Functionality and Security Analysis of ORACLE, IBM-DB2 & SQL Server

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***Abstract*-Information may be the most valuable commodity in the modern world as it takes many application dependent different forms. We need to store too much data in file cabinets or cardboard boxes. The need to safely store large collections of persistent data, efficiently "slice and dice" it from different angles by multiple users and update it easily when necessary is critical for every enterprise. Security pin the main feature of DBMS like Encryption, Authentication, Proxy Authentication, Authorization, Auditing, LDAP Support, etc. Functionality is the most important feature of any DBMS. How data function in different-different situation like Concurrency Model, index capabilities, partitioning options, Parallel execution, Clustered configurations, Additional data warehousing capabilities, Self tuning capabilities, Array, Trigger, Procedures, Tables etc. In this paper we compare the globally recognized database's to get the details of all these above features and also some extra comparative parametric features.**

I. Introduction

An organization must have accurate and reliable data for better decision making. The objective of the DBMS is to provide a convenient and effective method of defining, sorting, and retrieving the information contained in the database. The DBMS interfaces with application programs, so that the data contained in the database can be used by multiple application and multiple users. The database system allow these users to access and manipulate the data contained in the database in a convenient and effective manner. Every organization choose the database management system according to there need and requirement. Security and functionality is the biggest issue in any DBMS. There are many DBMS in market. Example of Database Management Systems is Alpha Five, DataEase, Oracle database, IBM DB2, Adaptive Server Enterprise, FileMaker, Firebird, Ingres, Informix, Mark Logic, Microsoft Access, Microsoft SQL Server, Microsoft Visual FoxPro, MonetDB, MySQL, PostgreSQL, Progress, SQLite, Teradata, CSQL, OpenLink Virtuoso, Daffodil DB, OpenOffice.org Base etc. But we select three type of database management system to compare there security and functionality these are Oracle, IBM DB2 and Microsoft SQL Server, we preferred these three because these three DBMS preferred widely in the market (as show in table 1) and follow the more security and functionality rather than other. I read & surveyed the many research paper and company profile where I get 93% were used oracle and 3% used IBM DB2 & SQL Server and only 4% other database management system. [2,8,15]

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Feature	Oracle	DB2	SQL Server
Concurrency Model	Multi-version read consistency Non-Escalating row level Locking	No Locks escalate	Shared read locks or dirty reads Locks escalate
Indexing capabilities	B-Tree indexes Index-organized Tables Bitmap indexes Bitmap Join Indexes	Only B-Tree and Dynamic Bitmap Index	B-Tree indexes Clustered Indexes Not supported Not supported
Partitioning options	Range, hash, list and composite partitioning Local and global indexes	Hash partitioning and Local index	Not supported Only local indexes with member tables
Parallel execution	Queries, INSERT, UPDATE, DELETE	Queries only	Queries only
Clustered configurations	Transparent scalability with Real Application Clusters	Rigid Data partitioning required with DB2 EEE	Requires data partitioning in member tables and Distributed Partitioned Views
Additional data warehousing capabilities	Materialized Views MERGE Multi-table INSERT Pipelined table Functions	Not Supported	Indexed Views Not supported Not supported Not supported
Self tuning capabilities	Automatic Performance diagnosis Automatic SQL Tuning Self-tuning memory, free space and I/O management	No equivalent or limited capabilities	No equivalent or limited capabilities
Array	Supported	Supported	Not Supported
Trigger	BEFORE triggers, AFTER triggers, INSTEAD OF triggers, Database Event triggers	BEFORE triggers, AFTER triggers, INSTEAD OF triggers	AFTER triggers, INSTEAD OF triggers
Procedures	PL/SQL statements, Java methods, third-generation language (3GL) routines	DB2 SQL dialect statements, Java methods, third-generation language (3GL) routines	T-SQL statements
Tables	Relational tables, Object tables, Temporary tables, Partitioned tables, External tables, Index organized tables	Relational tables, Object tables, Temporary tables	Relational tables, Temporary tables

Table 2 – Databases functionality comparison summary. [11, 12, 13]

Market structure

Given below is a list of top RDBMS vendors in 2009 with figures in millions of United States Dollars published in an IDC study.

Table 1 – Market wroth of database

Vendor	Global Revenue
Oracle	8,800
IBM	3,483
Microsoft	3,052
Sybase	524
Teradata	457
Others	1,624
Total	**16,452**

II. COMPARATIVE ANALYSIS

We compare Oracle, DB2 & SQL Server under the parameter of functionality and security

A. Functionality

The main features differences between three databases are summarized in the table 2: [3, 5]

OLTP environment have large volume of data for sort and frequent update and insert the data. So OLTP require high throughput, index strategy and excellent data concurrency etc. **Concurrency control** in multi-user environments ensures that data updates made by one user do not affect those made by other users. Oracle, DB2 and SQL Server differ greatly in their implementation of concurrency control. The main differences show in the below table 3.

Oracle	SQL Server	DB2
Multi-version read consistency	Not available	Not available
No read locks	Requires shared read locks to avoid dirty reads	Requires read locks to avoid dirty reads
No dirty reads	Dirty reads if not using shared locks	Dirty read if not using read lock
Non-escalating row-level locking	Locks escalate	Locks escalate
Readers don't block writers	Readers block writers	Readers block writers
Writers don't block readers	Writers block readers	Writers block readers
Minimal deadlocks under load	Deadlocks can be a serious problem under load	Deadlocks can be a problem under load

Table 3 - Sub table of functionality comparison (Concurrency Model). [3, 9, 14]

Oracle fully support the mix workload of simultaneously query and insert, update commands. In Oracle no read locks, no dirty reds, reader cannot block the writer, writer cannot block the readers. Data is always available for user because no deadlocks occur. Oracle's implementation of multi-version read consistency always provides consistent and accurate results. When an update occurs in a transaction, the original data values are recorded in the database's undo records. Oracle uses the current information in the undo records to construct a read-consistent view of a table's data, and to ensure that a version of the information, consistent at the beginning of the uncommitted transaction, can always be returned to any user.

DB2 block the reader for writers and writers for readers. DB2 does not provide multi-version read consistency. DB2 block the readers while writing and block the writers while reading. DB2 not allow the mix of read and write request. IBM also accepts this fact in their own documents.

SQL Server also does not provide multi-version read consistency. Instead it requires applications to either use shared locks for read operations, with various levels of isolation, or to accept dirty reads. Shared locks prevent data that is read from being changed by concurrent transactions. Shared lock's to ensure that data readers only see committed data. These readers take and release shared locks as they read data. These shared locks do not affect other readers. A reader waits for a writer to commit the changes before reading a record. A reader holding shared locks also blocks a writer trying to update the same data. Important thing is that releasing the locks quickly for other users in SQL Server than in Oracle.

Non-Escalating Row-Level Locking Row-level locking ensures that any user updating a row in a table will only lock that row, leaving all other rows available for concurrent operations. Oracle uses row-level locking as the default concurrency model and stores locking information within the actual rows themselves. By doing so, Oracle can have as many row level locks as there are rows or index entries in the database, providing unlimited data concurrency. Oracle never locks and as a consequence oracle users never face the situation of deadlock due to lock escalation.[7,3]

DB2 also supports row level locking by default. Lock list is an additional memory structure these lock lists have limited size so that limited number of lock are reside in memory structure or lock list. Lock escalation is an internal mechanism that is invoked by the DB2 lock manager to reduce the number of locks held in lock list. Escalatin occur from row locks to a table lock when the number of locks held exceed the threshold defined by the database configuration parameter Lock list. [5]

SQL Server also supports row-level locking as the default concurrency model. However, because it was not the default level of lock granularity in earlier versions of the database, the late addition of row-level locking was made possible only through the use of additional, separate pools of lock structures.

Indexes are basically used for sorting operation on table columns and provide a faster path to data. Using indexes can reduce disk I/O operations, so that increasing the performance of data retrieval. Oracle, DB2 and SQL Server support traditional B-Tree indexing schemes, which are

ordered lists of key values, associated with the storage location of the table row that contains these values.

Oracle support index-organized tables, (IOT itself a table space) bitmap and bitmap join index. DB2 support the dynamic bitmap index and clustered indexes in SQL server. Index-organized tables provide fast access to table data for queries involving exact match and/or range search on the primary key because table rows are stored in the leaf nodes of the primary key index. For example English dictionary that themselves an indexed.[1,5]

A bitmap index uses a bitmap (or bit vector) for each key value instead of a list of the table rows' storage locations (ROWIDs). Each bit in the bitmap corresponds to a row in the table. The bit is set when the table's row contains the key value.

In Oracle, it is also possible to create bitmap indexes on index-organized tables, thereby allowing index-organized tables to be used as fact tables in data warehousing environments. A bitmap join index is a bitmap index for the join of two or more tables. A bitmap join index can be used to avoid actual joins of tables, or to greatly reduce the volume of data that must be joined, by performing restrictions in advance. Queries using bitmap join indexes can be sped up via bit-wise operations.

Bitmap join indexes, which contain multiple dimension tables, can eliminate bitwise operations, which are necessary in the star transformation with bitmap indexes on single tables. Performance measurements performed under various types of star queries demonstrate tremendous response time improvements when queries use bitmap join indexes. DB2 and SQL Server do not support IOT, bitmap indexes and bitmap join indexes.[1,3,5]

Partitioning allow the large database in to small pieces and also store the pieces in different-different location. So that data can retrieve and stored fast with more I/O process.

Oracle hold the all Partitioning options like Range, hash, list and composite partitioning Local and global indexes. DB2 hold the Hash partitioning and Local index. And SQL Server hold the Only local indexes with member tables.

Here Oracle keep the more partitioning option that is not in DB2 neither in SQL Server.

Cluster is an group of independent server connected via a private network. All server work as a single system. Oracle and DB2 support the cluster but SQL Server does not support the Cluster. Oracle use the Real application cluster (RAC) to support the hardware cluster. RAC adopts a shared link approach for this database file are logically shared among the nodes of a loosely coupled system with each instance having access to all the data. RAC use the patented cache fusion architecture, a technology that utilizes the interconnected cache of all the nodes in the cluster to satisfy database request for any type of application (OLTP, DSS, Packaged application). RAC is unique feature of oracle and make it best. DB2 adopts the shared nothing approach. In this database file are partitioned among the instances running on the nodes of a multi computer system. Each instances on different subnet of the data and all access to this data is performed exclusively by this owing instance.[1,3,4,5]

Additional data warehousing capabilities Extraction, Transformation and loading (ETL) Oracle provide the additional feature of data warehousing environment like materialized view, Merge, Multi table insert, Pipelined table function. Both DB2 and SQL Server does not support the these additional features. Oracle need not tune the database because Oracle have self tuning means automatic storage management (ASM), Automatic work repository (AWR), Automatic database diagnostic monitor (ADDM), Automatic SQL tuning And automatic back and recovery management like this all work of tuning done in oracle by automatic but in the DB2 and SQL Server so the database tuning manually. [1, 3]

B. Security

Whenever any company plan to purchase DBMS firstly company think about security. Security feature at the top of buyer's list. DBMS purchasing decision must factor in security. A company reputation and livelihood may be ruled if it does not protect the data or customer information held inside. Today is e-business world, so security issues have become more complicated than ever.

Mainly security consists of these major factors specify in below table 4.

Authentication is ensuring only right user is connect to the database and use to prove the identity of the user. In large enterprises applications expand day-to-day, therefore need for strong user authentication techniques grows up. User-id/password, keys and biometric authentication are some of the solutions used to address the authentication problem. Authentication have three levels network, DBMS and in the operating system.

Security feature	Oracle	IBM DB2	SQL Server
Authentication	Yes	Yes	Yes
Proxy Authentication	Yes	No	No
Authorization	Yes	Yes	Yes
Encryption	Yes	Yes	No
LDAP Support	Yes	Yes	Yes
Auditing	Yes	Yes	No
Fine grained auditing	Yes	No	No
RACF Support	Yes	Yes	No

Table 4 – DBMS Security features. [1,3]

Oracle support strong authentication at the network and database layers by supporting X.509v3 digital certificate and also integrated with third party network authentication services i.e. token card smart card Kerberos, DCE, biometrics and Cyber Safe. To connect with remotely to oracle DBMS using RADIUS that is most secure in all database using the SecureID tokens, secure computing safeword token, smart card and active card tokens built-in into the database. Oracle's have many authentication methods like internal user authentication, OS authentication and network authentication methods.[3,9]

IBM support strong authentication at the database and operating system layers and in various Tivoli application.

That is 3rd party application. IBM support service such as DCE, Kerberos, and RACF. Tivoli secure way policy support only secureID the leading token or also called hard token, but leaving customers with only one choice. That use X.509v3 certification for strong authentication over SSL. DB2 have external authentication. DB2 always passes authentication requests to the operating system and/or 3rd party products such as IBM‘s Tivoli. To support this, DB2 has employed in version 8.2 an open plugin architecture. This architecture allows for easy integration of 3rd party or custom authentication plugins that allow for the extension of DB2‘s authentication capabilities. Operating system and Kerberos (previously only available on Windows, now available on UNIX platforms too) have been re-implemented using the plug-in architecture. On the Windows platform, the depth of integration into the OS authentication capabilities has been depend.

SQL Server offers the DBMS authentication via the operating system security (similar to DB2‘s implementation). Microsoft use the Active Directory components of Microsoft admin server using the LDAP and Kerberos protocols. The operating system authentication integrates extremely well with the operating system security features. The Kerberos framework is supported in conjunction with Active Directory. Oracle‘s strategy provides the most authentication alternatives. DB2 now has the architecture to accelerate the integration of new authentication methods. This applies not only for standardized 3rd party products but also for custom-developed authentication methods. SQL Server has tight integration with products supplied by Microsoft itself.

Authorization: Once a user is authenticated to the DBMS, A user‘s authorization tells us what data he should have to and what types of operation he can perform on those objects. It has to be verified that the user is authorized for accessing the queried data and/or function in the request. Authorization is normally bound to users and groups or roles. Oracle and DB2 both have the same definition of privileges and use standard SQL.

In DB2, authorization can be provide to users or groups. Roles are only supported in the sense of predefined system roles (Roles is the set of privilege). When utilizing group authorization, attaching users to groups is done outside the DBMS, i.e. in the operating system or through custom plugins. Oracle authorizes based on users and roles. Oracle roles can be local to a database or enterprise-wide when managed with an LDAP compliant server. For SQL Server, there is a distinction between a server login and database users, a user connection to a database is only allowed when the server login is mapped to a database user. SQL Server utilizes operating system group information directly without need for mapping. [3,5,10,14]In Oracle and SQL Server, can define application roles that are only used for applications. These prevent direct user access to tables and views. Although DB2 does not support roles, applications can connect to the database with a virtual user-id that implements the necessary level of access security. Content and functionality control can be implemented at 2 different levels: object and row level. Object level security is a central component of RDBMS technology and has been covered by all 3 DBMS‘ sufficiently for years. Views have been the traditional answer to row level security and are supported by all DBMS. DB2 and Oracle both support the use of view to limit access the data. Oracle offers an additional, integrated implementation of row level security with Virtual Private Database (VPD) and Label Security (OLS). VPD enables implementation of row level security into the database, OLS manages the actual labeling of both users and data. These labels are directly compared when accessing the data. This approach promises high performance during runtime security checks. However, the manageability is at a disadvantage when security definitions are updated (i.e. department split or join). In this case, labeling must be physically redone, meaning explicit data updates. For further performance improvement Oracle added static and context-sensitive policy execution strategies with 10g.DB2 and Oracle take the advantage of Resource Control Facility (RACF) for access control in mainframe environment. [3,6,7,10,14]

Encryption: Protecting data stored in the database against unauthorized user is enabled for both DB2 and Oracle by data or column encryption. Only Oracle support tablespace level encryption. SQL Server does not support data encryption. However, encryption of login and application role passwords stored at the server and catalog information (such as view and trigger definitions) is enabled. DB2 use the function that enable an application to encrypt data using an RC2 block cipher with a 128-bit key and using an MD2 message digest. It provides column-level encryption, enabling all values in a column to be encrypted with the same key an encryption password. Oracle provide DES (56-bit), 2-key and 3-key Triple-DES (112 and 168 bits) in an encryption toolkit package that enable application to encrypt within the database. DB2 password based key provide flexibility if not a slight overburden on the end user to choose a strong key. Where oracle has made stored data encryption enhancements in four development cycles.

Today everybody wants encrypting data passing over a network. Network encryption is addressed by all DBMS: DB2 has added encryption of network traffic in version 8.2 with DES and RC2 but customer must purchase additional IBM product to encrypt various network layers, SQL Server has integrated SSL encryption into its net libraries and Oracle provides SSL, _DES in 56 bit and 40 bit key length‘, _RC4 in 256 bit 128 bit 56 bit and 40 bit key length‘, _2key 112 bit‘ and _3key 168 bit‘ encryption with their Advanced Security option. Wherever the database is available Oracle provide the oracle advance security to protect all communication with the oracle database. to prevent modification or replay of data during transmission oracle use an MD5 or SHA-1 message digest included in each network packet. In short oracle provides a variety of ways to encrypt communication over all protocols with any database communication.[5,7,3]

LDAP integration for centralized user management: Oracle, IBM and SQL server are turning to Lightweight Directory Access Control (LDAP) directories to centrally store and manage users. Tivoli secure way user Administration provides an LDAPv3 compliant directory service. Oracle offer an LDAPv3 compliant directory service, Oracle internet directory, and many oracle product are it as a scalable, secure central information repository. SQL server also work with LDAP only support the Microsoft admin server at active directory. DB2 support the LDAP on OS/400, AIX, OS/390 and window. And oracle support the LDAP at all platforms plus Oracle internet directory.

Auditing is keeping the record of user activities in a table of database to track the user activity to ensure that user has done the right action. That is done by DBA. Flexible reporting on audit data is possible in all three databases.

Oracle use the LogMiner utility that is always available and does not drop records of any change made to it that use for recover the database and allow the customer to audit the database by system privileges, statements, by object and user. Oracle keep the all record whether the operation is successful or unsuccessful. Oracle also use the statistics report to audit the database. Their 15 security certificates are seen as the assurance that Oracle is unbreakable. No competitor is as active as Oracle in this area - DB2 and SQL Server have 1 certificate each. DB2's Common Criteria certification applies to the current version, 8.2. At the end of September 2004, we found 6 alerts for Oracle database and Enterprise Manager in 2004, more than 20 vulnerability and incident notes for SQL Server and no alerts for DB2. DB2 provide an administrator tool called db2audit for use by the DBA. DB2 capture the audit record at database level and instance level. DB2 has option of configure to audit trail synchronously or asynchronously. DB2 use Tivoli product to enhance the auditing features namely secure way security manager (login and access to various resources) and secure way PKI (PKI services). But oracle has mandatory log file to record the all entries of database. Oracle use the fine-grained auditing policies which specify the data access condition that audit event.

Oracle comes with its support for multiple authentication methods, its unique row level security, its unique proxy authentication and its support for enterprise users and roles. DB2 comes with advantages to SQL Server due to its new plug-in authentication architecture and the possibility to store data encrypted. [1, 3 5]

III. Conclusion

We compare Oracle, IBM DB2 and SQL Server DBMS with function and security parameter and we found that Oracle seems more secure DBMS in comparison to DB2 and SQL server. Because it support all the security feature like Authentication, Proxy Authentication, Authorization, Encryption, LDAP Support, Auditing, Fine grained auditing, RACF Support but on the other hand DB2 not support the Fine grained auditing, Proxy Authentication so DB2 is the challenger of Oracle but SQL server is behind of them because that support only Authentication, Authorization, LDAP Support.

Functionality is the most important feature of any database. Based on functionality we found that oracle has more function than other database. Oracle use some unique features like multi version read consistency and merge etc. Both oracle and DB2 use more fine-tuning to the configuration can be done via start-up parameters. DB2 is runner up and SQL Server behind of them.

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