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# Application Development with Oracle Database 12c

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## Introduction

The efficiency and capability of applications is largely governed by the capabilities of the underlying database. Oracle Database 12c delivers significant new functionality for application development and deployment. Oracle Database 12c is the first relational database designed for the Cloud. Oracle Multitenant is new in Oracle Database 12c and provides a highly secure, multitenant database architecture that makes it easier to develop for the Cloud by relieving developers of the need to code multitenancy at the application level.

Oracle Database 12c offers customers the power and performance of the industry's leading database delivered across a wide variety of the most popular application development technologies including Oracle APEX, PL/SQL, SQL, C, C++, Java, .NET, PHP, Perl, Python and Ruby. Oracle Database 12c is a single integrated database platform offering market-leading security, high performance, availability and scalability for on-line transaction processing, data warehousing and Big Data.

New functionality has been added to Oracle Database 12c with a focus on ease of use, security, scalability and performance. Many new features have been added to make it easier than ever to migrate from other databases to Oracle Database 12c. This paper provides an overview of key new features of interest to application developers.

## Database Access Infrastructure and APIs (Java, C, C++)

### Introduction

In this section, we'll look at new features for Oracle Database access infrastructure and APIs. The features focus on the performance, scalability, availability, security and usability of Java, C, and C++ applications. Scripting languages including PHP, Ruby/JRuby, Python/Jython and Perl that use Oracle JDBC or Oracle database adapters (PHP-OCI8, Ruby-OCI8, Oracle enhanced adapter for ActiveRecord, Python cx\_Oracle and Perl DBD::Oracle) will also benefit from these features once the communities which maintain this code do the integration work.

### Oracle Multitenant

Oracle Multitenant extends the notion of “Transportable Tablespace” to databases. The architecture consists of a root infrastructure called container database (CDB) that contains exclusively Oracle provided metadata, then a set of Pluggable Database (PDBs), which are full-fledged databases containing customer and application data and metadata- and which can be plugged/unplugged into/from CDBs.

The benefits of Pluggable Databases are:

- Fast provisioning of a new database or of a copy of an existing database.
- Fast redeployment, by unplug and plug, of an existing database to a new platform.
- Quick patch or upgrade by unplugging a PDB and plugging it into a different container database (CDB) in a later version.
- More PDB databases per machine than monolithic/traditional databases.
- Separate the duties of the application administrator (PDBs) from the duties of the administrator of the Oracle-supplied system (i.e., CDB).

JDBC, SQLJ, OCI and OCCI drivers support Pluggable Databases. From Java, C, and C++ applications perspective, PDBs feel and operate identically to traditional Oracle databases, provided SERVICE name (Net Services parlance) is used in connect strings.

### New SQL Data Types

Java, C, C++ applications may leverage new data types including: 32K VARCHAR, NVARCHAR, and RAW, invisible/hidden columns, implicit results, auto-increment or IDENTITY columns, and PL/SQL packaged types and Boolean as parameters.

#### **32K VARCHAR, NVARCHAR, and RAW**

The maximum size of the VARCHAR2, NVARCHAR2, and RAW data types has been increased from 4,000 to 32,767 bytes. Java, C and C++ applications using respectively JDBC, OCI, and OCCI will no longer need to switch to large objects (LOBs) for data inferior to 32K in size; indexes may also be built on top of columns declared with such data types.

Increasing the allotted size for these data types allows users to store more information before switching to large objects (LOBs). This is especially useful for brief textual data types and the capabilities to build indexes on these types of columns.

### **Auto-Increment (IDENTITY) Columns**

Table columns have been enhanced to support the American National Standards Institute (ANSI) IDENTITY keyword.

This provides a standards-based approach to the declaration of automatically incrementing columns simplifying application development and making the migration of DDL to Oracle simpler.

### **Invisible or Hidden Columns**

New columns can be created or added to table(s) then hidden, using the INVISIBLE SQL keyword. Invisible columns are not displayed during generic access such as a “SELECT \* FROM table” or “DESCRIBE table” however these may be displayed when specified explicitly in the SELECT list.

### **PL/SQL Package Types and Boolean Types as Parameters**

This feature allows database client APIs (for example, OCI and JDBC) to natively describe and bind PL/SQL package types and boolean types. Java and C-based applications can now easily bind and execute PL/SQL functions or procedures with PL/SQL package types or boolean types (except Java) as parameters.

This feature reduces the complexity of executing PL/SQL functions or procedures from client-side applications.

### **Implicit Results**

Implicit Results allows Java, C and C++ applications to retrieve the return of stored procedures (PL/SQL, Java) directly, without the need to use Ref Cursor, using the PL/SQL procedure DBMS\_SQL.RETURN\_RESULT. This feature makes it easier to migrate Java, C, C++ applications from third-party databases to Oracle Database.

## **Performance and Scalability**

Java, C and C++ applications can leverage the following performance and scalability features: SQL plan management, DRCP support for Java and other enhancements, very large network buffers, advanced network compression, and runtime load balancing across geographies with Global Data Services.

### **SQL Plan Management (SPM)**

SQL Plan Management enhancements in this release include:

- Storing execution plans for plan baselines
- Create automatic jobs that performs the evolve task

SQLJ now supports the creation of plan baselines. You can generate plan baselines at the time of translating the SQLJ files. The necessary SQL statements to create the plan baselines are generated in the .sql files.

### **Scale with Database Resident Connection Pool**

Database Resident Connection Pool (DRCP) is an RDBMS-side pool of servers processes shared across client applications, programming languages and middle-tiers. Introduced in Oracle Database 11g OCI for C, C++, PHP, Python and Perl, it is indispensable for single-threaded systems (such as PHP/Apache) that cannot do client/middle-tier connection pooling. The reduction of database server processes and memory may reach orders of magnitude, which makes DRCP beneficial for multi-threaded systems as well for the large scale deployment of thousands of middle-tier accessing the same database.

DRCP is now available for Java through Oracle JDBC drivers. A client-side connection pool e.g., Oracle's Universal Connection Pool (UCP) for Java (similar to OCI Session Pool for C/C++) is required for tracking connections check-in and check-out on the clients/mid-tiers.

New JDBC connection properties `oracle.jdbc.DRCP.name` and `oracle.jdbc.DRCP.purity` allow Java applications to name DRCP pools and sub-partition a single pool across several applications.

### **Global Data Services – Runtime Load-Balancing**

UCP now supports Runtime Load Balancing across geographies.

### **Large Network Buffers and Advanced Network Compression**

Oracle Net Services now supports very large network buffers a.k.a. Session Data Unit (SDU), up to 2 MB, up from 64K in Oracle database 11g Release 2. SDU can be configured in `SQLNET.ORA` on RDBMS side and in `SQLNET.ORA`, `TNSNAMES.ORA` or connect strings on clients/mid-tiers.

Advanced Network Compression reduces the size of Oracle Net Session Data Unit (SDU) transmitted over a network connection, thereby increasing response time, network throughput and reducing bandwidth utilization. Once configured, Advanced Network Compression works transparently to clients (applications, mid-tiers) and the server (RDBMS), resulting.

More details can be found in the “Advanced Network Compression” white paper on the Net Services portal and in the Net Services Administrator Guide.

### **Maximum Application Availability and Reliability**

Java, C and C++ application can achieve maximum availability and reliability through the following new features: a consolidated common HA events notification, Transaction Guard, Application Continuity and Fast Connection Failover across geographies with Global Data Services.

### **Common HA Events & Notification**

RAC and Data Guard emit HA events such as `NODE DOWN`, `INSTANCE UP/DOWN`, `SERVICE UP/DOWN`, and so on; these events are carried and notified to subscribers (drivers, applications)

using either ONS (Java) or AQ (C/C++). With Oracle database 12c C/C++ applications now use the same notification mechanism as Java (i.e., ONS).

### New Concepts

**Recoverable Error:** Oracle database 12c exposes a new error attribute `is_recoverable` that applications can use to determine if an error is recoverable or not. C and C++ applications using OCI/OCCI will now be on par with Java and will no longer need to maintain their own list of error codes (e.g., ORA-1033, ORA-1034, ORA-xxx).

**Database Request:** a unit of work submitted by the application, including SQL PL/SQL, local calls, and remote procedure calls; has typically one COMMIT but could have zero or more than one.

**Logical Transaction ID (LTXID):** a new concept to obtain last COMMIT outcome

Mutable Functions: non-deterministic functions that can change their results each time they are called e.g., SYSDATE, SYSTIMESTAMP, SEQUENCES, SYS\_GUID.

**Session State Consistency Model:** non-transactional session state; could be dynamic or static.

### Transaction Guard

Transaction Guard provides a generic tool to address the challenge of reliably determining the outcome of the last COMMIT operation following a break in communication between the client application and Oracle Database.

Without Transaction Guard, if a transaction has been started and commit has been issued, the commit message that is sent back to the client is not durable. The client is left not knowing whether the transaction committed or not. The transaction cannot be resubmitted if the non-transactional state is incorrect or if it already committed. In the absence of knowing the commit and completion information, resubmission can lead to transactions being applied more than once and in the incorrect state.

The benefits of Transaction Guard are:

- First RDBMS to preserve commit outcome.
- Known outcome for every transaction.
- A tool for at-most-once transaction execution.

The Transaction Guard API is available with JDBC-thin, OCI, OCCI, and ODP.NET.

For more details and code fragments, consult the “Maximum Application Availability” and “Transaction Guard” white papers on the Oracle Technology Network (OTN).

### Application Continuity

Application Continuity provides “almost non-intrusive” application availability, out-of-the-box when using RAC and Active Data Guard. Application Continuity transparently:

1. Captures in-flight work, during normal runtime, within “database request” boundaries

2. Upon RDBMS instance or site failure, on recoverable errors, uses Transaction Guard under the covers and reconnects to a good RDBMs instance (RAC) or disaster recovery site (ADG),
3. Replays captured in-flight work

Application Continuity provides the following benefits:

- Masks hardware, software, network, storage errors and outages
- Improved end user experience; i.e., a slight delay in response time, upon failures.

In Oracle database 12c, *Application Continuity for Java* is available out-of-the box through JDBC-Thin only and UCP. Third party drivers or connection pools may enable it by explicitly demarcating (beginRequest/endRequest) the units of work (a.k.a. “database requests”).

Application Continuity for Java requires standard JDBC interfaces instead of deprecated Oracle.SQL concrete classes: BLOB, CLOB, BFILE, OPAQUE, ARRAY, STRUCT, or ORADATA; see My Oracle Support Note 1364193.1 .

Although mostly non-intrusive, Application Continuity design considerations and restrictions are discussed at length in Oracle “Application Continuity” and “Maximum Application Availability” white papers.

### Global Data Services

The Oracle Universal Connection Pool (UCP) supports Fast Connection Failover and Application Continuity across geographies. See the Oracle Database 12c Active Data Guard white paper for more details on Global Data Services.

### Usability

Oracle database 12c furnishes the following application usability features: row count per iteration for array DML, client-side deployment descriptor, auto-tuning, monitoring and tracing database operations, intelligent client connectivity and faster dead connection detection.

#### Row Count per Iteration for Array DML

Java, C and C++ applications using respectively JDBC, OCI, and OCCI can now retrieve the number of rows affected by, each iteration of an array DML statement (array INSERT, UPDATE, DELETE).

For C and C++ applications, OCI furnishes:

- A new mode parameter attribute: OCI\_RETURN\_ROW\_COUNT\_ARRAY in the OCIStmtExecute() call
- And a new statement handle attribute: OCI\_ATTR\_ROW\_COUNT\_ARRAY

For Java applications, Oracle JDBC now returns the number of rows effected in each iteration. The following statement now prints the update count for each UPDATE.

```
...
int rcount[] = stmt.executeBatch();
```

## Client-Side Deployment Descriptors and Auto-Tuning

Similar to Java EE, the behavior of C or C++ applications using OCI or OCCI can now be controlled via a deployment descriptor `oraaccess.xml`. It can be used to configure selected OCI/OCCI parameters to change the behavior of C/C++ applications at deployment time, without the need to modify and recompile source code. The deployment time settings override programmatic settings.

Updates to `oraaccess.xml` will not affect already running clients; these need to be restarted to uptake the changes. The `oraaccess.xml` file is read either from the default location i.e., `$ORACLE_HOME/network/admin` on UNIX and `%ORACLE_HOME%\NETWORK\ADMIN` on Microsoft Windows, or from the directory specified by the `TNS_ADMIN` environment variable in regular and instant client installations.

Leveraging `oraaccess.xml` deployment descriptor, OCI now furnishes automatic and non-intrusive performance management of C/C++ applications, in the areas of Client Result cache, Connection cache, Statement cache, Prefetch memory size, and ONS.

In addition, a new session handle attribute `OCI_ATTR_MAX_OPEN_CURSORS` is also provided.

## Monitoring and Tracing Database Operations

For end-to-end tracing Oracle database furnishes a reserved namespace (OCSID) for storing tags: `MODULE`, `ACTION`, `CLIENTID`, `ExecutionContextID (ECID)`, `MODULE`, `SEQUENCE_NUMBER` and the new `DBOP`. These tags may be associated with a thread without requiring an active connection to the database or client/server. When the application makes a database call, the tags are sent along to the database, piggybacking on the application's connection.

Java applications can use `DBOP` and other OCSID through either JDBC `setClientInfo()` method or DMS APIs while C and C++ applications can use these through DMS APIs and the new OCI `OCI_ATTR_DBOP`.

## Intelligent Connectivity and Faster Dead Client Detection

Net Services is now smarter during connection attempts and decrease the priority of unresponsive nodes in the address string of connect descriptor, for subsequent attempts thereby increasing connectivity time and availability.

Similarly, the detection of terminated session/connection has been accelerated.

The `SQLNET.EXPIRE_TIME` parameter in the `sqlnet.ora` configuration file helps detect terminated clients faster. If the system supports TCP keepalive, then Oracle Net Services automatically uses the enhanced detection model, and tunes the TCP keepalive parameters.

## Security

### Customizing Default Java Security for Java in the Database

Oracle Database includes enhanced permission and policy management for Java runtime. The Java policy is reloadable by the system administrator after adding third-party encryption suites. In addition, the database administrator can change the algorithm search order.

These enhancements provide tighter permission and policy management, as well as flexible and advanced security support for third-party encryption libraries.

### JDBC Enhanced Security

Java Database Connectivity (JDBC) supports the security enhancements in Oracle Database including Kerberos authentication, SHA-2, and Windows Authentication (NTS).

This feature provides advanced security for Java applications.

### Advanced Security Option

Oracle Advanced Security uses the following hashing algorithms to generate the secure message digest and includes it with each message sent across a network: MD5, SHA1, SHA256, SHA384 or SHA512.

JDBC now supports SHA-2 hashing algorithms including: SHA-224, SHA-256, SHA-384, SHA-512.

DRCP in OCI now supports encryption and strong authentication (except TCPs).

### Invoking Runtime.exec with Java in the Database

For security reasons, it is advisable to run the processes forked by the Runtime.exec functionality with OS identity granted lesser rights. The following procedure associates a database user/schema DBUSER with an OS osuser account:

```
dbms_java.set_runtime_exec_credentials('DBUSER', 'osuser', 'ospass');
```

### Java Standards

Oracle Database 12c also brings the following Java standards: JDBC 4.1, JDK 1.7, Logging and JNDI.

#### JDBC 4.1

Oracle Database 12c now supports the JDBC 4.1 getObject() method with two signatures.

```
getObject(int parameterIndex, java.lang.Class<T> type)
```

throws SQLException

```
getObject(java.lang.String parameterName, java.lang.Class<T> type)
```

throws SQLException

#### Example

```
ResultSet rs = . . . ;
```

```
Character c = rs.getObject(1, java.lang.Character.class);
```

Other JDBC 4.1 feature include try-with-resources which will work however, Oracle JDBC does not yet have support for RowSetFactory interface.

### JDK 1.7 and Multiple JDK

Both Oracle JDBC and SQLJ drivers now support JDK 1.7 through `ojdbc7.jar`

The database-resident Java VM which allows running plain Java SE applications directly in the RDBMS now supports JDK 1.6 (the default) and JDK 1.7 with the ability to upgrade/downgrade from one to the other.

### JNDI

The database resident Java VM now supports a general purpose directory service for storing objects and object references including:

- A Java Directory Service Namespace Provider (OJDS)
- A namespace: similar to Unix file system structure `/pub /etc`
- A namespace browser (`ojvmjava` utility): enables browsing permissions and properties of objects stored in the OJDS

### Logging

The database-resident Java VM now furnishes a logging properties initialized once per session with the LogManager API that is extended with the database resource lookup.

- If `$ORACLE_HOME/javavm/lib/logging.properties` resource is set in the current user schema, this resource is used for configuring the LogManager and the `java.util.logging.config.file` property is set
- Otherwise the `$ORACLE_HOME/javavm/lib/logging.properties` resource in the SYS schema is used

You may configure a different properties file and load them in your schema using the `loadjava` utility.

### Applications Migration

In addition to new data types covered above, the following new features are provided, to simplify and reduce the cost of migrating Java, C and C++ applications built on foreign RDBMS onto Oracle Database: a framework and mechanism for translating foreign SQL syntax for execution against Oracle Database and a driver to run MySQL applications against Oracle Database.

### SQL Translation Framework

A key part of migrating non-Oracle databases to Oracle Database involves the conversion of non-Oracle SQL statements to SQL statements that are acceptable to Oracle Database. The conversion of the non-Oracle SQL statements of the applications is a manual and tedious process. To minimize the effort, or to eliminate the need to convert these statements, Oracle Database Release 12c introduces a new feature called SQL Translation Framework which will accept SQL statements from client applications and translate them at run-time before execution.

Inside the Database, the SQL statements are translated by the SQL Translator, registered with the SQL Translation Profile, to handle the translation for the non-Oracle client application. If an error occurs

while a SQL statement is executed, then the SQL Translator can also translate the Oracle error code and the ANSI SQLSTATE to the vendor-specific values expected by the application. The translated statements are then saved in the SQL Translation Profile, so that you can examine and edit at your discretion.

The advantages of SQL Translation Framework are the following:

- The translation of SQL statements, Oracle error codes, and ANSI SQLSTATE is automatic.
- The translations are centralized and examinable.
- You can extract the translations and insert them back to the applications at a later point.

Java, C and C++ applications using ODBC, OCI and JDBC may now use the new SQL Translation mechanism which allows the text of a SQL statement to be translated to Oracle SQL syntax before being submitted to the Oracle Database SQL compiler.

### **Driver for MySQL Applications**

The Oracle Database driver for MySQL applications is a drop-in replacement for the client library for MySQL 5.5. It enables applications and tools built on languages based on MySQL C API (PHP, Ruby, Perl, Python, and so on) to run against an Oracle Database using the new library that implements the MySQL C API.

The driver assumes that the translation of MySQL SQL dialect is taken care of by, either the SQL Translation framework (with a MySQL profile), or a custom hand-made SQL translation mechanism.

The key benefits are the reuse of MySQL applications against both MySQL and Oracle and the reduction in the costs and complexities of migrating MySQL applications to Oracle.

### **Additional Resources**

More information about the products and features covered in this section can be found below.

OCI: <http://www.oracle.com/technetwork/database/features/oci/index-090945.html>

Oracle Java, JDBC, UCP, & Database Web Services:

<http://www.oracle.com/technetwork/database/enterprise-edition/index-097123.html>

## **Oracle Database Cloud Service**

The Oracle Database is the world's leading enterprise database. The Oracle Database Cloud Service is a rich and robust offering combining a rapid application development tool, instant deployment for applications, RESTful Web Service access and a set of packaged applications which install with a few mouse clicks. The Oracle Database Cloud is built on the Oracle Database and delivers the power and robustness of the Database, but also provides additional capabilities in a fully managed service.

In terms of Cloud computing, the Oracle Database Cloud Service, although based on and resident in the Oracle Database, is a Platform-as-a-Service product, rather than a Database-as-a-Service product.

The Database Cloud Service comes with three main components – a rapid application development and deployment tool, Oracle Application Express, that has been proven capable of enterprise-strength application development since its release in 2004; a RESTful Web Service interface which gives secure access to SQL and PL/SQL through this popular Web Service standard; and a collection of applications that can be installed and run with just a few clicks, providing instant business value. The Database Cloud Service is currently running Oracle Database 11g and will be upgraded to Oracle Database 12c in the future.

For more on Oracle Database Cloud Service, go to:

<https://cloud.oracle.com/mycloud/?p=service:database:0>

## SQL and PL/SQL

PL/SQL is an imperative 3GL that was designed specifically for the seamless processing of SQL commands. It provides specific syntax for this purpose and supports exactly the same datatypes as SQL. While it is available in other environments, this document focuses on PL/SQL that is stored and compiled in Oracle Database and that runs within the Oracle executable where it automatically inherits the portability of Oracle Database.

A best practice used by many Oracle customers is to have client code access Oracle Database only by calling PL/SQL subprograms. This approach not only reflects generic modular programming best practices (define a clean, functional API and hide the implementation); also, it typically drastically reduces network round trips between the client and Oracle Database.

### SQL and PL/SQL Key New Features

The following sections highlight SQL and PL/SQL new features included in Oracle Database 12c .

#### **Native SQL Support for Query RowLimits and RowOffsets**

The FETCH FIRST and OFFSET clauses enable native SQL queries to limit the number of rows returned and to specify a starting row for the return set.

Many queries need to limit the number of rows returned or offset the starting row of the results. For example, Top-N queries sort their result set and then return only the first n rows. FETCH FIRST and OFFSET simplify syntax and comply with the ANSI SQL standard.

#### **SQL CROSS APPLY, OUTERAPPLY and LATERAL**

The APPLY SQL syntax allows a table-valued function to be invoked for each row returned by a query's outer table expression. The table-valued function acts as the right input; the outer table expression acts as the left input. The right input is evaluated for each row from the left input and the rows produced are combined for the final output. Therefore, one can pass left-correlations to the table-valued functions.

There are two forms of APPLY - CROSS APPLY and OUTER APPLY. CROSS APPLY returns only rows from the outer table that produce a result set from the table-valued function. OUTER APPLY

returns both rows that produce a result set, and rows that do not, with NULL values in the columns produced by the table-valued function.

LATERAL, part of the ANSI standard, is an extension of the inline view syntax that provides left-correlation scoping within the inline view. These new keywords provide easier and more flexible ways to evaluate and return SQL query results.

### **Enhanced Oracle Native LEFT OUTER JOIN Syntax**

This release provides an extension of the Oracle native LEFT OUTER JOIN syntax that allows multiple tables on the left hand side of an outer join.

Prior to Oracle Database 12c, having multiple tables on the left hand side of an outer join was illegal and resulted in an ORA-01417 error. The only way to execute such a query was to translate it into ANSI syntax. In Oracle Database 12c, the native syntax for a LEFT OUTER JOIN has been expanded to allow multiple tables on the left hand side. This expansion provides the following benefits:

- Merging of multiple table views on the left hand side of an outer join. Such views can originate from the user query or they may be generated during conversion from LEFT OUTER JOIN syntax.
- Merging of such views allows more join reordering and, therefore, more optimal execution plans. These views are merged in a heuristic manner without having to go through cost-based query transformation.
- It relieves the application developers from the burden of formulating queries in terms of views or LEFT OUTER JOIN syntax.

### **Define Tables with Valid-Time Support**

You can add a valid time dimension to a table using existing columns or using columns automatically created by the database. This can be done with both the CREATE TABLE and ALTER TABLE statements.

Applications often indicate the validity of a fact recorded in the database with dates or time stamps that are relevant to the underlying business they manage. Examples of such dates include the hire date of an employee in a Human Resources application, the effective date of coverage for an insurance policy, or the effective date of a change in address. This is in contrast to the date or time at which the fact was recorded in the database. The former temporal attribute is usually called valid-time (VT), while the latter is called transaction-time (TT). Valid-time is typically controlled by the user or application, while transaction-time is system managed. Flashback Data Archive, first introduced with Oracle Database 11g Release 1 (11.1) as part of Total Recall, implements transaction-time functionality. Valid-time support in Oracle Database reduces the complexity of application code by providing a simple declarative interface to allow the database to manage the validity of rows.

### **Valid-Time Temporal Flashback Queries**

Users can now execute queries with the AS OF and VERSIONS BETWEEN clauses based on valid-time. Queries that mix valid-time and transaction-time are called bi-temporal queries.

Users can now query data based on current values (that is, current in valid-time and transaction-time), what we know now (that is, AS OF in valid-time; CURRENT in transaction-time), or what we knew before (that is, AS OF in valid-time and transaction-time), giving declarative access to all possible views of data based on the two time dimensions. Bi-temporal queries in Oracle Database 12c Release 1 (12.1) provide functionality previously available only with extensive and complex application code.

### **PL/SQL Functions Defined in the SQL WITH Clause**

You can define a PL/SQL function in the WITH clause of a subquery and use it as an ordinary function beginning with this release.

The procedural logic needed to support a SQL statement is encapsulated with the SQL statement. This is particularly useful in a read-only database.

Using this construct results in better performance as compared with schema-level functions.

### **PL/SQL-Specific Data Types Allowed Across the PL/SQL to SQL Interface**

Through Oracle Database 11g Release 2 (11.2), when PL/SQL invoked SQL, only values with data types supported by SQL could be bound. This restriction applied even when the called SQL was a PL/SQL anonymous block. This restriction is removed in Oracle Database 12c Release 1 (12.1). For example, a PL/SQL subprogram with a formal parameter whose data type is BOOLEAN can now be invoked dynamically using an anonymous block.

Other restrictions are also removed. The table operator can now be used in a PL/SQL program on a collection whose data type is declared in PL/SQL. This also allows the data type to be a PL/SQL associative array. (In prior releases, the collection's data type had to be declared at the schema level.)

The removal of these restrictions increases the power of expression and the usefulness of PL/SQL. In particular, the extended flexibility of the table operator allows code written to run other vendors' stored procedure languages to be easily migrated to PL/SQL.

### **Mechanism to Restrict the Ability to Reference a PL/SQL Unit to a White List of Database Objects**

It is now possible to mark a schema-level function, procedure, package, or type specification with a white list of allowed callers. The allowed caller may be of any object type that can invoke a PL/SQL subprogram (for example, a trigger, view, table, or index), but it must be in the same schema as the unit that has the white list. The white list is optional but, when used, only the listed objects may reference the unit in question. Cross-schema references to a unit with a white list are, therefore, disallowed even when the reference is attempted from a schema owned by SYS.

This capability supports the robust implementation of a module, consisting of a main unit and helper units, by allowing the helper units to be inaccessible from anywhere except the unit they are intended to help.

### **An Invoker's Rights Function Can Be Result Cached**

Through Oracle Database 11g Release 2 (11.2), only definer's rights PL/SQL functions could be result cached. Now, invoker's rights PL/SQL functions can also be result cached. (The identity of the invoking user is implicitly added to the key of the result.)

At times, it may be appropriate to use an invoker's rights PL/SQL function to issue one or more SELECT statements. This feature improves performance.

### **An Object of Type LIBRARY Can Be Defined Using an Object of Type DIRECTORY**

In previous releases, an object of the LIBRARY type could only be defined by using an explicit path. However, now the DIRECTORY type can be the single point of maintenance for file system paths. Moreover, using a DIRECTORY type has security benefits. A directory object can be defined using a DIRECTORY type.

Additionally, the definition of an object of the LIBRARY type can now include a credential so that the designated external program can be run as a different operating system user than the owner of the Oracle installation.

These enhancements improve security and portability of an application that uses external procedures.

### **New PL/SQL Package UTL\_CALL\_STACK**

The UTL\_CALL\_STACK package provides subprograms to return the current call stack for a PL/SQL program.

It is functionally similar to the existing DBMS\_UTILITY.FORMAT\_CALL\_STACK which returns information as a human-readable essay. This new package makes this information available in a structured representation amenable for programmatic analysis.

### **New PL/SQL Subprogram DBMS\_UTILITY.EXPAND\_SQL\_TEXT**

The DBMS\_UTILITY.EXPAND\_SQL\_TEXT subprogram accepts a subquery that references views and returns a subquery with the identical meaning that references only tables.

This functionality can help in the analysis of SQL which depends on views with the aim of fixing application logic or resolving performance issues.

### **New Predefined PL/SQL Inquiry Directives**

The \$\$PLSQL\_OWNER and \$\$PLSQL\_TYPE predefined PL/SQL inquiry directives are now supported in this release.

Through Oracle Database 11g Release 2 (11.2), the predefined inquiry directives, \$\$PLSQL\_LINE and \$\$PLSQL\_UNIT, allowed diagnostic code to identify the current PL/SQL statement, but with a certain ambiguity. This ambiguity is now removed.

### New SCHEMA Formal for DBMS\_SQL.PARSE()

DBMS\_SQL.PARSE() has a new formal SCHEMA. It specifies the schema in which to resolve unqualified object names.

This allows a definer's rights unit to control the name resolution for the dynamic SQL it issues.

For more information about PL/SQL, go to:

<http://www.oracle.com/technetwork/database/features/plsql>

## Oracle SQL Developer

Oracle SQL Developer is a no cost integrated development environment that simplifies the development and management of the Oracle Database. SQL Developer offers complete end-to-end development of your PL/SQL applications, a worksheet for running queries and scripts, a DBA console for managing the database, a reports interface, a complete data modeling solution, and a migration platform for moving your 3rd party databases to Oracle.

### Oracle SQL Developer Core Areas

**Development** - Using SQL Developer, users can browse, edit and create database objects, run SQL statements, edit and debug PL/SQL statements, build PL/SQL unit tests, run reports, and place files under version control.

**Database Administration** - With the DBA Navigator, DBAs can better manage their databases and maximize productivity and performance with SQL Developer's DBA utilities such as Database Diff and Database Copy as well as its graphical user interfaces for RMAN, Data Pump, Real Time SQL Monitoring, Explain Plan and Autotrace.

**Modeling** - Oracle SQL Developer Data Modeler is a graphical tool that enhances productivity and simplifies data modeling tasks. Using SQL Developer Data Modeler, users can create, browse and edit, logical, relational, physical, multi-dimensional, and data type models. The Data Modeler provides forward and reverse engineering capabilities and supports collaborative development through integrated source code control. Users can use Oracle SQL Data Modeler as a standalone tool or within Oracle SQL Developer.

**Migrations** - SQL Developer supports migrating 3rd party databases to Oracle. The tight integration capabilities provide users with a single point to browse database objects and data in third party databases, and to migrate from these databases to Oracle. SQL Developer supports IBM DB2 UDB LUW, Microsoft SQL Server and Microsoft Access, MySQL, Sybase Adaptive Server and Teradata.

For more information on migrating from another database to Oracle Database, please go to:

<http://www.oracle.com/technetwork/products/migration/index-084442.html>

### Benefits

Developed in Java, SQL Developer runs on Windows, Linux and Mac OS X. This is a great advantage to the ever-increasing numbers of developers using multiple platforms. Multiple platform support also

means that users can install SQL Developer on the same system as the database and connect remotely from their desktops, thus avoiding client-server network traffic. Default connectivity to the database is through the JDBC thin driver, so no Oracle Home is required. To install SQL Developer simply unzip the downloaded file. With SQL Developer, users can connect to any supported Oracle Databases including Oracle Express Edition. Users can create database connections for non-Oracle databases for object and data browsing and migration. SQL Developer is a supported product for all customers with Oracle Database Support contracts.

## Oracle Database 12c Support

Oracle SQL Developer Release 3.2 continues to support the latest Oracle Database 12c features.

**Oracle Multitenant** – Oracle Database 12c brings a new architecture to allow for many Pluggable Databases inside a single Oracle Database instance. Using SQL Developer, DBAs can connect to a 12c Database and create a Container Database to consolidate the Pluggable Databases. Full management capabilities such as creating, dropping, cloning, unplugging and syncing a Pluggable Database are available through easy to use wizards.

**SQL Translation Framework** – SQL Developer is the official Database Migration tool for Oracle. The introduction of the SQL Translation Framework in Oracle Database 12c allows for the support of migrating applications to Oracle. The SQL Translation Framework allows for minimal changes to the application code. The non-Oracle SQL will be sent unmodified to Oracle Database where the application SQL will then be recorded and translated. Users can review, tune and modify the translated SQL. The Translation Framework consists of the Translation profile to collect the translated statements and the SQL Translator, a Java compiler that translates the SQL. Using SQL Developer, users can create a SQL Translation Profile for each application and install a SQL Translator. SQL Developer supports Sybase and SQL Server translators.

**Oracle Data Redaction** – Part of the Oracle Advanced Security option in Oracle Database 12c, enables the masking of data that is returned from queries issued by low privileged users or applications. Different masking styles such as full, partial, random, and regular expressions can be applied to mask data. These masking styles are applied through a Redaction Policy. With SQL Developer, Redaction Policies are managed centrally. Policies can be created and applied to disguise any sensitive data.

You should always download the latest version of Oracle SQL Developer from the Oracle Technology Network (OTN). For more information about Oracle SQL Developer, go to:

<http://www.oracle.com/sqldeveloper>

## Oracle Application Express

Oracle Application Express (Oracle APEX) is a declarative, rapid web application development tool for the Oracle database. It is a fully supported, no cost option available with all editions of the Oracle database. Using only a web browser, you can develop and deploy professional applications that are both fast and secure.

Whether you are an experienced SQL and PL/SQL developer or a power user used to writing reports, wizards allow you to quickly build Web applications on top of your Oracle database objects. Enhancing and maintaining these applications is done using a declarative framework, all of which increases your productivity.

Oracle Application Express is database-centric and suited to building a vast array of applications. You can start with webifying a spreadsheet to facilitate collaboration or dive right into extremely complex applications with numerous external interfaces such as the Oracle Store. Because Oracle APEX resides within the Oracle Database and can easily integrate with authentication schemes (such as Oracle Access Manager, SSO, LDAP, etc.) you can build secure applications that can scale to meet your largest user communities.

Oracle Application Express provides four primary tools:

- Application Builder - to create dynamic database driven Web applications.
- SQL Workshop - to browse and maintain database objects, run ad-hoc SQL queries, as well as a graphical query builder. Utilities are provided to load and unload data, set user interface defaults, generate DDL scripts, and review various aspects of the database. RESTful Web Services provides stateless access to data and logic, through the use of SQL and PL/SQL using the Oracle APEX Listener 2.0 or later.
- Team Development - to manage software development projects using integrated features, to-dos, bugs, milestones and feedback.
- Administration – to manage the Application Express Workspace including managing the service, maintaining users, and monitoring activity.

With Oracle Application Express you can easily build applications that report on database data. Reports can be hypertext linked with other reports allowing users to navigate through database data in the same way they navigate Web sites. Columns in reports can be easily linked to other reports, charts and data entry forms. An extensive charting engine allows SQL queries to be represented graphically. Oracle Application Express is also very adept at editing database data and supports a large number of declarative form controls including radio groups, checkboxes, select lists, shuttles, text editors and date pickers.

Many organizations have experienced the proliferation of workgroup databases. These databases are created primarily because users need immediate solutions that they can control. Departments continuously create decentralized databases to solve tactical issues. Costs are driven up as hundreds of inefficient, ad-hoc databases are deployed. These databases often contain business critical data. They tend to have issues with security, sharing, data accuracy, and high availability. Unfortunately, users of these databases usually end up working against their IT organization.

The Oracle Application Express consolidated model provides decentralized development with centralized management. Customers can consolidate workgroup data and the application development service into Oracle Database 12c with Oracle Application Express. Developers maintain full control over application development while their IT organization provides professional data management. End users experience dramatically improved data access via modern Web based applications. Oracle

Database 12c ensures that Oracle Application Express applications are secure, reliable and scalable. The browser-based design time interface, declarative programming framework and simple wizards make Oracle Application Express a natural replacement for multi-user workgroup database applications such as Microsoft Access.

SQL-aware application developers with little or no Web development experience can easily create database applications with Oracle Application Express. You don't need to learn scripting languages or complex deployment frameworks, you simply write a few queries and choose from the provided set of user interface themes and form controls to create highly professional, secure, and scalable applications.

## Oracle Application Express 4.2 Key Features

Oracle Application Express 4.2, which is included with Oracle Database 12c, contains the following key features.

### **Interactive Reports**

Interactive Reports are very simple to write “SELECT \* FROM My\_Favorite\_Table”, but provide a very powerful reporting capability. End Users can manipulate the data by selecting columns, sorting, filtering, adding computations, highlights, aggregates and more. Then they can save the reports, download them or subscribe to the report.

### **Interoperate with Spreadsheets**

Application Express developers can readily build a wizard to allow end-users to upload spreadsheet data into an existing table. Rather than relying on the IT department to upload data into an existing table, this feature allows the end users to step through a simple wizard and upload data into an existing table, allowing end users to be more self-sufficient.

Alternatively, developers and power-users can easily create a complete CRUD application using the Create Application Wizard based on a spreadsheet. So instead of sending out a spreadsheet users can now build an application based on that data in minutes. They can then send out a URL so there is only a single source of truth and the data is securely stored in Oracle Database 12c.

### **Charting Capabilities**

Oracle Application Express includes a wide variety of “Flash-preferred” or HTML5 charts to visually show your data. When defined as “Flash-preferred”, if Flash is not available, such as on an iPad, then the chart will be rendered using HTML5. Maps can show country or state aggregates and you can also define project and resource Gantt charts.

### **Master-Detail and Tabular Forms**

The wizards within Application Express allow you to build pages within minutes for updating multiple records at once. Defining a Master-Detail page is as simple as selecting the parent table and then selecting the child table and the fields from each you want displayed. These multi-record constructs include the ability to quickly define row and column validations making it just as easy to validate rows as it is to validate a single record in a regular form page.

### **Dynamic Actions**

Incorporate rich client-side interactivity declaratively using Dynamic Actions. This feature enables developers to declaratively define client-side behaviors without needing to know JavaScript and AJAX. Developers use the simple wizards and declarative constructs to specify when to fire, what to do, and what to operate on. Replacing hand crafted JavaScript and AJAX with declarative definitions greatly improves the quality, consistency, and manageability of rich client-side interactivity.

### **Plug-Ins**

This feature enables development of and the ability to share custom item types, region types, processes, dynamic actions, plus authentication and authorizations schemes. This dramatically broadens the reach of Oracle Application Express applications and provides a library of custom features for Oracle Application Express. When developers require functionality not available with native components, this architecture allows them to extend their applications in a manner that is both supported and maintained. There are a number of plug-ins available from the Application Express development team and also over 120 available on APEX community sites.

### **Mobile Applications**

You have the ability to declaratively define mobile applications and mobile application components including HTML5 charts, HTML5 item types, and mobile calendars. You can develop applications with both desktop and mobile user interfaces together with automatic detection. The mobile applications are built using jQuery Mobile. Instead of building separate applications for different mobile operating systems (for example iOS, Android, Blackberry, and Windows), the same application can be run on any mobile device using a mobile browser.

Development of mobile applications uses the same builder and declarative framework as used for developing desktop applications. Therefore, mobile applications can be built very rapidly using the same SQL and PL/SQL skill set.

Application Express also includes HTML5 Charts and Calendars together with other HTML5 attributes such as optimized keyboard layouts for email, phone numbers and URLs.

### **Packaged Applications**

Oracle Application Express includes a number of packaged business applications, which are available free of charge, and are supported by Oracle. The productivity applications enable customers to improve their business processes and immediately start utilizing their Oracle Database 12c investment. There is also a collection of sample applications that have been designed to help developers quickly understand specific capabilities of Application Express.

The productivity applications are locked by default and can't be modified by developers. If you wish to modify a packaged application or simply review its implementation and learn best practices, you can easily unlock it. Once unlocked, the application is no longer supported by Oracle and can no longer be updated. You can always return to a supported version by removing the unlocked copy and re-installing the locked version.

## Websheets

Websheets are a different class of application development within Oracle Application Express, lowering the bar even further to manage data in an Oracle Database from a Web browser. Websheets are designed for business users rather than developers. They combine design and runtime into a common environment and is similar in operation to WIKIs. Using only a Web browser, end users can define pages, data grids and reports and then select the community that can see and edit the content.

The major difference between a WIKI and Websheets is that once you add data to a WIKI it becomes stale and dated, whereas with Websheets you can incorporate data elements directly into your pages.

Within a Websheet you can define data-grids ,which are spreadsheets stored in the database, define reports on tables, or write SQL directly against tables within your Oracle Database 12c schema.

Whenever a user accesses the Websheet page the data is now queried directly from the database.

You should always download the latest version of Oracle Application Express from the Oracle Technology Network (OTN). For more information about Oracle Application Express, go to:

<http://www.oracle.com/technetwork/developer-tools/apex/overview/index.html>

## .NET

Oracle offers four components that simplify .NET development with Oracle Developer Tools for Visual Studio, Oracle Data Provider for .NET (ODP.NET), Oracle Database Extensions for .NET, and Oracle Providers for ASP.NET. There is no charge for these components and they are easy to use for either the novice database programmer or the advanced programmer. These products fully support existing Microsoft standards, such as Entity Framework, and tools, such as Visual Studio, while also exposing powerful Oracle Database enterprise technologies, including Oracle Real Application Clusters (RAC) and Oracle Data Guard.

The Oracle Developer Tools for Visual Studio (ODT) is a tightly integrated "Add-in" for Microsoft Visual Studio. ODT is free and it is available for Visual Studio 2012, Visual Studio 2010, and Visual Studio 2008.

ODT makes developing .NET code for Oracle easy and fast, allowing developers to stay in Visual Studio for the entire development lifecycle. ODT makes it easy to browse and edit Oracle schema objects using integrated visual designers and can automatically generate .NET code via a simple drag and drop. Developers can easily modify table data, execute Oracle SQL statements, edit and debug PL/SQL code, automatically generate SQL deployment scripts using schema comparison tools and then check them into source control. Integration with Oracle Multitenant makes it easy for developers to clone databases and perform testing. The integrated context sensitive online help, including the Oracle SQL and PL/SQL Users Guides, puts Oracle Database documentation at your fingertips.

For more information about Oracle Developer Tools for Visual Studio, go to:

<http://www.oracle.com/technetwork/developer-tools/visual-studio>

ODP.NET features optimized data access to Oracle databases from a .NET environment. ODP.NET allows developers to take advantage of advanced Oracle Database functionality, including RAC and Data Guard; self-tuning and caching; XML DB and REF Cursor; and security features. ODP.NET gives programmers optimal performance, flexibility, and feature choice for .NET Framework and Oracle Database development. With it, developers bring Oracle's powerful data management capabilities to .NET. ODP.NET 12c natively supports .NET Framework 3.5 and higher.

For more information about ODP.NET, go to:

<http://www.oracle.com/technetwork/topics/dotnet/index-085163.html>

Oracle Database Extensions for .NET is a feature of Oracle Database 12c on Windows that makes it easy to develop, deploy, and run stored procedures and functions written in a .NET managed language, such as C# or VB.NET. .NET stored procedures or functions are developed using Microsoft Visual Studio and deployed using the tightly integrated .NET Deployment Wizard, which is a feature of the Oracle Developer Tools for Visual Studio. After deployment, a .NET stored procedure can be called from within .NET application code; from SQL or PL/SQL; from another .NET, PL/SQL, or Java stored procedure; from a trigger; or from anywhere else a stored procedure or function call is allowed.

For more information about Oracle Database Extensions for .NET, go to:

<http://www.oracle.com/technetwork/topics/dotnet/index-085095.html>

Oracle Providers for ASP.NET are a collection of data services that follow the ASP.NET provider model and use Oracle Database as the data source. Developers store web application state, such as shopping cart or user information, in a persistent Oracle database. ASP.NET developers are now more productive as they build their Web applications through ASP.NET services and controls that are part of the .NET Framework. By simply configuring the Oracle Providers for ASP.NET as default providers in a configuration file, ASP.NET applications can store various types of application states in an Oracle database. Oracle offers the following providers: Membership, Role, Site Map, Session State, Profile, Web Event, Web Parts Personalization, and Cache Dependency.

For more information about Oracle Providers for ASP.NET, go to:

<http://www.oracle.com/technetwork/topics/dotnet/index-087367.html>

## .NET Key New Features

### **ODP.NET, Managed Driver**

ODP.NET 12 introduces a new fully managed provider version, containing 100% native .NET code. ODP.NET, Managed Driver includes nearly all the features of ODP.NET, Unmanaged Driver and uses the same application programming interface. This makes migrating existing ODP.NET applications to ODP.NET, Managed Driver simple.

With ODP.NET, Managed Driver, it is easier and faster to deploy ODP.NET. There are fewer assemblies, as few as one to deploy, which also makes patching straightforward. The install size is smaller at less than 10 MB. Only one ODP.NET, Managed Driver assembly is necessary whether you are using 32-bit or 64-bit .NET Framework. Side-by-side deployment with other ODP.NET versions is

simple since there are no unmanaged assemblies to account for. As a fully managed provider, ODP.NET can better integrate with .NET Code Access Security and ClickOnce deployment.

### **Oracle Multitenant**

ODT and ODP.NET are seamlessly integrated with Oracle Multitenant allowing developers to easily and quickly clone databases for use during development and testing. These pluggable databases can be viewed and managed directly from Server Explorer in Visual Studio with operations such as "Clone", "Plug" and "Unplug" among others. ODP.NET works out of the box with PDBs, requiring no code changes to use them in .NET.

### **Schema Compare Tools**

ODT introduces Schema Compare tools integrated within Visual Studio. These tools allow developers to detect changes between individual Oracle schema objects or entire schemas. When it comes time for deployment, these tools can be used to generate a deployment ("diff") script to upgrade the target database to include the new schema changes required.

### **Transaction Guard – High Availability**

Transaction Guard preserves transaction outcomes during planned and unplanned outages so that every transaction outcome can be made known to the ODP.NET application. This prevents applications from re-committing the same transaction. Following an outage, ODP.NET returns the `OracleException.IsRecoverable` property indicating whether the transaction is recoverable. If recoverable, ODP.NET can retrieve a logical transaction identifier to determine the last open transaction's outcome status. The transaction status allows .NET applications to proceed recovering transactions with a clear plan.

Planned outages are now possible to undertake without disrupting end users. Databases can be brought offline more quickly by communicating its planned outage status to ODP.NET applications. ODP.NET then removes idle pool connections and disallows new connections to these databases.

### **Global Data Services – High Availability and Performance**

With Global Data Services, ODP.NET applications can extend RAC's automatic workload management capabilities to their Active Data Guard and Oracle GoldenGate instances. .NET applications can utilize all available global database resources to improve performance and availability.

### **Entity Framework and Language Integrated Query – SQL APPLY**

ODAC 11.2 Release 4 introduced Entity Framework and Language Integrated Query (LINQ) integration with ODT and ODP.NET. LINQ is translated into native database SQL before it can query the database. In some circumstances, LINQ uses the non-standard APPLY keyword in SQL for retrieving lateral views. Oracle Database and ODP.NET support the APPLY keyword in Oracle Database 12c to more fully support LINQ.

### **Ease of Development**

Oracle Database 12c and ODP.NET 12c support new ease of database development features:

- Auto Increment Identity Column – Simplifies .NET development for data having no natural primary key.
- Larger VARCHAR2, NVARCHAR2, and RAW Data Types – Each data type now stores up to 32 KB in data size.
- Boolean Data Type – ODP.NET data type, OracleBoolean, maps to the new database PL/SQL Boolean data type.
- Enhanced Implicit REF Cursor Binding – Retrieves stored procedure result sets implicitly without a declared return type, except in the case of Entity Framework and user-defined types.
- Returning Row Counts from Array Binding – When executing multiple parameter array-bound DML statements, ODP.NET now returns the number of rows affected for each array input value

## Globalization Support

Oracle Database 12c delivers enriched globalization support by introducing a set of new features that facilitate the deployment of databases in the Unicode® character set and the development of multilingual, standards-compliant enterprise applications. Oracle recommends a Unicode-based system architecture which enables the storage, processing, and retrieval of character data in any languages. The new built-in database capabilities offer enhanced usability and industry compatibility in building a complete Unicode solution that meets your business requirements.

### Globalization Support New Features

#### Unicode 6.1 Support

Unicode Standard defines the universal character set for encoding characters used in most of the writing systems of the world. It provides a uniform representation of textual information independent of platform or programming language. Oracle has been supporting the Unicode character sets since Oracle 7. In Oracle Database 12c, this support has been updated to include version 6.1 of the Unicode Standard.

#### Unicode Collation Algorithm (UCA) Conformance

Unicode Collation Algorithm (UCA) is a Unicode standard for determining the linguistic order of Unicode strings. The UCA defines a Default Unicode Collation Element Table (DUCET) that supplies a reasonable default collation for all Unicode characters. The DUCET is also customizable to accommodate the special ordering of specific languages. The UCA is fully compatible with the international collation standard ISO 14651 but offers extended features and flexibility in the collation behavior.

Oracle Database 12c introduces UCA support in addition to the existing database monolingual and multilingual linguistic collations. Oracle's implementation of UCA is compliant with Unicode Standard 6.1. The main features include:

- Full collation ordering based on Unicode 6.1 DUCET

- Multilevel comparison algorithm up to 4 collation levels
- Configurable options for sorting variable weighting characters (spaces, punctuations, symbols)
  - Blanked
  - Non-ignorable
  - Shifted
- 12 tailored language-specific UCA collations for Spanish, Traditional Spanish, Canadian French, Danish, Thai, Simplified Chinese (pinyin, stroke, radical), Traditional Chinese (stroke, radical), Japanese, and Korean

The linguistic operations involve transforming the character data into binary values called collation keys before evaluating the relative order. As the collation keys are represented in Oracle with the RAW data type, you can now sort longer text with higher precision in Oracle Database 12c since the maximum length limits of the VARCHAR2, NVARCHAR2, and RAW data types have been extended to 32767 bytes.

#### **New Locale Coverage**

As part of the continued effort to expand the scope of globalization support and address fast evolving customer requirements, Oracle Database 12c has introduced a set of 12 new languages and 32 new territories to supported database locales, covering additional regions of Asia, Africa, Americas, and Europe:

- New languages – Amharic, Armenian, Dari, Divehi, Khmer, Lao, Latin Bosnian, Maltese, Nepali, Persian, Sinhala, Swahili
- New Territories – Afghanistan, Armenia, Bahamas, Belize, Bermuda, Bolivia, Bosnia and Herzegovina, Cambodia, Cameroon, Congo Brazzaville, Congo Kinshasa, Ethiopia, Gabon, Honduras, Iran, Ivory Coast, Kenya, Laos, Maldives, Malta, Montenegro, Nepal, Nigeria, Pakistan, Paraguay, Senegal, Serbia, Sri Lanka, Tanzania, Uganda, Uruguay, Zambia

Moreover, it also includes the support for Ethiopian calendar, a calendar system based on the Coptic calendar with a 13th month of either 5 or 6 days in length.

#### **Database Migration Assistant for Unicode (DMU)**

Migrating to the Unicode character set is an intricate process that involves many different operational aspects which can be both time-consuming and resource intensive. Any misstep along the way can lead to data loss and serious business consequences. Oracle Database Migration Assistant for Unicode (DMU) is a next-generation migration tool that streamlines the entire migration process with an intuitive GUI to minimize the DBA's manual workload and decision-making. It helps ensure all migration issues are addressed beforehand and the conversion of data is carried out correctly and efficiently. The DMU migration workflow covers:

- Enumeration - auto-identification of database objects containing textual data that requires conversion

- Scanning - comprehensive assessment of migration feasibility and discovery of potential data issues
- Cleansing - sophisticated toolsets for iterative data analysis and cleansing to ensure data safety
- Conversion - automated in-place data conversion to minimize time and space requirements

The DMU also goes beyond helping migration to the Unicode character set by providing the capability to conduct ongoing health check of your post-migration database to maintain data compliance with the Unicode Standard. Even with a database that uses the Unicode character set, incorrectly configured applications may introduce invalid character codes into the database and cause data corruption. The DMU's Validation Mode feature can help expose the source of the issues and detect data problems before these issues are noted by end-users.

The DMU was first released in April 2011 on OTN as a free downloadable product. The latest DMU version 1.2 is bundled with Oracle Database 12c and is the officially supported method for migrating databases to the Unicode character set. The DMU also supports migrating selected prior database releases of 10.2, 11.1, and 11.2. The legacy command-line utilities CSSCAN and CSALTER have been desupported.

An added benefit of performing the migration in Oracle Database 12c is that the new extended VARCHAR2 type limit of 32767 bytes guarantees any VARCHAR2 column with the pre-12.1 limit of 4000 bytes or less can just be lengthened to accommodate longer values resulting from data expanding in conversion to Unicode. Neither truncation nor migration to the CLOB data type is now necessary for such columns.

## Conclusion

Oracle Database 12c delivers a highly productive and powerful set of application development tools supporting the most popular development technologies including Oracle APEX, PL/SQL, SQL, C, C++, Java, .NET, PHP, Perl, Python and Ruby. Oracle Multitenant and Oracle Database Cloud Service make it easy for application developers to create applications for the Cloud. Transaction Guard and Application Continuity take application availability and reliability to an extraordinary high level.

Migrating to Oracle Database is easier than ever with the addition of 32K VARCHAR, NVARCHAR, and RAW datatypes and Auto-Increment (IDENTITY) columns. The SQL Translation Framework and the Driver for MySQL applications greatly reduce the amount of effort required to migrate applications to Oracle Database. Other migration support features include: Enhanced SQL to PL/SQL Bind Handling, and Native SQL Support for Query Row Limits and Row Offsets.

Oracle Application Express is a unique Web application development tool that is ideal for rapidly building desktop and mobile applications using Oracle Database. Oracle SQL Developer Data Modeler supports logical or conceptual modeling (including multi-dimensional modeling for Business Intelligence), relational database modeling and the final detailed physical implementation. Oracle SQL Developer provides a graphical work environment for the Oracle Database that increases database developer productivity and eases migrations from other databases to Oracle Database.

Oracle Database's .NET components support the latest .NET features including Entity Framework and Language Integrated Query as well as Oracle Database 12c features such as Oracle Multitenant and Transaction Guard.

The new globalization support features in Oracle Database 12c enable the development of database applications that conform to the Unicode Standard 6.1. The Unicode Collation Algorithm (UCA) implementation supports the industry standard multilingual collation with flexible capabilities. The additional database locale coverage further expands the application localization support to provide behaviors that match local users' cultural conventions. The Oracle Database Migration Assistant for Unicode (DMU) significantly reduces the downtime, lowers the costs, and simplifies the tasks of migrating databases to the Unicode character set.

Collectively these tools simplify your development tasks, reduce costs and enable your organization to reduce application development time. Oracle Database 12c introduces new and innovative features which allow you to create secure, highly available, high performance applications.



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**Hardware and Software, Engineered to Work Together**