first approach is implemented using EBR, it is very unlikely that the advanced firing rules for crossedition triggers will be useful. The exercise will use only a single new edition, and no crossedition trigger *Trg2* will implement logic to respond to a change that a different crossedition trigger *Trg1* will make. (Rather, *Trg1* will implement directly the logic that *Trg2* otherwise would have implemented.)

However, when the second approach is implemented using EBR, it might happen that one crossedition trigger *Trg2* must fire only after another crossedition trigger *Trg1* has fired because, in the ordering scheme for individual fixes, it is realized that *Trg2* (on table *t2*) must read data that *Trg1* (on table *t1*) must first have changed. In relatively rare cases, not only might *Trg1* do DML to *t2* but also *Trg2* might do DML to *t1*—in other words, a possibility of circularity might arise.

The conceptually simple way to avoid such circularity is to use a new edition for each fix, where the parent-child order of the editions reflects the designed order of applying the fixes. End-user sessions would use only the ultimate ancestor edition and the ultimate descendent edition. The fact that crossedition trigger DML from a forward crossedition trigger will fire only those forward crossedition triggers in descendent editions (and correspondingly for reverse crossedition triggers) avoids circular firing. However, it is less cumbersome to use only a single new edition; in this case, that fact that crossedition trigger DML will never fire crossedition triggers in the same edition unless this is explicitly requested with a *follows* or *precedes* mutual relationship avoids circular firing.

64. ISV stands for Independent Software Vendor and here denotes a vendor that produces an application for Oracle Database that is deployed by many different customers.

EBR-readying an application

EBR-readying an application requires that at lest one user be editions-enabled and that an editioning view be introduced to cover each of the application's tables. It might be necessary to do some schema reorganization in order that the intended editions-enabling will succeed.

This EBR-readying step is a non-negotiably offline operation. And, because of the requirement for testing that the various changes to the application imply, the vehicle must be a new version of the application. The application author must decide if a new version will be dedicated to be the vehicle for delivering the EBR-readied application or if other functionality changes might be bundled into the same new version.

Editions-enabling the intended users

Because an editioning view can be owned only by an editions-enabled user, then every user that owns a table that belongs to the application, and that therefore will be covered by an editioning view, must be editions-enabled[65]. Further, every user that owns a synonym, view, or PL/SQL object that belongs to the application should be editions-enabled so that such objects can be modified as appropriate in the child edition during an EBR exercise. Note though that an evolved ADT cannot be editioned and nor can a view that is the source or the target of a foreign key constraint. This implies that, when the application has such objects, some kind of explicit fix will be necessary.

Recall that an object that is not editioned cannot depend on one that is editioned. This means that the attempt to editions-enable a user that owns an object whose type is editionable will fail[66] if that object has an object that is not editioned in the closure of its dependants that is not owned by the to-be-editions-enabled user. If this failure occurs, then the *force* keyword can be used. The *alter user... enable editions force* command will succeed but all the not editioned objects in the closure of dependants of each now editioned object owned by the newly editions-enabled user, not owned by the user, will be invalidated.

The invalidation will be *recoverable* for an invalidated object of editionable type if its owner can, in turn, be successfully editions-enabled. But the invalidation will be *irrecoverable* for an invalidated object that cannot become an editioned object, either because its type is not editionable or because its owner cannot be editions-enabled.

It might prove necessary to designate one or more users that own objects that belong to the application that will *not* be editions-enabled for the specific purpose of owning objects whose type is editionable but that must become editioned in order to avoid irrecoverable invalidations.

Introducing an editioning view in front of every table

Suppose that an extant application that runs in *11.1* has a table *The_Rows* with columns *PK*, *a*, *b*, *c*, and *d*. Of course, these names will be reflected in very many places in the application's install scripts and in its code. In order to take advantage of EBR, application code must no longer refer to this table explicitly but must instead refer to an editioning view that covers the table.

65. Oracle recommends that no attempt be made to predict which tables are likely to suffer change in patches and upgrades to the application in the hope that only each of these needs to be covered by an editioning view. This is bound to be a false economy of effort.

66. The attempt causes *ORA-38819*.

In fact, each one of an application's tables must be covered by an editioning view; and all data access from application code must reference the covering editioning view; only crossedition triggers[67] and, of course, editioning views, should be allowed to reference tables.

The least invasive way to effect this regime is to rename the table, giving it a name that is conventionally related to its former name, and then to create an editioning view with the table's former name and that exposes the same column list as did the table. It is natural, but not necessary, to rename the table's columns using a convention that denotes the change history.

Code_24 shows an example of a *create editioning view* statement that follows such a naming convention[68].

```
-- Code_24
create editioning view The_Rows as
  select
    a.PK_1 PK,
    a.a_1  a,
    a.b_1  b,
    a.c_2  c,
    a.d_3  d
  from   The_Rows_ a
```

Notice that EBR cannot be used to support the introduction of an editioning view to cover each of an applications tables[69]. Rather, the one-time operation, like the upgrade of the Oracle Database to *11.2*, is the price that must be paid to EBR-ready the application. It would be natural to do both first the upgrade to *11.2* and then the introduction of the editioning views in the same downtime exercise.

Notice that constraints and indexes (with the exception of join indexes[70]) remain valid when their tables, and the columns in these, are renamed because the rename command automatically updates the constraint and index metadata. However, such renaming will, in general, invalidate triggers because the trigger prologue is automatically edited but the PL/SQLcode that implements the trigger is not. The remedy is simply to re-run the scripts that created the triggers once the covering editioning views are in place. This will have the effect of moving each trigger from a table to the editioning view that covers it, in line with the recommended practice.

67. See *"The crossedition trigger"* on page 22.

68. The name *PK* is meant to suggest *primary key*. Suppose that a particular application upgrade intended to split a single primary key column into two which then would be then new primary key. Because constraints are defined at the table level, this step would require the intermediate use of unique indexes.

69. This restriction needs to be stated more carefully. When the aim is to cover each table *The_Rows* with an editioning view *The_Rows* by first renaming the table to *The_Rows_*, then EBR cannot be used to support this. If, rather, each table retains its old name and each editioning view has a new name, then EBR *can* be used. In this approach, a new edition would be used for the creation of the editioning views. Of course, every database object that had referred directly to the table would now need to be edited so that it referred to the corresponding editioning view. When such a reference was made from the code of an editioned object, then a new occurrence could be ordinarily made in the new edition. However, when the reference was made from a noneditioned object, then this would need to be manually versioned by giving the new occurrence a new name. It is expected that the effort, and therefore the risk of introducing bugs, of using EBR to introduce the editioning views will be considered by most customers too great and that they will choose, instead, to EBR-ready their applications offline.

70. A join index is created like this.

An attempt to rename the column *Masters.Val* fails with *ORA-23293: Cannot rename a column which is part of a join index*.

Existing features in the presence of editions

Database links

A database link has always been allowed between databases at different versions of Oracle Database. However, we need not consider the case where a database link in a database at *11.1* or earlier denotes a *11.2* database[71]. We need only consider a database link in a database at *11.2* or later that denotes a database at its own version or at an earlier version. The interesting case is when a database with more than one edition has a database link that denotes another database with more than one edition. It turns out that the case where the target database has just one edition, or is at *11.1* or earlier where there is no such thing as an edition, is a just degenerate case of the more interesting one.

Though a database link is a code object, the object type is not editionable.

The *create database link* statement has no way to identify the edition at the target database[72]. When this target has more than one edition, then the session that supports the reference to an object *@Some_Link* uses the target's default edition. The local database therefore sees a "flat" picture of the remote database. It cannot tell whether the target is at a version of Oracle Database that knows nothing of editions, has is just one edition, or has several editions. Especially, it cannot detect whether a remote object is editioned or not[73].

For objects within a single database, an object that is not editioned cannot depend on an editioned object. This restriction is necessary because of the rules which are used to determine which actual occurrence of an editioned referenced object to resolve to. These rules rely on knowing the edition of the dependent object.

The general rule, that an object that is not editioned cannot depend on one that is, needs to be stated very carefully when the referenced object is remote. In this case, the flattening effect of seeing the referenced object via the link trumps the fact that it might be editioned. For a remote dependency, the mechanism of the link is sufficient to uniquely identify which actual occurrence of the reference object to use when it is editioned. Therefore, a local object that is not editioned *can* depend on a remote object that is editioned.

The pre-*11.2* understanding about remote dependencies (timestamp mode *versus* signature mode) holds even when both the local dependent object and the remote referenced object are editioned and when the local database and the remote database each has several editions.

Application Contexts

Code_25 shows a SQL statement that creates a global application context.

```
-- Code_25
create context My_Context
using Usr.My_Context_API
accessed globally
```

Objects whose type is *context* are listed in the *DBA_Objects* catalog view family and they are never editioned[74]. While it appears that *My_Context* depends on the package *Usr.My_Context_API*, this is not a

71. The source database should not be at an earlier version than the target. This rule holds for any client, for example SQL*Plus; the client version must be at least the same as the database version. If a *9.2* SQL*Plus client connects to a *11.1* database, many operations might seem to work, but some will fail. The advent of editions doesn't change this.

72. The power of expression of the connect string could be extended to allow the target edition to be specified.

73. Of course, if the local database executes a PL/SQL unit that uses remote procedure call to invoke the overload of *DBMS_Sql_Parse()* in the remote database that allows the edition to be specified, and other appropriate *DBMS_Sql* subroutines, then it can discover arbitrary information about the remote objects and execute SQL statements of all sorts in any remote edition that it chooses. But such a unit is not expected to be part of an ordinary application.

formal relationship. The *create context* statement will succeed even if the package *Usr.My_Context_API* does not exist. Therefore, even though *My_Context* is not editioned, *Usr.My_Context_API* may be.

The consequence of this is best understood by an example. Suppose that the database has two editions, *Pre_Upgrade* and *Post_Upgrade* and that package *Usr.My_Context_API* with the source shown in *Code_26* is actual in *Pre_Upgrade* and inherited in *Post_Upgrade*.

```
-- Code_26
package My_Context_API authid Current_User is
  procedure Set_Value(Key in varchar2, Val in varchar2);
  function  Key_Value(Key in varchar2) return varchar2;
end My_Context_API;
```

Suppose, too, that the implementation in the body of *My_Context_API* is actual in both *Pre_Upgrade* and *Post_Upgrade* because improved functionality is introduced in the newer occurrence. It is common to use *Set_Value()* to restrict the choice of key using a list of allowed keys and, therefore, a common improvement is to add a new key with a new meaning for the clients of the context it controls. Such details are unimportant for this example; it is sufficient to consider the *Pre_Upgrade* implementation shown in *Code_27*

```
-- Code_27
package body My_Context_API is
  procedure Set_Value(Key in varchar2, Val in varchar2) is
  begin
    DBMS_Session.Set_Context(
      namespace => 'My_Context',
      attribute => Key,
      value     => 'Using the Pre_Upgrade''s Set:  '||Val);
  end Set_Value;

  function Key_Value(Key in varchar2)return varchar2 is
  begin
    return 'Using Pre_Upgrade''s Key_Value:  '||
           Sys_Context('My_Context', Key);
  end Key_Value;
end My_Context_API;
```

and a *Post_Upgrade* implementation that simply replaces the text *Pre_Upgrade* with *Post_Upgrade*.

Suppose now that the SQL*Plus script shown in *Code_28* is used to store values in the context.

```
-- Code_28
alter session set edition = Pre_Upgrade
/
begin
  My_Context_API.Set_Value(Key=>'a', Val=>'Apple');
  My_Context_API.Set_Value(Key=>'b', Val=>'Banana');
  My_Context_API.Set_Value(Key=>'c', Val=>'Carrot');
end;
/
alter session set edition = Post_Upgrade
/
begin
  My_Context_API.Set_Value(Key=>'d', Val=>'Date');
  My_Context_API.Set_Value(Key=>'e', Val=>'Eggplant');
  My_Context_API.Set_Value(Key=>'f', Val=>'Fig');
end;
/
```

The result stands in contrast to that for package state[75]. All six key-value pairs are stored in the same context but are (in this example) annotated differently reflecting the current edition at the time that *Set_Value()* was invoked.

---

74. The list of editionable object types is given in *"editionable object types, editions-enabled users, and editioned objects"* on page 7; *context* is not among them.

---

75. See *"Package state when the same package is instantiated in more than one edition"* on page 17.

Suppose, finally, that the SQL*Plus script shown in *Code_29* is used to retrieve values from the context.

```
-- Code_29
alter session set edition = Pre_Upgrade
/
begin
  DBMS_Output.Put_Line('a: '||
    Usr.My_Context_API.Key_Value('a'));
  ...
  DBMS_Output.Put_Line('d: '||
    Usr.My_Context_API.Key_Value('d'));
  ...
end;
/
alter session set edition = Post_Upgrade
/
begin
  DBMS_Output.Put_Line('a: '||
    Usr.My_Context_API.Key_Value('a'));
  ...
  DBMS_Output.Put_Line('d: '||
    Usr.My_Context_API.Key_Value('a'));
  ...
end;
/
```

It produces this output:

```
a: Using Pre_Upgrade's Key_Value:  Using the Pre_Upgrade's Set:  Apple
b: Using Pre_Upgrade's Key_Value:  Using the Pre_Upgrade's Set:  Banana
c: Using Pre_Upgrade's Key_Value:  Using the Pre_Upgrade's Set:  Carrot
d: Using Pre_Upgrade's Key_Value:  Using the Post_Upgrade's Set: Date
e: Using Pre_Upgrade's Key_Value:  Using the Post_Upgrade's Set: Eggplant
f: Using Pre_Upgrade's Key_Value:  Using the Post_Upgrade's Set: Fig

a: Using Post_Upgrade's Key_Value: Using the Pre_Upgrade's Set:  Apple
b: Using Post_Upgrade's Key_Value: Using the Pre_Upgrade's Set:  Banana
c: Using Post_Upgrade's Key_Value: Using the Pre_Upgrade's Set:  Carrot
d: Using Post_Upgrade's Key_Value: Using the Post_Upgrade's Set: Date
e: Using Post_Upgrade's Key_Value: Using the Post_Upgrade's Set: Eggplant
f: Using Post_Upgrade's Key_Value: Using the Post_Upgrade's Set: Fig
```

This shows that both the old and new implementations of *Key_Value()* see the same edition-independent set of values stored in the context.

It is essential to understand this behavior when designing an upgrade to an application that uses a context. Different strategies will serve different purposes. For example, if the setter and getter subprograms did no more than enforce the list of allowed keys, then a new key could be added in a new edition without considering the representation of the values that the context stores, and the both the new and the old implementations could populate the same context. For a more radical change, the new setter and getter subprograms could use a different context than the old ones[76].

VPD policies on editioning views and synonyms

Oracle recommends that any VPD policy that is attached to a table in the application before it has been readied for EBR be dropped and re-created on the editioning view that covers the table after the application has been readied for EBR. The main reason is that the *apply* step needs to visit every row in the table; and a VPD policy can block the table's owner from seeing every row in he table.

Regular and fine-grained audit policies

Oracle recommends that any regular or fine-grained auditing policy that is attached to a table in the application before it has been readied for EBR be left at the table level after the application has been readied for EBR. This is because auditing is the last line of defense in a security design. It is conceivable that a person who knows

76. This discussion reinforces the wisdom of the discipline of using a getter function in all application code, thereby hiding the name of the context, rather than invoking *Sys_Context('My_Context', Key)* directly.

the password of the user that owns a table could turn out to be untrustworthy and might make unauthorized changes to the data that the table stores.

Conclusion

This whitepaper has explained how edition-based redefinition is used to allow an application's database objects to be patched or upgraded while the application remains in uninterrupted use. It has drawn attention to the following characteristics that distinguish the capability markedly from other Oracle Database capabilities that support the other subgoals of the overall high availability goal.

- An application's database backend must be specifically prepared to use EBR. This will need a new version of the application as the vehicle. The new version will be designed by the application's architect and will be delivered by upgrade scripts created in by the application's developers. The upgrade to the EBR-readied version must be done in downtime because tables will be renamed and dependent objects will be invalidated. Only when an editioning view covers each table and restores its former name will revalidation be possible[77].
- If the extant application, before it is EBR-readied, has unfavorable occurrences of objects that cannot be editioned that depend on objects that will be editioned, if it has occurrences of evolved ADTs owned by users that will be editions-enabled, or if it has occurrences of views that are the source or target of foreign key constraints owned by users that will be editions-enabled, then the application's architect will need to design some non-trivial changes to the distribution of objects among the applications owners.
- Once the application has been EBR-readied, then subsequent upgrades and patches may be done online.
- Such scripted EBR exercises, just like scripted classical offline upgrades and patches, will be designed by the application's architect and implemented by the application's developers. An administrator at the deployed site of an application cannot perform an online application upgrade unless the application's developers have delivered the upgrade scripts as an EBR exercise.

Should a particular upgrade require to change only synonyms, views, or PL/SQL objects, then the upgrade scripts will be identical to those used for a classical offline upgrade. The only difference will be that they are executed using a new edition.

Should a particular upgrade require additionally (or alternatively) to change the shape or content of only those tables that do not suffer changes in consequence of ordinary end-user activity, then the design and implementation of the EBR exercise will not need to use crossedition triggers; it will need only to change editioning views, and possibly other editioned objects, in the new edition.

Only when the upgrade requires to change the shape or content of tables that *do* suffer changes in consequence of ordinary end-user activity, is the use of crossedition triggers required. These crossedition triggers are created to sustain the EBR exercise and are dropped when it is complete; in contrast to editioning views, they are not a permanent part of the application.

Enjoy!

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77. Of course, this revalidation will be possible without changing the code of the dependent objects.

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