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Evolution of Oracle Database Architecture: A Comparing Study of Oracle 10g and Oracle 21c in Terms of Cloud Integration, Automation, and Performance Optimization

Sultan Mohammed Alghamdi[1], Mohammed Ahmed Alomani[2]

[1]Computer Science Trainer, TVTC, HafrAlbatin Technical College, Saudi Arabia
[2]Telecommunication and Network Engineering Trainer, TVTC, HafrAlbatin Technical College, Saudi Arabia

ABSTRACT

This research deeply studies the DBMS, “Oracle10g” and "Oracle 21c". Oracle DB (normally alluded to as Oracle RDBMS or essentially as Oracle) is an object-relational DB management system developed and marketed by Oracle Corporation. However, the new version of Oracle 21c, is the fact the everyone uses today. Many people thought the simplicity of oracle which established in the 2003 will be disappeared in the beginning of 2020. Yet, still alive and working very well and very valid. Now days, its clearly appeared that competitive is present in many fieldsspecially in the world of computers and technicians. The decision that oracle company have made to serially update their versions of database lead them today to a great position between their competitors.

INTRODUCTION

A relational DB is a digital DB which is organized by classifying information into entities with relationships among them. This DB is a way to maintain a data digitally in a way that it’s easier to use in Desktop and other Applications. A (DBMS) is an application that interacts with the client, different systems, and the DB itself to break down information.

Surely understood DBMSs incorporate Oracle and MySQL etc.To build a relational DB, there are a No. of DB designing techniques available in literature and industrial practices. In the course of the most recent 45 years, Oracle DB has made

gigantic changes in its center DB item. With each new release comes an occasionally confounding showcase of new abilities and components, once in a while leaving developers, IT administrators, and even prepared DBAs pondering which new elements will advantage those most.

A Comparative Study of Oracle 10g and Oracle 21c in Terms of Cloud Integration, Automation, and Performance Optimization

Oracle Database has seen significant evolution from version 10g to version 21c. These two versions differ in terms of cloud integration, automation, and performance optimization. This comparative study highlights the key advancements Oracle 21c has made over Oracle 10g, which was released in 2003, with Oracle 21c being a much more modern release (released in 2021). Following paragraphs will explain more in details for the faces of comparison:

Cloud Integration

Both Oracle 10g and Oracle 21c have served generations for a long period of time. It is very important to know that every year the technical people develop the computer to reach the highest level of service and safety. In fact, Limited Cloud Integration: Oracle 10g was released before cloud computing became mainstream. Therefore, it was designed primarily for on-premises environments. While it was possible to integrate Oracle 10g with early forms of cloud infrastructure, this would typically require additional configurations and third-party tools. Also, Oracle Grid Computing: The 10g release introduced Oracle Grid Computing, which allowed for a more flexible, shared infrastructure, though it was primarily focused on large-scale on-premise deployments rather than the cloud. On the other hand, Oracle 21c is designed with cloud-native architecture in mind. The database is tightly integrated with Oracle Cloud Infrastructure (OCI), offering more seamless cloud deployment and management. It includes features like Oracle Autonomous Database, which eliminates the need for manual intervention in database management tasks such as provisioning, patching, and scaling. Moreover, Hybrid and Multi-cloud: 21c allows for easier hybrid and multi-cloud configurations, enabling databases to operate both on-premises and in the cloud with better scalability, flexibility, and security. Finally, Oracle Autonomous Database: A key feature in 21c, which automatically optimizes itself, manages its security, and can scale up or down based on workload requirements, reducing human intervention and offering better integration with Oracle Cloud services.

Automation

Automation in the context of Oracle databases refers to the use of technologies and features that perform tasks without human intervention. These tasks can range from system maintenance, performance optimization, backup, security patching, and scaling. Firstly, Basic Automation: Oracle 10g introduced automated features such as the Oracle Scheduler, which allowed for job automation. However, much of the database management process, including backups, patching, and performance tuning, required manual intervention. Secondly,Limited Self-Managing Features: The automation features were limited to specific tasks, with administrators still required to perform many tasks manually, such as tuning and maintaining the system.However, Advanced Automation: Oracle 21c offers much more advanced automation capabilities, primarily through the Autonomous Database. Key tasks like patching, tuning, backups, and even security management are automated, reducing human error and maintenance overhead. More importantly,Autonomous Data Warehouse (ADW): ADW in Oracle 21c optimizes the performance and scaling of data warehouses without human intervention. It automatically configures, patches, tunes, and scales based on workload demands. Additionally, AI-Driven Optimizations: Automation in 21c is enhanced by AI and machine learning capabilities that predict workloads and automate adjustments to enhance database performance, security, and availability.

Performance Optimization

Initially, Basic Performance Optimization: Oracle 10g included important features like Automatic Storage Management (ASM), which helped to improve storage management performance. It also introduced Automatic Database Diagnostic Monitor (ADDM) for basic performance diagnostics and tuning. More significantly, Manual Tuning: While there were features to assist in performance monitoring, Oracle 10g still required significant manual intervention for performance tuning, query optimization, and resource management. Furthermore, Partitioning and Parallelism: Oracle 10g introduced support for table partitioning and parallel query execution, which improved performance for large-scale databases, although tuning these features still required expertise.

However, Automatic Performance Tuning: Oracle 21c has taken performance optimization to the next level with its Autonomous Database features. The database automatically tunes itself using advanced algorithms, reducing the need for DBA intervention. Additionally, In-Memory and Hybrid Storage: Oracle 21c introduces in-memory column store for faster analytics and hybrid storage for performance optimization between the cloud and on-prem environments. More importantly, Advanced Indexing and Query Optimization: The new version includes more sophisticated indexing methods, such as inverted indexes and auto-indexing, as well as machine learning-based query optimization, which allow Oracle 21c to provide automatic tuning and performance improvements with little to no manual input. Lastly, Real-Time Performance

Insights: Oracle 21c provides real-time monitoring and insights into system performance with much greater granularity, offering DBAs detailed reports for proactive performance management.

Key Differences in Features:

Feature	Oracle 10g	Oracle 21c
Cloud Integration	Limited cloud capabilities, primarily on-premises	Full cloud-native capabilities with OCI and Autonomous Database
Automation	Basic automation with Oracle Scheduler and tools like ADDM	Full automation with Autonomous Database, including patching, tuning, and backups
Performance Optimization	Manual performance tuning and diagnostic tools	AI-driven automatic optimization and tuning, in-memory processing, and real-time insights
Storage and Scalability	Primarily on-premise, with Grid Computing	Hybrid, multi-cloud, and cloud-native scalability
Security	Basic security features	Advanced security with AI-driven patching and data encryption, Autonomous Data Guard
AI and Machine Learning	Limited AI integration	Integrated AI and machine learning for predictive analysis and optimization

The journey of Oracle has started on 2003 and still valid in several types of usages: comparing the generation of Oracle 10g and the generation of Oracle 21c.

Firstly, it is very important that this research mentioned the age period between the generation of Oracle 10g and the generation of Oracle 21c, was 17 years.Oracle10g is the first DB for grid computing.It reduces affordability issues of administration and gives the most notable administration quality. Oracle 10g is a version of Oracle's relational database management system (RDBMS) that was released in 2003. The "g" in 10g stands for "grid," reflecting Oracle's focus on grid computing, which involves pooling and sharing computing resources across a network to increase scalability, availability, and manageability. After providing the whole information about Oracle 10g, the research will deeply describe the high technique of Oracle 21c. Some features of oracle 10g include the following: -

Additionally, Grid Computing: Oracle 10g was designed to work seamlessly in a grid computing environment, where resources (such as servers, storage, and network devices) are pooled together to provide flexible, scalable, and cost-effective IT infrastructure. Secondly, Automatic Storage Management (ASM): This feature allows for simplified management of database storage by abstracting the underlying storage architecture. ASM ensures that storage is distributed efficiently across multiple disks. Third, Oracle Real Application Clusters (RAC): This feature enables multiple Oracle database instances to run on different servers, allowing for high availability, scalability, and load balancing. Also, Automatic Database Optimization: Oracle 10g introduced the Automatic Shared Memory Management (ASMM) and Automatic Workload Repository (AWR), which automatically adjust database resources and monitor performance metrics to optimize the database's performance. Moreover, SQL*Plus and Improved Tools: Oracle 10g improved the SQL*Plus interface, adding new features such as script-based automation and better integration with Oracle Enterprise Manager. In addition, Flashback Technology: Oracle 10g expanded the Flashback features, which allow users to query data as it existed at a particular point in time or revert a database back to a previous state without needing traditional backup restore methods.

Also, Advanced Security: Oracle 10g introduced several security enhancements, including improved user authentication methods, data encryption capabilities, and support for secure database connections. Furthermore, Oracle Data Guard: Oracle Data Guard was enhanced to provide more robust disaster recovery capabilities, ensuring data availability in case of server or system failures. Likewise, Self-Managing Database: Oracle 10g aimed to reduce administrative overhead by automating database tuning and maintenance tasks. This includes features like Automatic Memory Management (AMM)

and Automatic Database Diagnostics to automatically monitor and resolve issues. Finally, Oracle Streams: A feature that provides data replication and integration for real-time data synchronization between Oracle databases.

All these features were provided on the two versions of oracle 10g (10g. 01 – 10g. 02) at that time about 17 years ago. More importantly, the sustainability of Oracle has reached the version of Oracle 21c which considered as one of the best DB globally people use.

Secondly, Oracle 21c, released in 2021, is a major version of Oracle Database that introduces a wide array of new features, enhancements, and capabilities aimed at improving database performance, security, scalability, and integration with modern technologies. Some of the key features of Oracle 21c include:

Blockchain Tables

Blockchain Tables: Oracle 21c introduces a Blockchain Table feature, which provides an immutable, tamper-proof data storage solution. This technology uses blockchain principles to prevent any data from being modified after it is inserted into the table. Any attempt to alter data results in a log entry, making this ideal for applications requiring strong data integrity and auditability (e.g., financial transactions or supply chain management).

Automatic In-Memory Management

Automatic Population of In-Memory Column Store: With Oracle 21c, the In-Memory Column Store is automatically managed. Previously, users had to manually choose which tables or columns to store in memory for performance optimization. Now, Oracle automatically identifies which objects to populate in the in-memory column store based on workload patterns, ensuring better query performance with minimal configuration effort.

JSON Improvements

JSON Data Type Enhancements: Oracle 21c expands its support for JSON by introducing native JSON data types and better integration into SQL operations. This version improves support for JSON Schema validation, allowing data to be validated directly within the database, improving application data integrity. Moreover, JSON Path Expressions: Oracle 21c introduces JSON path expressions, enabling more advanced querying of JSON data stored in the database. This feature offers flexible querying for semi-structured data, making it easier to handle JSON documents.

Sharding Enhancements

Sharding with Automatic Failover: Oracle 21c enhances database sharding, allowing distributed databases to scale horizontally across multiple nodes. With automatic failover for sharded databases, if one shard becomes unavailable, requests are automatically rerouted to other shards without manual intervention, ensuring higher availability and fault tolerance. Sharding Management: Oracle 21c also improves the ease of managing and monitoring sharded databases, making it more scalable for large, global applications.

Autonomous Database Enhancements

Autonomous Database on Shared Infrastructure: Oracle 21c enhances the Autonomous Database offering, particularly with better cloud management features. It reduces manual tasks for provisioning, tuning, and patching databases, and improves resource management. Autonomous JSON Database: Oracle 21c introduces an Autonomous JSON Database, which is optimized for applications that primarily use JSON data. This fully managed service allows developers to work with JSON without needing to manage infrastructure, bringing the power of autonomous cloud databases to JSON-based workloads.

Real-Time Materialized Views, and SQL Enhancements

Real-Time Materialized Views: Oracle 21c supports real-time materialized views, which automatically refresh whenever the base data changes. This feature is highly beneficial for analytical queries and reporting, ensuring data is always up to date without waiting for scheduled refresh intervals. Moreover, SQL Macros: Oracle 21c introduces SQL macros, a new feature that allows users to create reusable SQL expressions. These macros can encapsulate complex queries and logic, making SQL code cleaner and more maintainable. Also, Recursive WITH Clauses: Enhancements to recursive WITH clauses (also known as common table expressions or CTEs) allow more complex queries involving hierarchical and graph-based data to be written in SQL. In addition, Pipelined Table Functions: Pipelined table functions are enhanced to return results directly as SQL tables, improving performance for complex data processing tasks.

Machine Learning and AI Integration

Oracle Machine Learning (OML): Oracle 21c deepens its integration of machine learning within the database by embedding machine learning algorithms directly into SQL. This allows users to run models and predictions directly on their database without needing to move the data outside of Oracle Database. Furthermore, Tensor Flow and PyTorch

Integration: Oracle 21c introduces better support for popular AI frameworks, such as Tensor Flow and PyTorch, allowing developers to run machine learning and deep learning models directly inside the Oracle Database.

Advanced Security Features

Transparent Data Encryption (TDE) Enhancements: Oracle 21c provides more granular control over data encryption, including the ability to encrypt specific table spaces or columns, rather than the entire database. This makes it easier to manage encryption based on security needs.

Similarly, Data Redaction Enhancements: Oracle 21c enhances data redaction, a feature that helps protect sensitive data by hiding it from users or applications that do not have the proper privileges. New redaction policies allow for more fine-grained control. Clearly, Multi-Factor Authentication (MFA): Oracle 21c introduces native support for multi-factor authentication (MFA), adding another layer of security for database access.

Hybrid Cloud and Cloud-Native Features

Cloud-Native Deployment: Oracle 21c improves support for cloud-native applications by providing a containerized deployment option. It integrates with Kubernetes and Docker, making it easier to deploy Oracle Database in hybrid or multi-cloud environments. Besides, Database Migration Enhancements: Oracle 21c introduces enhanced tools to simplify database migration from on-premises to Oracle Cloud, reducing downtime and improving migration efficiency.

Incremental Database Cloning and Partitioning and Parallel Execution Improvements

Incremental Database Cloning: Oracle 21c introduces incremental cloning, allowing users to clone a database more efficiently by only copying the changes made since the last clone. This significantly reduces the time and resources required for cloning operations, especially in large environments. More importantly, Partitioning Enhancements: Oracle 21c adds new partitioning methods, such as range lists and hybrid partitioning, which combine multiple partitioning types in a single table.

This improves the flexibility of partitioning strategies and supports more complex workloads. Moreover, Parallel Execution Enhancements: Oracle 21c enhances parallel query execution for better performance in environments with large-scale data and complex queries. These improvements help reduce query response times for analytical workloads.

Oracle Real Application Clusters (RAC) Enhancements, and Improved High Availability and Disaster Recovery

RAC Enhancements: Oracle 21c introduces improvements to Oracle Real Application Clusters (RAC), including more efficient cluster management and faster failover capabilities. These improvements ensure higher availability and scalability in high-demand environments. Also, Oracle Active Data Guard Enhancements: Oracle 21c improves Active Data Guard for better disaster recovery, including faster failover and more efficient management of standby databases. Additionally, Data Guard with Automatic Failover: New capabilities in Oracle Data Guard automatically switch to a standby database in case of failure, ensuring business continuity without manual intervention.

XML and Hybrid Data Types, and Other Miscellaneous Features

Hybrid JSON/XML Data Types: Oracle 21c allows for the use of hybrid JSON/XML data types, making it easier to store and query both structured (relational) and semi-structured (JSON/XML) data in the same database. In fact, XML Type Enhancements: Oracle 21c also introduces new features for working with XML data, including better integration with SQL queries. More significantly, Invisible Indexes: Oracle 21c introduces invisible indexes, which can be created for performance tuning or testing without impacting the query execution plan.

These indexes remain invisible to the optimizer until they are explicitly made visible. Auto-Shrink for Tablespaces: Oracle 21c introduces auto-shrinking for tablespaces, helping to reclaim unused space in a more efficient manner, without requiring manual intervention.

Summary Comparison Table

Feature	Oracle 10g	Oracle 21c
Release Year	2003	2021
Cloud Integration	Limited	Full cloud-native support, Autonomous DB
Multitenancy	None	CDB/PDB architecture
Autonomous Capabilities	No	Full automation (Autonomous DB)
In-Memory Database	No	Yes
Blockchain	No	Blockchain Tables
Security	Basic encryption, VPD	Enhanced encryption, Data Masking, TDE
JSON/XML/NoSQL Support	Limited	Advanced support (JSON, Graph, REST APIs)
Auto-indexing	No	Yes
Machine Learning	No	Integrated Machine Learning
High Availability (RAC/Data Guard)	Supported	Enhanced RAC/Data Guard + Cloud support
Data Recovery (Flashback)	Flashback capabilities	Enhanced Flashback and Auto Backup
Performance Optimization	Basic auto-tuning	Auto-indexing, Adaptive Query Optimization
Automation	Minimal	Fully automated (Patching, Scaling, etc.)

Is there anybody still use Oracle 10g?
While Oracle 10g may still work in legacy environments, it is no longer safe or advisable to continue using it, particularly for critical applications or systems that handle sensitive data. Upgrading to a supported version like Oracle 19c or Oracle 21c is crucial to ensuring security, compliance, performance, and long-term support for your database systems. Oracle 10g is a legacy version designed primarily for on-premises deployments with basic features for performance, scalability, and security.Oracle 21c is a modern, cloud-first database that introduces cutting-edge features such as Autonomous Database, Blockchain Tables, In-memory processing, Auto-indexing, Advanced Security, and Cloud-native integration. It is designed for highly automated, scalable, and secure environments, especially in cloud and hybrid cloud setups.

Introduction to Relational DBs:-
A critical part of practically every business is record keeping. In our data society, this has turned into a critical part of business, and a great part of the world's figuring force is devoted to keep up and utilizing DBs.DBs of various sorts invade each business. A wide area of information, from messages and contact data to money-related information and records of offers, are put away in some type ofDB. The journey is on for significant stockpiling of less-organized data, for example, subject information.

History
The idea of social DBs was initially portrayed by Edgar Frank Codd (solely referenced as E. F. Codd in specialized writing) in the IBM exploration report RJ599, dated August nineteenth, 1969.1 However, the article that is generally viewed as the foundation of this innovation is "A Relational Model of Data for Large Shared Data Banks," distributed in Communications of the ACM (Vol. 13, No. 6, June 1970, pp. 377-87). Just the first piece of the article is accessible on the web. Extra articles by E. F. Codd all through the 1970s and 80s are still considered gospel for social DB executions. His well-known "Twelve Rules for Relational DBs"2 were distributed in twoComputerworld articles, "Is Your DBMS Really Relational?" and "Does Your DBMS Run by the Rules?" on October 14, 1985, and October 21, 1985, separately. He has developed the following 12 tenets, and they are now No. 333, as distributed in his book "The Relational Model for DB Management, Version 2" (Addison - Wesley, 1990).

Codd's twelve guidelines require a dialect that can be utilized to characterize, control, and question the information in the DB, communicated as a series of characters. The dialect, STRUCTURED QUERY LANGUAGE, was initially created in the exploration division of IBM (at first at Yorktown Heights, N.Y., and later at San Jose, Calif., and Raymond Boyce and Donald Chamberlin were the first designers.)3 and has been embraced by all major social DB merchants. The name STRUCTURED QUERY LANGUAGE initially remained for Structured Query Language. The principal industrially accessible usage of the dialect was named SEQUEL (for Sequential English Query Language) and was a piece of IBM's

SEQUEL/DS item. The name was later changed for lawful reasons. In this manner, some long-lasting DB developers utilize the elocution "see-suppress."

How to Design the DB

Designing a database involves several critical steps, each of which helps ensure that the database is efficient, scalable, secure, and meets the business requirements. A good database design is crucial for ensuring data integrity, performance, and maintainability. Below are the steps you should follow when designing a database, along with important considerations for each phase.

Requirements Gathering

Before starting to design the database, it is important to understand the purpose and requirements of the system. This phase involves interacting with stakeholders such as business analysts, developers, and end-users to gather the following information:

- **Business requirements**: What problem is the database solving? What business processes or functions need to be supported?
- **Data requirements**: What kind of data will the system store? Are there any specific constraints (e.g., data types, sizes)?
- **User requirements**: Who will use the database, and how? What are the access control requirements?
- **Performance requirements**: What are the expected transaction volumes? Are there specific performance goals, like query response times or throughput?
- **Security requirements**: What are the data privacy and security requirements? Are there compliance considerations (e.g., GDPR, HIPAA)?

Conceptual Design (ERD - Entity Relationship Diagram)

At this stage, you need to define the entities (things of interest) and their relationships without worrying about how the data will be stored. The goal is to capture the business requirements and data relationships clearly.

- **Identify entities**: These represent real-world objects, such as Customers, Orders, Employees, etc.
- **Define attributes**: These are characteristics of entities, such as Customer Name, Order Date, etc.
- **Identify relationships**: Define how entities are related to each other, such as:
  - One-to-one (1:1)
  - One-to-many (1:M)
  - Many-to-many (M:N)

  A ERD (Entity-Relationship Diagram) is a great tool to visually represent the entities, attributes, and relationships. For example, a relationship between Customers and Orders might be a one-to-many relationship, where a customer can place many orders, but each order is associated with one customer.

Example:

- **Entities**: **Customer, Order, Product**
- **Attributes for Customer: CustomerID, Name, Address, etc**.
- **Relationships**:
  - One-to-many: **Customer → Order**
  - Many-to-many: **Order ↔ Product**(A single order can have multiple products, and a product can appear in multiple orders)

Logical Design

The logical design involves converting the conceptual model (ERD) into a schema that can be implemented in a relational database. This phase focuses on defining the structure of the data in terms of tables, keys, and constraints.

- **Define Tables**: Convert entities from the ERD into database tables. For example:
  - Customer becomes a Customers table
  - Order becomes an Orders table
- **Define Primary Keys (PK)**: Each table must have a primary key that uniquely identifies a row. For example, CustomerID for the Customers table.

- **Define Foreign Keys (FK)**: Establish relationships by defining foreign keys. For example, the CustomerID in the Orders table would be a foreign key referencing the Customers table.
- **Define Attributes**: Attributes from the ERD are mapped to columns in the table.
- **Define Data Types**: Choose appropriate data types for each attribute (e.g., VARCHAR, INT, DATE).
- **Define Constraints**: Add constraints like:
  - **NOT NULL**: Ensure certain columns cannot be empty.
  - **UNIQUE**: Ensure that data in a column is unique.
  - **CHECK**: Ensure that values in a column meet specific conditions.

Example:
For a Customer table:
sql
Copy code
```
CREATE TABLE Customers (
CustomerID INT PRIMARY KEY,
  Name VARCHAR(100) NOT NULL,
  Address VARCHAR(255),
  Email VARCHAR(100) UNIQUE,
PhoneNumberVARCHAR(20)
);
```
And for an Order table:
sql
Copy code
```
CREATE TABLE Orders (
OrderID INT PRIMARY KEY,
CustomerID INT,
OrderDate DATE NOT NULL,
TotalAmountDECIMAL(10, 2),
  FOREIGN KEY (CustomerID) REFERENCES Customers(CustomerID)
);
```

Physical Design
The physical design involves optimizing the logical design for actual implementation in the database. At this stage, the focus is on performance and storage optimization. More clearly, Indexes: Create indexes to improve query performance, especially for frequently queried columns. For example, if you often search for customers by email, an index on the Email column would speed up queries.
Example:
sql

Copy code
```
CREATE INDEX idx_email ON Customers(Email);
```

- **Denormalization**: In some cases, you may want to denormalize the database schema to improve performance, especially in OLAP (Online Analytical Processing) systems. Denormalization involves combining tables to reduce the number of joins in queries.
- **Partitioning**: Large tables might benefit from partitioning, which divides large tables into smaller, more manageable pieces based on certain criteria (e.g., date range, customer region).
- **Table Storage**: You may need to decide on specific storage parameters, like tablespaces, storage engines (in MySQL), or file organization.

Normalization and De-Normalization

- **Normalization**: The process of organizing data to minimize redundancy and dependency. This is done by dividing large tables into smaller, related tables. Normal forms (1NF, 2NF, 3NF, BCNF) are used to guide this process. The goal is to ensure data integrity by eliminating update, insert, and delete anomalies.

Examples of Normalization:
- **1NF** (First Normal Form): Ensures that there are no repeating groups or arrays in a table.

- **2NF** (Second Normal Form): Ensures that all non-key attributes are fully dependent on the primary key.
- **3NF** (Third Normal Form): Ensures that there are no transitive dependencies (i.e., non-key attributes are not dependent on other non-key attributes).
- **De-normalization**: In some cases, it might be appropriate to de-normalize (combine tables) for performance reasons, especially in read-heavy environments where you need to reduce the number of joins.

Security Design
At this stage, you focus on ensuring that the database is secure and that access controls are in place.

- **User Accounts and Roles**: Define database user roles (e.g., admin, read-only) and permissions.
- **Data Encryption**: Use encryption techniques to protect sensitive data, both at rest and in transit (e.g., encrypt passwords, credit card numbers).
- **Backup and Recovery**: Implement a backup strategy to ensure that data can be recovered in case of failures.
- **Audit Trails**: Set up auditing to monitor who accesses the database and what operations they perform.

Query Optimization and Performance Tuning
After the physical design, ensure that queries can be executed efficiently by:

- **Creating indexes**on frequently queried columns.
- **Reviewing query execution plans**: Use tools like EXPLAIN PLAN to understand how queries are being executed and identify inefficiencies.
- **Optimizing joins**: Ensure that queries use the most efficient join types (e.g., inner joins instead of outer joins when possible).
- **Optimizing storage**: Make sure that tables are not excessively large and are partitioned or indexed appropriately.

Testing the Database Design
Before implementing the database in a production environment, thoroughly test the database design:

- **Data Integrity Testing**: Ensure that data integrity constraints (e.g., foreign keys, uniqueness) are functioning as expected.
- **Performance Testing**: Test the performance of the system with sample data and typical queries. Use tools to analyze query execution times and identify bottlenecks.
- **Security Testing**: Test the access control mechanisms to ensure only authorized users can access sensitive data.

Documentation
Finally, document the design decisions, data model, table structures, relationships, and any other important details. This documentation is important for:

- **Maintaining the database**: Helps DBAs and developers understand the design.
- **Future enhancements**: Makes it easier to expand the design as requirements change.
- **Collaboration**: Helps different teams (e.g., developers, business analysts) understand the database schema.
  Maintenance and Iteration
  Once the database is implemented, it's important to:
- **Monitor the database:**regularly for performance, security, and data integrity.
- **Optimize the database:**periodically based on new usage patterns or performance issues.
- **Iterate**: the design as the business requirements evolve over time.

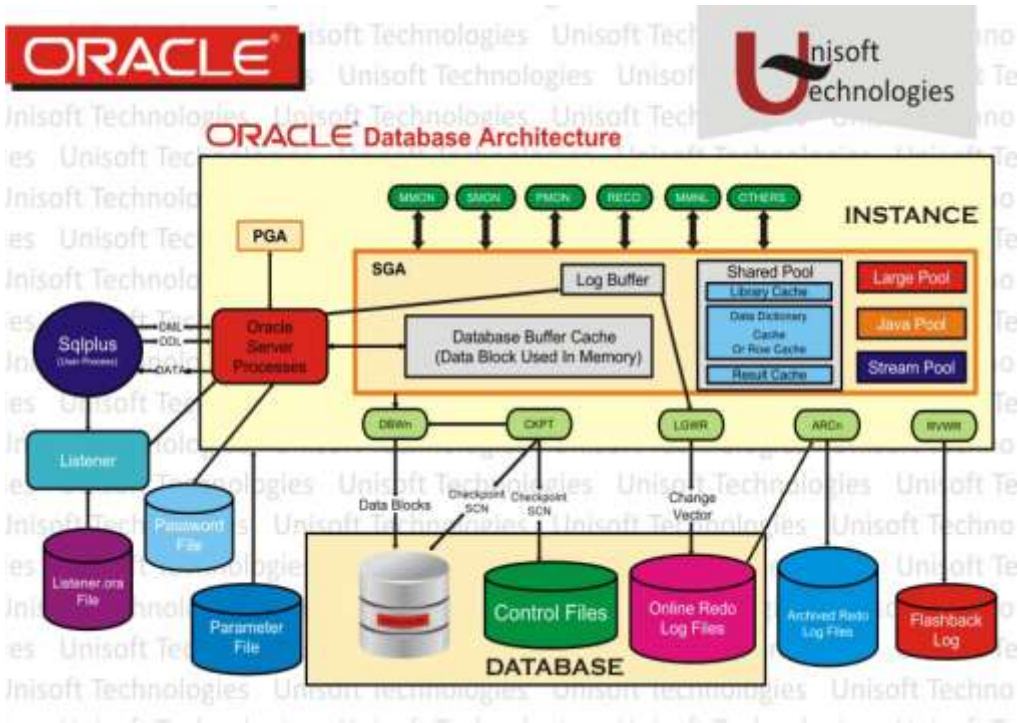
Overview of Shared Pool
The Shared Pool in Oracle is a critical memory structure in the System Global Area (SGA) that stores shared data and control information for the Oracle Database. It plays a vital role in improving performance by reducing the need to read from disk and optimizing memory access. While the core functionality of the Shared Pool remains similar in both Oracle 10g and Oracle 21c, there are some notable changes and improvements, particularly with respect to memory management, dynamic sizing, and performance optimization. Let's explore these changes in detail. The Shared Pool in Oracle consists of several important components that work together to manage SQL execution and cache various types of data. Firstly, Library Cache: Caches SQL and PL/SQL statements, including parsed queries and execution plans. Secondly, Data Dictionary Cache: Caches data dictionary information (metadata such as table definitions, column names, etc.). third, Control Structures: Stores other control information related to parsing, library cache management, and context for various

database operations. Finally, Shared SQL Area: Caches the SQL statements that are parsed and executed, including stored procedures, functions, and triggers.Both Oracle 10g and Oracle 21c maintain these core components, but there have been significant changes in terms of how memory management is handled and how the shared pool interacts with other parts of the Oracle architecture.

Shared Pool in Oracle 10g

Static Memory Management: In Oracle 10g, memory allocation for the Shared Pool is manually configured by the DBA. The size of the Shared Pool must be explicitly defined using the SHARED_POOL_SIZE parameter.The size of the Shared Pool is a critical factor in performance. If it is too small, Oracle might have to perform additional disk I/O for metadata, which can slow down operations. If it's too large, it may lead to memory contention.Oracle 10g uses the Library Cache and Data Dictionary Cache for optimizing SQL execution and metadata lookups, respectively.Manual Tuning: DBAs need to monitor the Shared Pool usage and tune it manually based on memory usage patterns. This can be done using various tools such as V$SGASTAT and V$SQLAREA views to track memory consumption.Shared Pool Fragmentation: As memory usage increases, the Shared Pool can become fragmented.

Fragmentation occurs when memory is allocated and deallocated dynamically, leaving gaps that cannot be efficiently reused. To handle this, DBAs might periodically need to flush the Shared Pool (via ALTER SYSTEM FLUSH SHARED_POOL) or increase its size.Memory Allocation for SQL Statements: When a SQL statement is executed, Oracle first checks if an identical statement is already parsed and stored in the Library Cache. If so, Oracle reuses the existing execution plan, saving time and resources.



Example:
sql
Copy code
-- Set the shared pool size to 500MB in Oracle 10g
ALTER SYSTEM SET SHARED_POOL_SIZE = 500M;

Shared Pool in Oracle 21c

Oracle 21c brings several new features and improvements to memory management, including better automation, dynamic memory resizing, and enhanced performance for modern workloads. The concept of the Shared Pool remains the same, but its management is more integrated with Automatic Memory Management (AMM) and Automatic Shared Memory Management (ASMM).Automatic Shared Memory Management (ASMM):Oracle 21c utilizes ASMM to automatically allocate memory between different parts of the SGA, including the Shared Pool. With ASMM, Oracle dynamically adjusts the size of the Shared Pool and other SGA components based on workload demands and available system memory.The

SGA_TARGET parameter defines the total amount of memory that Oracle can allocate to the SGA, and Oracle automatically adjusts the Shared Pool size within that limit. The DBA no longer needs to manually manage the size of the Shared Pool or worry about fragmentation as much.

Dynamic Memory Allocation:
In Oracle 21c, the system automatically adjusts the Shared Pool size (within limits set by the DBA), based on memory usage. For example, if there is more memory available, Oracle can allocate more to the Shared Pool to store more SQL and PL/SQL code, while other components like the Database Buffer Cache or Redo Log Buffers might have their size adjusted as well.With MEMORY_TARGET and MEMORY_MAX_TARGET, Oracle can dynamically redistribute memory across the entire SGA and PGA (Program Global Area) to maximize performance.

Automatic Memory Tuning:
Oracle 21c is more efficient in terms of memory tuning due to auto-tuning capabilities for the Shared Pool. This includes automatic handling of SQL area fragmentation and more efficient caching strategies for both data and execution plans. Moreover, In-Memory Enhancements:Oracle 21c includes enhanced support for In-Memory Database features, allowing certain parts of the database (such as analytics data) to be cached in a columnar format in In-Memory Column Store (IMCS). This reduces the dependency on the traditional Shared Pool for certain types of queries, but the Shared Pool still manages all SQL parsing and metadata caching.

Enhanced Memory Management for SQL and PL/SQL:
Oracle 21c provides improvements in Library Cache management, especially in environments with high concurrency. The SQL Plan Management and SQL Plan Baselines are enhanced, helping to ensure that memory used for execution plans is optimized. In addition, Pluggable Database (PDB) Support:With the introduction of Multitenant Architecture in Oracle 21c, the Shared Pool is managed at both the Container Database (CDB) level and the Pluggable Database (PDB) level. Each PDB has its own Shared Pool, which can be managed independently, offering more flexibility in a multi-tenant environment.

Example:
sql
Copy code
-- Set the SGA_TARGET parameter to allow Oracle to auto-tune memory allocation
ALTER SYSTEM SET SGA_TARGET = 2G;

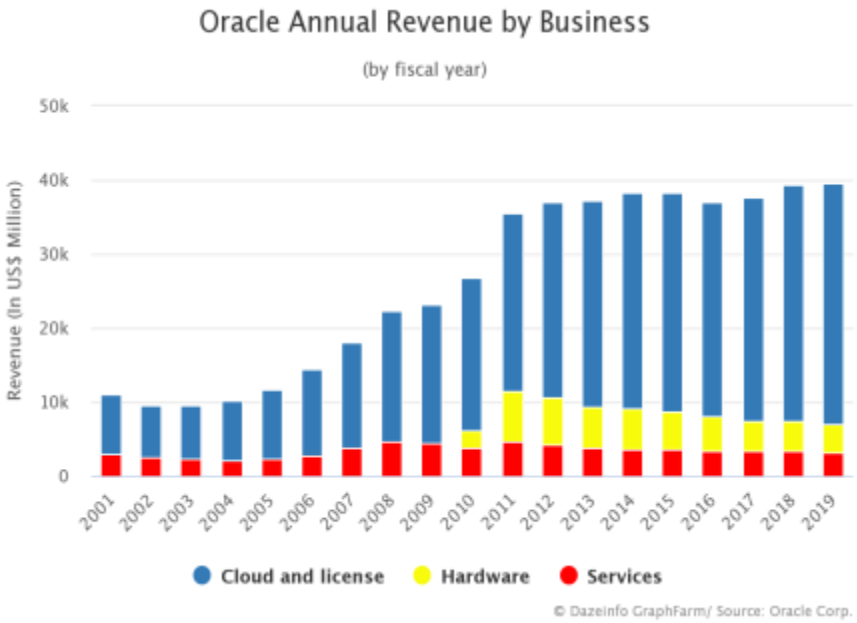
-- You can also set MEMORY_TARGET for auto-tuning
ALTER SYSTEM SET MEMORY_TARGET = 4G;

Key Differences between Oracle 10g and Oracle 21c Shared Pool

Feature/Attribute	Oracle 10g	Oracle 21c
Memory Management	Manual configuration of SHARED_POOL_SIZE	Automatic Shared Memory Management (ASMM), Dynamic resizing
Tuning Approach	Manual tuning and monitoring required	Automatic memory tuning, no manual intervention needed
SQL Caching	Library Cache stores parsed SQL and execution plans	Same, but enhanced with **In-Memory Column Store** and **SQL Plan Management**
Dynamic Sizing	Static sizing; DBA must manually adjust	Dynamic sizing of the Shared Pool within the SGA_TARGET limit
Fragmentation	Possible fragmentation; DBA may need to flush Shared Pool	Less prone to fragmentation due to dynamic adjustments
Multitenancy	No support for pluggable databases (CDB/PDB)	Supports Shared Pool management at both CDB and PDB levels
In-Memory	Limited to traditional buffer cache and disk I/O	Advanced **In-Memory Column Store** integration for faster queries

Impact of Changes on Performance

Oracle 10g: The Shared Pool is managed statically, which means DBAs need to carefully allocate memory to ensure that the system performs efficiently. Improper sizing can lead to fragmentation, suboptimal performance, or excessive disk I/O if the memory is insufficient for the workload. However, Oracle 21c: The introduction of Automatic Shared Memory Management (ASMM) and Automatic Memory Management (AMM) has significantly improved the efficiency and flexibility of the Shared Pool. By automatically adjusting the memory allocation based on current needs, Oracle 21c reduces the need for manual tuning and helps ensure optimal performance, especially in large-scale or cloud environments with varying workloads.Moreover, Oracle 21c's integration with In-Memory Database capabilities and multitenancy (via PDBs) means that Oracle can better optimize memory usage in environments with large, complex, or dynamic workloads, leading to better overall performance.



CONCLUSION

All in all, Oracle 10g, released in 2003, and Oracle 21c, launched in 2021, represent two distinct eras of database technology, with Oracle 21c incorporating vast improvements in cloud integration, automation, and performance optimization. Oracle 10g, focused on on-premises deployments, had limited cloud integration, requiring third-party tools for cloud connections and offering basic grid computing features for scalability. In contrast, Oracle 21c is designed with a cloud-native architecture, offering seamless integration with Oracle Cloud Infrastructure (OCI) and features like Autonomous Database, which automates key tasks such as scaling, patching, and provisioning. This shift allows for more efficient hybrid and multi-cloud deployments with enhanced scalability and flexibility.In terms of automation, Oracle 10g provided basic tools like the Oracle Scheduler, but many tasks, such as performance tuning and system maintenance, still required significant manual intervention. Oracle 21c, however, takes automation to the next level with its Autonomous Database, which fully automates key administrative functions, including performance tuning, backups, and security management. Leveraging AI and machine learning, Oracle 21c predicts workload changes and automatically adjusts database performance without human input, significantly reducing the risk of errors and administrative overhead.

Performance optimization in Oracle 10g relied heavily on manual tuning, with tools like Automatic Storage Management (ASM) and Automatic Database Diagnostic Monitor (ADDM) assisting with diagnostics and resource management. In contrast, Oracle 21c uses advanced algorithms, in-memory processing, and machine learning-based query optimization to automatically optimize performance with minimal user intervention. It also provides real-time performance insights, allowing DBAs to manage system performance proactively. Furthermore, Oracle 21c introduces innovative features like blockchain tables, enhanced security with multi-factor authentication, and improvements in data encryption and redaction.

Overall, Oracle 21c represents a major leap forward in database technology, offering a fully automated, AI-driven, cloud-first solution with advanced security, scalability, and performance optimization features that were not present in Oracle 10g. The evolution from Oracle 10g to 21c highlights the significant transformation in database management, moving from on-premises systems to integrated, intelligent cloud solutions.

Oracle 21c is highly recommended for organizations seeking to modernize their database infrastructure and improve operational efficiency through automation, advanced performance optimization, and robust cloud integration. Its cloud-native architecture, seamless integration with Oracle Cloud Infrastructure (OCI), and support for hybrid and multi-cloud environments make it ideal for businesses transitioning to the cloud or operating in multi-cloud setups. The Autonomous Database feature offers significant automation in provisioning, scaling, and patching, reducing manual intervention and administrative overhead. Additionally, its AI-driven optimizations, enhanced security features like multi-factor authentication and blockchain tables, and real-time analytics capabilities provide significant benefits for improving data integrity, performance, and security. Organizations should prioritize training for their IT teams to fully leverage these advanced features and ensure scalable, secure, and efficient database management.

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