ORACLE DATABASE 12c

Unstructured Data Management with Oracle Database 12*c*

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ORACLE

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Introduction

The successful operation of corporations, enterprises, and other organizations relies on the management, understanding and efficient use of vast amounts of unstructured data and information often referred to as Big Data that may come from social media, web content, sensors and machine output, XML, and documents. Traditional business applications – finance, order processing, manufacturing, and customer relationship management systems that easily conform to standard data structures (such as rows and columns with well defined schema) also contribute to Big Data analysis. Increasingly, deriving business value and successful operations depend on management, analysis and understanding of information that is not readily accessible without human or machine based interpretation. Common examples range from documents, XML, multimedia content, and web content to specialized information such as satellite and medical imagery, maps and geographic information, sensor data, and semantic web structures.

In the context of database systems, Oracle has been supporting Unstructured Data for over a decade. Big Data workflow involves many technologies to acquire, organize, analyze and perform discovery and decision making, and Oracle Database 12*c* includes a wide range of capabilities that allow for intelligent management and support deep analytics of these forms of Unstructured Data.

With Oracle Database 12*c* we have focused dramatic performance improvements for Unstructured Data query and analysis, improved integration of these data type with other features in Oracle Database and moved more of the application logic and analytics associated with specific data types and analysis into the database to simplify application code.

The ways in which these types of Unstructured Data are managed in Oracle Database 12*c* vary based on how the data is created and used:

- Huge volumes of data in desktop office systems (documents, spreadsheets and presentations) and specialized workstations and devices (geospatial analysis systems and medical capture and analysis systems)
- Multi-terabyte archives and digital libraries in government, academia and industry
- Image data banks and libraries used in life sciences and pharmaceutical research
- Public sector, telecommunications, utility and energy geospatial data warehouses
- Integrated operational systems including business or health records, location and project data, and related audio, video and image information in retail, insurance, healthcare, government and public safety systems
- RDF semantic data (triples) used in academic, pharmaceutical and intelligence research and discovery applications

Unstructured Data Management Capabilities

For decades now, Oracle database technology has been used to address the unique problems encountered when managing large volumes of all forms of information. Databases are often used to catalog and reference documents, images and media content stored in files through "pointer-based" implementations. To store this unstructured data inside database tables, Binary Large Objects, or BLOBs have been available as containers. Beyond simple BLOBs, Oracle Database has also incorporated intelligent data types and optimized data structures with operators to analyze and manipulate XML documents, multimedia content, text, and geospatial information. With Oracle Database 12*c*, Oracle is once again breaking new ground in the management of this information through dramatic performance improvements and by driving more application-level processing into the database server.

There are many reasons organizations store all forms of information in their Oracle database.

- Robust Administration, Tuning and Management: Content stored in the database can be directly linked with associated data. Metadata and content are maintained in sync; they are managed under transactional control. The database also offers robust services for backup, recovery, physical and logical tuning.
- Simplicity of Application Development: Oracle's support for a specific type of content includes SQL language extensions, PL/SQL and JAVA APIs, and, in many cases, JSP Tag Libraries, as well as algorithms that perform common or valuable operations through built in operators. For certain content, Oracle Database includes specific query languages such as Xquery for XML, SPARQL for RDF graphs, DICOM access commands for medical imagery, and file system operations for unstructured data accessed through Oracle DBFS.
- High Availability: Oracle's Maximum Availability Architecture makes "zero data-loss" configurations possible for all data. Unlike common configurations where attribute information is stored in the database with pointers to unstructured data in files, only a single recovery procedure is required in the event of failure.
- Scalable Architecture: In many cases, the ability to index, partition, and perform operations through triggers, view processing, or table and database level parameters allows for dramatically larger datasets to be supported by applications that are built on the database rather than on file systems.
- Security: Oracle Database allows for fine-grained (row level and column level) security. The same security mechanisms are used for all forms of information. When using many file systems, directory services do not allow fine-grained levels of access control. It may not be possible to restrict access to individual users; in many systems enabling a user to access any content in the directory gives access to all content in the directory.

Oracle Database 12*c* Support for Unstructured Data

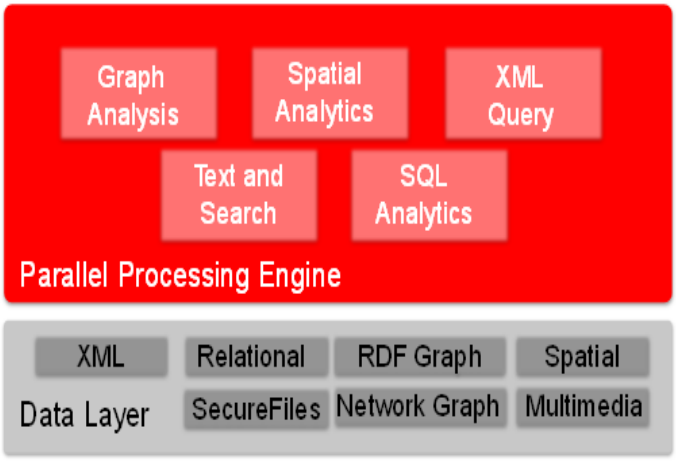
There are 5 aspects to Oracle Database 12*c* support for unstructured data:

- Storage – Oracle Database 12c allows you to store and query unstructured data efficiently – with highly efficient compression and, in many instances, query languages, semantics, and other mechanisms designed for specific data types.
- Data types – Oracle Database 12c supports specialized data types for many common forms of unstructured data. This enables application developers, development tools and database utilities to interact with unstructured data with the same ease as with standard relational data.
- Management – Because unstructured data is stored in Oracle Database 12c, managing unstructured data can use the exact same administrative, monitoring and management features as any other database content.
- Indexing – To enable high performance querying, Oracle Database 12c has specialized indexes to access many types of unstructured data. These include XML, Text, RDF Graph, and Spatial indexing.
- In-database analytics specific to many types of unstructured data including operators and functions relevant to the data type.

Faster, More integrated Unstructured Data Capabilities

When Oracle first introduced support for unstructured data nearly 15 years ago, the key benefits were development simplicity and extending the availability, manageability and security of Oracle database to applications where unstructured data was essential to business operations. Database features like domain indexes, partitioning, and parallelism make geospatial applications, graph analysis and query and update-intensive XML applications perform better with content stored in the database than with content stored inside traditional file systems.

With SecureFile LOBs, Oracle addressed the performance and storage issues that occurred with some forms of unstructured data in the database to give at least parity and in many cases leadership over file-based alternatives for handling images, audio, video and binary data. SecureFiles is a high-performance storage feature that enables storage and retrieval of LOBs at speeds equal or superior to that of equivalent file system configurations. SecureFiles is the default LOB data type for Oracle Database 12*c*.

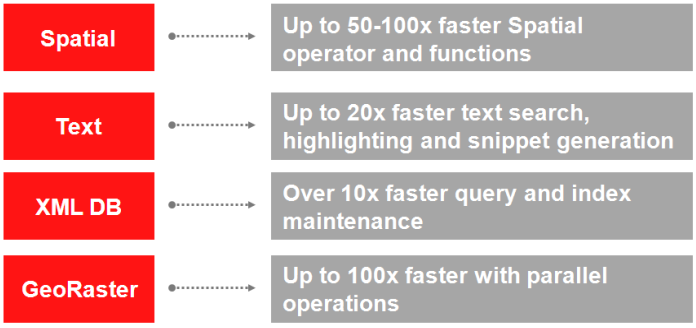


Specialized Data Types and Data Structures

In the same way that database management systems include data types, storage and index structures, and operators to allow for meaningful query and analysis of structured data, they require these elements to add value when managing unstructured data. These features of Oracle Database 12*c* offer unique advantages specific to the management of XML, Text, Spatial, Network Data Model graphs and RDF Semantic graphs, and Multimedia and DICOM data.

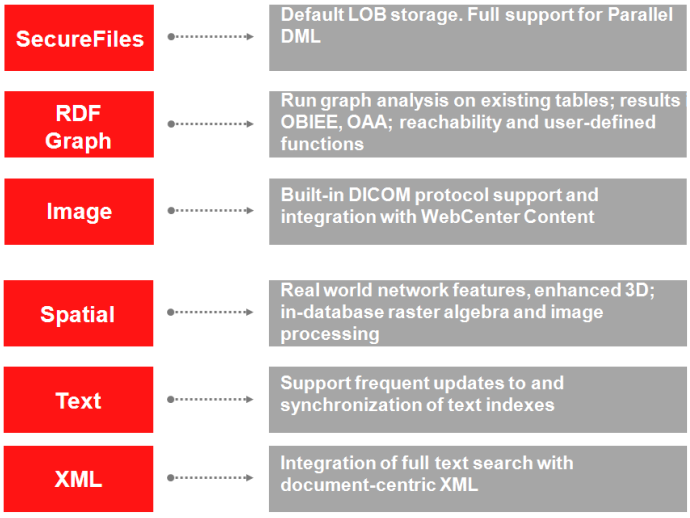
Oracle Database 12c primarily focuses on two aspects: dramatically faster performance for unstructured data analysis and moving more application logic and analytics into the database. This enables analysis on dramatically larger datasets, simplifies application code, and will allow applications to take better advantage of Oracle Exadata and other engineered systems.

Improved Performance



Simplified Application Development

Tight Integration with Database and Tools



Oracle Spatial and Graph (formerly Oracle Spatial)

Oracle Spatial and Graph, an Oracle Database Enterprise Edition option offers customers comprehensive spatial database capabilities, including native support for vector and raster data, topology and network models, 3D data, geocoding, routing, and OGC-standard Web Services. In addition, Oracle Spatial and Graph includes support for RDF semantic graphs used in social networks and linked data applications for research, health sciences, finance, media and intelligence applications. It also includes Network Data Model (NDM) graphs used in traditional network applications in major transportation, telcos, utilities and energy organizations. These are proven, robust graph database technologies.

Spatial features in Oracle Spatial and Graph

The spatial capabilities in Oracle Spatial and Graph deliver a comprehensive spatial database offering, including the highest performance native support for vector and raster analysis operations, topology and network models, 3D data, geocoding, routing, and OGC-standard Web Services. It is designed to meet the advanced geospatial requirements of business and government applications such as business intelligence, land management, utilities, defense, and homeland security. With open native spatial support, Oracle Spatial and Graph eliminates the cost and complexity of separate, proprietary systems while enabling the use of all leading GIS tools. This extends Oracle's industry-leading security, performance, scalability, and manageability to mission critical spatial assets.

In Oracle Database 12*c*, Oracle Spatial and Graph option introduces:

- Up to 50 to 100 times performance improvement for common spatial query and analysis functions and operators through Vector Performance Acceleration. While Oracle Spatial and Graph functions and operators currently perform as fast or faster than other spatial database analytics, with vector performance acceleration invoked, spatial join, touch, contains, overlaps, and complex mask operations can now be 50, and in some cases, 100 times faster. Relate, DML operations and single inserts, and coordinate transformation performance are also improved substantially.
- Parallel Raster operations, support for in-database raster algebra, and virtual mosaic support in the GeoRaster feature. The GeoRaster features now enable more image processing to be performed inside Oracle Database. They support on-the-fly creation of virtual mosaics from heterogeneous image formats and raster algebra operations that work on individual raster cells, or pixels to allow Oracle Spatial and Graph to generate new maps from two or more raster layers. Raster algebra operations enable applications to implement sophisticated analytical algorithms, such as a Normalized Difference Vegetation Index (NDVI), and TCT (Tasseled Cap Transformation). Raster operation performance is also substantially faster and can be parallelized to scale to 100s of times faster for large data sets.
- Support for parametric curves or Non-uniform rational B-splines (NURBs) used in design and transportation applications. These simplify the management and editing of curves represented in Oracle Spatial and Graph.
- The ability to model real world features natively in the Network Data Model graph as well as support to incorporate traffic pattern data and perform multi-modal analysis on networks.
- The 3D and Point Cloud capabilities now have dramatically increased scalability for multisession point cloud creation and provide a considerable savings of storage space, pyramiding support for Point Cloud and TIN data, contour generation from Point Cloud data, and support for 3D geodetic calculations and distance calculations for 3D segments.

RDF Semantic Graph features in Oracle Spatial and Graph

As part of Oracle Spatial and Graph, Oracle delivers advanced RDF Semantic Graph data management and analysis. With native support for World Wide Web Consortium (W3C) standards – the Resource Description Framework (RDF) and Web Ontology Language (OWL) are standards for representing and defining semantic data and SPARQL is a query language designed specifically for graph analysis – application developers benefit from the industry's leading open, scalable graph data platform and its fine-grained security. Graphs are central to a new category of social network and linked data applications common in health sciences, finance, media and intelligence communities.

Application developers can add meaning to data and metadata by defining a set of terms and the relationships between them. These sets of terms ("ontologies") enable query, analysis and actions based on semantic content, rather than simply data values. Ontologies are increasingly used to build applications that utilize domain-specific knowledge. Ontological data sets, often containing 100s of millions of data items and relationships, can be stored in groups of three, or "triples" using the RDF data model. Oracle enables scaling to billions of triples to meet the needs of the most demanding applications.

RDF graph analysis enables discovery of relationships across data sets and documents and integration and access by applications to systems with disparate metadata.

In Oracle Database 12*c*, Oracle Spatial and Graph option introduces:

- RDF Views on Relational Tables removing the need to duplicate data and the associated storage previously required to perform RDF graph queries on relational data sets. Semantic graph queries on RDF views can integrate relational data and RDF Semantic Graph triple data stored in Oracle. Semantic queries on these views can be written in the SPARQL query language or by embedding SPARQL in an Oracle SQL SEM_MATCH table function.
- RDF Semantic Graph "Named Graph" support as defined by the World Wide Web Consortium (W3C).
- Support for Analytic Operations and Tools. RDF Semantic Graph now supports SPARQL 1.1 path expressions for simple and complex paths. RDF Semantic Graph can also be used in conjunction with the Network Data Model Java API to provide fast in-memory graph analytics, including shortest path, reachability, within-cost, and nearest-neighbor analysis of RDF graphs. Results from graph queries can be materialized as views for use with Oracle Advanced Analytics to enable the use of Oracle Data Mining clustering, classification, regression, anomaly detection, and decision tree algorithms as well as Oracle R Enterprise algorithms.
- RDF Semantic Graph support for XML Schema, Text and Spatial Data Types to add, drop, and alter data type indexes and to enable the filtering of semantic queries written in SPARQL or SQL using XML schema, text, and spatial attributes.
- RDF Semantic Graph document indexing Enhancements:
  - Batch indexing of documents.
  - Flexible framework for managing entity extraction engines and associated rules.
  - Local partitioned indexing.
  - Operator to calculate the relevance of found documents.

Oracle XML DB

XML has been widely adopted in just about every industry. XML based standards can be found in the Health-care, Manufacturing Financial Services, Government and Publishing sectors. The introduction of XML-based standards, such as XBRL, has led to XML becoming the de-facto mechanism for exchanging information among application systems. This has led to a growth in the use of XML as a persistence model for mission critical data.

To meet this need, Oracle developed Oracle XML DB. This is a high-performance, native XML storage and retrieval technology that is delivered with all versions of Oracle Database. It provides full support for all of the key XML standards, including XML, Namespaces, DOM, XQuery, SQL/XML and XSLT. Oracle XML DB is the first platform to deliver true hybrid relational / XML capabilities, making it possible to bring the full power of the SQL language to bear on XML content and the full power of the XML paradigm to relational data.

Oracle Database 12*c* extends its industry leading XML support ensuring that Oracle Database remains the best platform for storing, managing and querying all possible types of XML content. Features in Oracle Database 12*c* offer improved performance and scalability and enable complete support for the flexibility that makes the XML data model so attractive to so many different organizations.

Oracle Database 12*c* offers a number of improvements for users of Oracle XML Database. We have continued to enhance our support for the XML Developer by extending our XQuery implementation to include:

- Support for XQuery Update, allowing users to efficiently update large XML Documents by performing fragment and node-level modifications using the W3C Query language.
- Support for XQuery Full-Text Specification, allowing document centric applications to take full advantage of full text searching and indexing.

» Support for XQuery API for Java (XQJ) as an API which is the Java Specification Request (JSR) for executing XQuery statements from Java programs.

Oracle Database 12*c* also includes on-going improvements to core Oracle XML DB features:

» Over 10x faster query and index maintenance.

» Extended Partitioning Support for Binary XML Storage and Indexing

» Oracle XML DB and domain index support of hash tables.

» Repository has been enhanced to support digest authentication, provide more robust security for users using HTTP to access content stored in the database.

» Repository now allows WebDAV, HTTP, and FTP to be used to access content stored in DBFS.

Oracle XML Developer's Kit (XDK) is a versatile set of components that enables you to build and deploy C, C++, and Java software programs that process XML. You can assemble these components into an XML application that serves your business needs. Oracle XML Developers Kit has been enhanced to provide:

» Oracle XDK/J DOM improvements that add support for W3C DOM Level 3 Core API's and reduces the memory footprint associated with using XML schemas.

» Integrated Oracle XQuery Implementation to unify the Oracle and BEA XQuery engines creating a single Java-based XQuery engine.

» Oracle XSLT/XPath engine interoperability to enable the use of non-XDK-based data models with the Oracle XDK/J XSLT/XPath engine, which supports interoperability between these Oracle engines and third-party XML processors.

» A Standalone XQuery Virtual Machine, allowing High performance XQuery operations to be performed on XML content stored outside the Oracle Database.

Oracle Text

Oracle Text is the leading text searching, retrieval and management system to be integrated into a database environment. With Oracle Database 12*c*, Oracle Text introduces many new features that improve index and query performance and improve usability.

These new features include:

» Near real-time indexing to support applications with frequently updated indexes. Recently changed index information remains in memory and can be periodically moved into the main index.

» Improved performance for highlighting and snippet generation by storing a tokenized and compressed version of the document in the Oracle Text index removing the need to access, filter and tokenize the original document.

» Native support of snippet information from the result set interface provides faster, easier to maintain, more highly available and more flexible applications.

» Improved performance with BIG_IO large TOKEN_INFO option that avoids the need to do many seeks when loading large TOKEN_INFO data items from disk.

» Query Filter Cache feature allows you to cache the results of a particular query, or part of a query, and use those results to filter future searches resulting in better performance for queries that have components shared with other queries.

» The number of MDATA sections allowed is now effectively unlimited. The previous maximum was 100.

» Indexes can be modified to reflect new business requirements without having to rebuild the index from scratch. The value of an SDATA item may be updated without requiring reindexing of all the data in that row and the maximum number of SDATA sections has been increased from 32 to 99.

» Increased number of field sections from 64 to an almost unlimited number (10,000+) of field sections.

Oracle Multimedia

Oracle Multimedia is a feature that enables Oracle Database to store, manage, and retrieve images, audio, video, or other media data in an integrated fashion with other enterprise information. Oracle Multimedia extends Oracle Database reliability, availability, and data management to multimedia content in traditional, Internet, electronic commerce, and media-rich applications.

Oracle Multimedia also supports SecureFiles to dramatically improve performance and significantly strengthen the native content management capabilities of Oracle Database. The size limit for individual media objects that can be stored and retrieved within database storage structures (BLOB) is 128 terabytes.

In addition to storing and retrieving large images, Multimedia can also extract image attributes including height, width, and compression format for images that contain up to two billion pixels, or with a resolution of up to 46000x46000.

Enhanced support for DICOM Medical Content Management

DICOM (Digital Imaging and Communications in Medicine) is a standard for handling, storing, printing, and transmitting information in medical imaging. It includes a file format definition and a network communications protocol. Oracle Database 12*c* includes features and delivers the performance necessary to build large-scale repositories and archives of DICOM format medical images. By extending Multimedia to store image, audio and video using SecureFiles in Oracle databases, all the security, performance and management tools that have made Oracle Database the standard for enterprise class databases are now available for huge archives of media objects as well.

Specifically for medical image applications, Oracle Database provides methods to:

- Convert images to formats useful in web applications to simplify development of visually oriented applications.
- Extract both standard and private metadata for indexing.
- Validate that the metadata conforms to the DICOM standard and/or user -and vendor-specific extensions of the standard.
- Remove all private patient data to create anonymous images for research or training.
- Create new images with corrected metadata.
- Create DICOM format images from non-DICOM images.

Oracle Database 12*c* offers a number of improvements for DICOM support:

- DICOM Protocol Support for Oracle Database. While Oracle Multimedia has supported the management of Digital Imaging and Communications in Medicine (DICOM) format data types since Oracle Database 11g, Oracle Database 12*c* now has support for the DICOM protocol to allow DICOM applications and devices to easily access DICOM data in Oracle Database enabling storage and management of DICOM content as part of a clinical workflow.
- DICOM content can now be stored in and accessed from Oracle WebCenter Content to simplify the development and management of image-enabled patient portals, referring physician portals, electronic medical records (EMRs), and life sciences research applications.
- Oracle Multimedia now supports full mode database export and import using Oracle Data Pump with Oracle Multimedia DICOM data model.

Oracle SecureFiles

SecureFiles is designed with a completely new approach to how the database handles file data, and delivers file system-like performance for basic query and insert operations. The optimized algorithms in SecureFiles make it up to 10x faster than previous LOB support (now called BasicFiles). SecureFiles can take advantage of several advanced Oracle Database capabilities that are not possible with file systems:

- In an Oracle Real Application Clusters environment, SecureFiles offers high levels of scalability that go far beyond what is offered in file systems
- SecureFiles allows for easy migration from older LOBs using Online Table Redefinition without affecting existing applications
- Applications no longer have to deal with multiple interfaces for manipulating relational and associated file data
- With SecureFiles, all information can be part of a database transaction, freeing the application from the complexity of guaranteeing atomicity, read consistency and other backup and recovery requirements
- SecureFiles also extends Transparent Data Encryption (TDE) capability to LOB data. The Oracle database supports automatic key management for all LOB columns within a table and transparently encrypts/decrypts data, backups and redo/undo log files.

Storage Optimization in SecureFiles

Also available with SecureFiles are advanced file system features such as Deduplication and Compression. Deduplication eliminates multiple, redundant copies of SecureFiles data and is completely transparent to applications. Oracle Database automatically detects multiple, identical SecureFiles data and stores only one copy, thereby saving storage space. Deduplication simplifies storage management resulting in significantly better performance, especially for copy operations.

SecureFiles data can be compressed using industry standard compression algorithms resulting in significant savings in storage and improved performance. Oracle Database automatically determines if the SecureFiles file is compressible or if compression savings are beneficial. SecureFiles uses a server-wide default LOB compression algorithm and provides for varying levels of compression. Each compression level represents a tradeoff between compression factor and speed. Organizations can choose the compression level which best suits their needs based on storage and CPU usage constraints. SecureFiles files are compressed and uncompressed automatically, transparent to applications.

Both Deduplication and Compression are part of the Advanced Compression Option, a separately licensed database option available with Oracle Database 12c.

New Features in SecureFiles with Oracle Database 12*c*

- Parallel DML Support for SecureFiles LOBs is enhanced, providing improved performance.
- SecureFiles LOB is the default storage option for LOBs, instead of BasicFiles LOB.
- The maximum size of SQL data types VARCHAR2, NVARCHAR2, and RAW change respectively from 4,000 bytes and 2,000 bytes to 32,767 bytes each. The corresponding PL/SQL data types remain at 32,767 bytes.
- Data Pump uses SecureFiles as default LOB storage. When you import tables, you can recreate all LOB columns as SecureFiles LOBs, thus converting BasicFiles LOBs to SecureFiles LOBs as part of data pump imports.
- SecureFiles supports components that enable HTTP, WebDAV, and FTP access to DBFS over the Internet, using various XML DB server protocols

Files in the Database Reinvented

Through the combination of SecureFiles high performance file storage, and the implementation of simple file system interfaces to files stored in the database, Oracle has enabled existing file based tools to access database files. Oracle Database File System (DBFS) provides familiar file access through pathnames, directories, and links. These files are kept in a dedicated SecureFiles store, or may be stored as SecureFiles LOBs in existing application tables. With DBFS, storing business data files inside the database is now simpler, faster, and more robust than storing them outside the database.

Oracle Database File System (DBFS)

DBFS provides a client for Linux that allows the mounting of DBFS file systems on Linux hosts, similar to a standard Network File System (NFS) mount, allowing applications to make normal file system calls. The Linux FUSE module forwards file system calls to the DBFS client executable, which makes remote calls to DBFS "Stores" in the database.

Oracle Database comes with two built-in Store Providers: DBFS SecureFiles Store and DBFS Hierarchical Store (or HSM). The DBFS SecureFiles Store utilizes a table with a SecureFiles column to store the file system data. It implements POSIX-like capabilities. The DBFS Hierarchical Store allows files to be written to any tape storage units supported by Oracle Recovery Manager (RMAN) or to a cloud storage system.

DBFS also has a client component called dbfs_client, which provides a command interface to allow files to be easily copied in and out of the database from any host on the network. It implements simple file system commands like list and copy in a manner that is similar to the Linux shell utilities ls and rcp. The command interface creates a direct connection to the database without requiring an OS mount of DBFS.

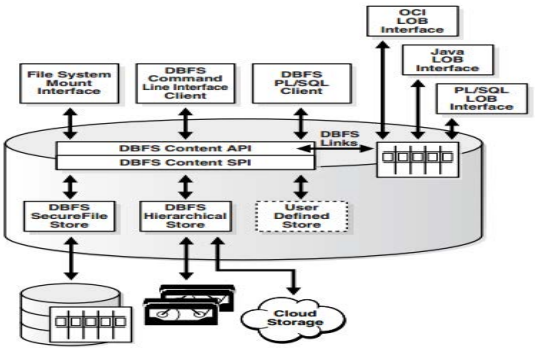
One key advantage of DBFS is that it can use Oracle Real Application Clusters (RAC) to deliver high availability and scalability beyond what is available with traditional file systems. For seamless scalability, RAC allows for additional processing and storage resources to be added to the system without disrupting applications. In the event of a failure, Oracle RAC transparently redirects file access to alternate RAC instances.

DBFS Store API

DBFS uses an API referred to as the DBFS Store API. This API includes Create and Delete file operators for directories and links, Get/Put to read and write LOBs and attributes of existing file paths, Directory operations, Locking operations, and Snapshot creation. The DBFS Store API offers strong support for storage of metadata associated with files and transactional file system operations.

Developers can build file system implementations in the database by writing a PL/SQL package matching the DBFS Store API. This approach is conceptually similar to Linux FUSE user mode file system interface, and it allows many kinds of DBFS Store Providers to be created. Some examples include:

- A provider to allow file system access to LOBs in an application table
- A filter file system provider that passes operations to an underlying file system, but adds additional logic, e.g. A virus check filter, or filter that enforces application rules on access
- A provider that translates relational data into file data, or vice-versa



Conclusion

In combination with Advanced Analytics and Data Warehouse features of Oracle Database, the Unstructured Data capabilities enable Oracle Database 12*c* to deliver scalable, high performance management and analysis capabilities for many Big Data and other application workflows. Traditional business applications – finance, order processing, manufacturing, and customer relationship management systems that easily conform to standard data structures (such as rows and columns with well defined schema) as well as applications based on analysis of web, social, multimedia, mobile and sensor data now increasingly incorporate Unstructured Data. With Oracle Database 12*c* we have focused on two things: dramatically faster performance and moving more of the application logic and analytics into the database to simplify application code, enable analysis on dramatically larger datasets and to enable better use of Exadata and other engineered systems.

The dramatic performance and functional improvements in Oracle Database 12*c* make the two essential elements for better use of Unstructured Data: the ability to manage, secure, query, and administer Unstructured Data with the highest levels of performance, and the ability to derive understanding and knowledge in an open, standard manner from all types of data that had previously been dependent upon proprietary application or device logic. Over a decade of development, research, and close collaboration with customers and application providers have resulted in these unique Unstructured Data capabilities found only in Oracle Database 12*c*.

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