Enterprise Oracle Database Upgrade Strategy

This paper describes an effective and working Oracle Database Upgrade strategy, approach and an execution methodology for Enterprise-wide Database Upgrade program.

Today, most of the organizations use shared service database management functions involving multiple applications and as a result the database upgrades are very complex and needs to be driven as an enterprise-wide program.

We also analyze how a customer can handle large and complex Oracle Database Upgrade programs using an appropriate upgrade strategy and approach. It is envisaged that successful upgrade depends, not only on the strategy and approach, but also on program governance, commitment from various stakeholders and the usage of best practices.
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**List of Abbreviations**

The following table illustrates the list of various abbreviations used in this document.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Expanded Form</th>
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<tbody>
<tr>
<td>ASM</td>
<td>Automatic Storage Management</td>
</tr>
<tr>
<td>BAU</td>
<td>Business As Usual</td>
</tr>
<tr>
<td>CapEx</td>
<td>Capital Expenses</td>
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<tr>
<td>CMDB</td>
<td>Configuration Management Database</td>
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<tr>
<td>COTS</td>
<td>Commercial Off-the-Shelf</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>DBA</td>
<td>Database Administrator</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management System</td>
</tr>
<tr>
<td>DBUA</td>
<td>Database Upgrade Assistant</td>
</tr>
<tr>
<td>DR</td>
<td>Disaster Recovery</td>
</tr>
<tr>
<td>ETL</td>
<td>Extract, Transform and Load</td>
</tr>
<tr>
<td>OpEx</td>
<td>Operational Expenses</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>PSG</td>
<td>Program Steering Group</td>
</tr>
<tr>
<td>RAC</td>
<td>Real Application Clusters</td>
</tr>
<tr>
<td>ROoM</td>
<td>Rough Order of Magnitude</td>
</tr>
<tr>
<td>SAN</td>
<td>Storage Area Network</td>
</tr>
<tr>
<td>TCS</td>
<td>Tata Consultancy Services</td>
</tr>
<tr>
<td>TTS</td>
<td>Transportable Tablespace</td>
</tr>
<tr>
<td>QA</td>
<td>Quality Assurance</td>
</tr>
<tr>
<td>UAT</td>
<td>User Acceptance Testing</td>
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</table>
Need for Database Upgrade

Based on changing business needs, Database Administrators (DBAs) need to develop a highly robust database and scale-up the Database Management System (DBMS) solutions to match business needs. If any of these challenges exist in an IT environment hosting large databases, it is time to upgrade to the latest DBMS version available in the market, in order to overcome the following challenges:

- The applications are diverse with different performance and data needs
- Business user base has increased to a large extent
- The Database vendor has withdrawn support for the current version
- The data is growing exponentially

Upgrade Strategy Options

One of the key elements of the Enterprise Oracle Upgrade program is to determine the most appropriate upgrade strategy for database instances. Customers usually perform in-place upgrades when there is no change in the underlying hardware. However, some customers might opt for hardware refresh or update and in such scenarios, ‘out-of-place’ or ‘side-by-side’ upgrade methods are used for database upgrade. Some customers perform a platform migration in conjunction with the Oracle upgrade (for example, migration from Solaris to Linux or vice-versa).

In the following sub-sections the Oracle Database Upgrade strategy options are discussed at a high level.

In-place Upgrades

In-place upgrade of Oracle databases can be performed in two ways which are as follows:

- **Database Upgrade Assistant (DBUA):** DBUA is used to guide and perform an in-place upgrade of the database. It supports Oracle Real Application Clusters (RAC) and Automatic Storage Management (ASM). DBUA is a GUI utility and is an interactive tool that evaluates the current database functions and recommends remediation that can be applied during the upgrade process. Once the remediation suggestions are reviewed and accepted, the DBUA then upgrades the database.

- **Manual Upgrade (Script Based):** Manual upgrade involves the DBAs developing and executing upgrade scripts in a step-by-step manner following an upgrade checklist. This provides a greater level of control, but increases the risk, since the steps need to be performed manually in a specified order.

Out-of-place Upgrades

Out-of-place upgrade of Oracle databases can be performed in the following ways:

- **Export/Import:** Oracle export/import utility can be used for migrating Oracle Databases from 8i to 10g. The major concern when using this approach is the available downtime which is directly proportional to the size of the database. The export/import option may not be the suitable option for large size critical databases.
Transportable Tablespaces (TTS): Transportable tablespace option allows a set of tablespaces to be moved from one Oracle database to another. The movement of data using transportable tablespaces is much faster than performing either an export/import or unload/load of the same data, as the data files are simply copied to the destination location. In this case, the import utility is used to transfer the metadata of the tablespace objects to the new database.

Standby Databases: The database migration is achieved by creating a standby database in the target, upgrading it using conventional methods like DBUA and switching over the database. The restriction in using this option is that the primary and standby databases should belong to the same family of the Operating System (OS).

Complex Upgrade Options: There are other complex upgrade options which consume less downtime. Oracle GoldenGate is one such product which helps in ‘rolling’ database upgrades with near-zero downtime. Oracle GoldenGate enables exchange and manipulation of data at the transaction level among multiple, heterogeneous platforms across the enterprise. Its modular architecture provides the flexibility to extract and replicate selected data records, transactional variations and changes to Data Definition Language (DDL) across various topologies. The flexibility, transformation and custom processing features of Oracle GoldenGate enable it to be used during side-by-side database upgrades.

Choosing a Right Upgrade Strategy

Choosing a right upgrade strategy requires an evaluation of the following criteria:

- Acceptable downtime of the database during the upgrade
- Quantum of data involved in the upgrade/migration
- Need for change in the hardware and/or operating system
- Technical expertise available in the IT organization, especially for complex database upgrades involving techniques like GoldenGate and so on.

The upgrade strategy may vary for each database instance in the enterprise based on existing evaluation criteria. However, it is recommended that enterprises adopt a minimum set of upgrade approaches for a database upgrade program. This clearly indicates that the DBAs need to use tools or build scripts to automate the upgrade process and thereby improve productivity.
Approach for Enterprise Oracle Upgrade Program

The following figure illustrates the approach for Enterprise-wide Oracle Database Upgrade program.

The subsequent sections provide a detailed explanation on each phase of the upgrade program.

**Ideate Phase**

The database upgrade program is initiated by defining the scope and vision. The ideate phase consists of the following activities:

- Produce a skeleton scope document
- Prepare Rough Order of Magnitude (ROoM) of Capital Expenses (CapEx) and Operational Expenses (OpEx)
- Identify and engage all stakeholders and vendors impacted by the initiative
- Confirm and secure funding for the discovery and planning phase
Discovery and Planning Phase

Discovery

The discovery phase primarily involves preparing a comprehensive inventory of Oracle databases, dependent applications, IT Infrastructure components (Server and Storage) and technology products used by the applications and database management/administration team and so on. A majority of information can be obtained from various sources such as the Configuration Management Database (CMDB) or any kind of enterprise repository available with the IT organization. In cases where the information is not readily available, it will be gathered by means of questionnaires and data collection templates circulated to the relevant stakeholders.

Preparation of a comprehensive inventory and baselining it is a key factor for the success of the upgrade program. The inventory consists of the following components:

- **Database Inventory** – It involves collecting the source environment database details along with other information such as hostname, version, environment (production/integration/development/QA and so on) and applications using the database, database patch/maintenance level and so on.

- **Database Server Inventory** – It involves collecting information such as server model, CPU count, OS version and patch level, server CPU utilization levels and so on.

- **Application Inventory** – It involves collecting the source application details along with other information such as the associated Oracle database, application criticality, application availability classification, technologies used, vendor (Commercial Off-the-Shelf (COTS) product packages/application support vendor and so on), web server/application server version and patch set details, application architecture style (workstation based/multi-tier application/monolithic) and so on.

- **Technology Products and Tools Inventory** – It involves collecting details such as database administration and maintenance tools, reporting utilities, data replication tools, ETL tools and so on.

Impact Analysis

Impact analysis is performed to understand the impact of the database upgrade on applications, operating systems, database objects, tools, products and so on.

Impact analysis involves the following:

- Identification of application components impacted by the upgrade in the form of SQL changes, changes in behavior of SQL statements or usage of new Oracle reserved keywords

- Analyzing and determining the impact on hardware, OS, tools and products

- Determining the vendor certification for the database upgrades in case of third party package software or COTS packages

- Determining the minimum level to which a database can be upgraded, if other application components or technologies cannot. (For instance, an application using Weblogic 8.0.x may not be compatible with Oracle 11gR2)
Planning

Planning phase involves creation of a roadmap and the business benefits case for the Oracle Upgrade. It involves the following:

- Determining the suitable upgrade strategy, path and methodology for each database instance
- Planning the capacity for the target state infrastructure (servers and storage)
- Developing strategies for testing, backup, back-out, monitoring and so on
- Estimating the effort for upgrading the following:
  - System Administration (Unix / Linux Server and Storage admin)
  - Oracle Database Administrators (Application DBAs)
  - Oracle System DBAs
  - Application remediation
  - Application testing
  - Tools/products upgrades/changes
  - Program Management and Co-ordination
- Detailed implementation planning and scheduling of upgrades
- Fall back planning
- Risk and mitigation planning
- Cost benefit analysis
- Preparation of a business case for upgrade

Rollback Strategy

An important best practice to be followed while upgrading the database is to always have a well-tested rollback strategy. If the upgraded database is unstable or its performance is poor and there is no time to troubleshoot the issue, consider downgrading or implementing the rollback plan to return to the previous version.

A comprehensive rollback plan including application rollback consideration, products/packages/tool upgrade related rollback and database level rollback should be developed prior to the upgrade of each database instance. It is also recommended to test the rollback process at least once for each of the upgrade strategies that are adopted (for example, script based, export/import and so on) in the development environments.

Proof of Concept Considerations

Proof-of-Concepts (PoCs) should be performed prior to the enterprise-wide upgrade program to fine-tune and revise the strategy, findings and conclusions made during the discovery and planning phase.
PoCs are performed in the following scenarios:

- Compatibility testing of certain out-of-support application software that is used in the enterprise
- Compatibility testing of certain products/product versions which are not certified to work with target versions of the Oracle database
- Testing the feasibility of an untested upgrade method
- Improving confidence in IT application teams that are reluctant to upgrade

The PoC consists of the following steps:

- Identifying the databases, applications and products to be used in PoC
- Performing the database upgrade
- Performing application testing/product compatibility testing
- Documenting the challenges, lessons learnt and results
- Refining/fine-tuning the upgrade strategy and deployment plan

**Build and Test Phase**

The build and test phase primarily consists of non-production environment upgrades, application remediation and testing.

**Non-Production Environment Upgrade**

Non-production environments (development, integration, User Acceptance Testing (UAT)/Quality Assurance (QA), training and so on) are upgraded and tested in this stage.

The activities listed in the following table are performed in this stage:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Responsible Team</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server Provisioning</td>
<td>System Administration (Unix / Linux Admin)</td>
<td>In cases, where a new hardware is procured to build target (upgraded) databases, the operating system is built and the server is deployed in the network.</td>
</tr>
<tr>
<td>Storage Provisioning</td>
<td>Storage Administrator</td>
<td>The required storage is allocated to Storage Area Network (SAN) and mapped to respective servers.</td>
</tr>
<tr>
<td>Oracle Installation</td>
<td>Oracle System DBA or Oracle DBA</td>
<td>The new Oracle software is installed in the target server.</td>
</tr>
<tr>
<td>Oracle Upgrade</td>
<td>Oracle DBA</td>
<td>In-place upgrade or side-by-side upgrade involving data migration is performed using the selected upgrade method (export/import, TTS and so on).</td>
</tr>
<tr>
<td>Database Validation</td>
<td>Oracle DBA</td>
<td>The database object counts, row-counts and so on are validated in this step. This step is critical in case of side-by-side upgrade.</td>
</tr>
<tr>
<td>User Validation / Checkout</td>
<td>IT Application Teams</td>
<td>The upgraded database is validated and tested by the IT application users.</td>
</tr>
</tbody>
</table>

*Table 1: Non-Production Environment Upgrade Activities*
The database upgrade in the non-prod environment is followed by remediation of known application compatibility issues. This will follow a full-fledged application functional testing and solving any upgrade related incompatibilities that are discovered during functional testing. Depending on the criticality of the application, several other types of testing (performance, regression and so on) will be carried out to ensure a defect-free deployment.

**Application Remediation**

Baseline functional and performance testing is performed prior to the database upgrade using the current database version. Application access paths are saved in a repository to create a performance baseline and the application remediation changes are documented.

The application changes in connection with the upgrade are primarily due to database version/release related incompatibilities which are as follows:

- Removal of deprecated/un-supported features
- Making adjustment to change the behavior of SQL statements (for example, Oracle 10g requires an explicit “order by” clause to ensure that the statements using “group by” produce results in a sorted order)
- Making adjustments to application programs or stored procedures due to release specific changes (for example, new SQL codes are introduced which needs to be handled by the application)

Application remediation is typically handled by the respective Business As Usual (BAU) application support teams. However, some IT organizations deploy a shared services team called “Application Remediation”, which will perform activities like baseline testing, application remediation changes and post-upgrade testing.

**Testing Guidelines**

The high-level testing guidelines listed in the following table are recommended for Oracle Upgrade programs.

<table>
<thead>
<tr>
<th>Type of Testing</th>
<th>Responsible Team</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Testing</td>
<td>IT Application Teams</td>
<td>Baseline functional and performance testing is performed prior to the upgrade using the existing database version. Application access paths are stored for performance critical applications.</td>
</tr>
<tr>
<td>Unit Testing</td>
<td>IT Application Teams</td>
<td>The planned application changes are unit tested.</td>
</tr>
<tr>
<td>Functional Testing</td>
<td>IT Application Teams</td>
<td>The test coverage varies from 70% to 20% depending on the criticality of the application.</td>
</tr>
<tr>
<td>Fallback Testing</td>
<td>DBA Team</td>
<td>A trial rollback testing for the upgrade ‘execute’ rollback is carried out at least once for each of the upgrade methods that are adopted (for example, manual scripts, TTS, export/import and so on).</td>
</tr>
<tr>
<td>Performance Testing</td>
<td>IT App Teams</td>
<td>It is recommended for performance critical applications.</td>
</tr>
<tr>
<td>User Acceptance</td>
<td>IT Application Teams</td>
<td>All production implementations will be preceded by a UAT in the designated environment.</td>
</tr>
</tbody>
</table>

*Table 2: Testing Guidelines*
Deployment Phase

This phase primarily involves deployment planning and execution of the database upgrade for the production databases and also the associated Disaster Recovery (DR) databases if any.

Deployment Planning

A full-fledged deployment planning is the key to ensure a smooth roll-out of production database upgrade. Though the set of tasks may seem similar for all database upgrades, it is strongly recommended to have a separate detailed plan (typically known as “run-book”) for each and every production database deployment. This is because no two deployments are identical and there will be specific tasks to be performed for a given database.

A comprehensive deployment plan should address the following:

- Identification of all affected applications (including dependent applications which have upstream and downstream dependencies) for a given database
- Identification of all processes (such as batch jobs that are scheduled through an enterprise scheduler) to be put on “hold” during the upgrade activities and later triggered after a successful upgrade
- Identification of a run-book comprising the chronological sequence of events and milestones such as:
  - Preparatory and pre-requisite tasks/milestones to be accomplished prior to the scheduled downtime for the upgrade
  - Tasks and assigned responsibility during the upgrade
  - Post upgrade validation tasks performed by the DBA team
  - Post upgrade configuration changes performed by administrators (for example, TNS entry changes in LDAP servers)
  - Post upgrade IT/business checkout/validation of application components
  - Go/no-go decision
  - Rollback steps in the event of a no-go decision
- Stakeholder communication plan covering all affected applications and support groups involved in the upgrade activities directly or indirectly
- A comprehensive list and contact details of stakeholders, including the on-call support personnel who may be required during the upgrade process
- A timeline estimate of the upgrade activities especially if it involves a sizeable downtime and is performed using methods like export/import, TTS and so on. The timeline should also include the estimates for a possible rollback in the event of a no-go decision by the application teams
- Rollback plan
Program Planning

Following figure illustrates the key service components involved in the Enterprise Oracle Upgrade program.

Another key to the success of Enterprise Oracle Upgrade initiatives is the establishment of a strong program management function and governance framework. An enterprise-wide upgrade program requires extensive coordination across various groups in the IT organization and external vendors. A Program Steering Group (PSG) comprising senior IT managers is essential to ensure a sustained commitment from all the involved parties. The PSG should have representatives from senior management belonging to various functions like application development/maintenance, database administration, infrastructure services, QA, production support and so on.
TCS has pioneered a ‘factory model’ for executing large-scale database upgrade programs, which has been very effective and operational in several customer sites. The ‘upgrade factory’ is essentially a core team that consists of dedicated resources with an end-to-end perspective of the upgrade program. The core team comprises program and project managers, database administrators and application impact analysts who will work through-out the lifecycle of the upgrade program starting from the discovery and planning phase through the deployment phase. They engage the respective Business-As-Usual (BAU) teams like infrastructure (server and storage administrators), system, application DBA team, application support teams and so on, in various stages of the project according to the program schedule. Some of the critical tasks performed by the BAU teams are also coordinated and tracked by the upgrade program management team and some other tasks are managed by the respective teams themselves.

**Challenges Faced**

The most common challenges faced during the enterprise-wide Oracle Upgrade programs are as follows:

- Application complexity and legacy nature of applications often makes application analysis/technology compatibility analysis or upgrade feasibility analysis challenging
- Lack of application/environment knowledge makes application discovery a critical issue
- Shared databases (databases shared by multiple applications and stakeholder groups within the enterprise) often create challenges while scheduling upgrades due to strict SLAs on the database availability
- Retrofitting application remediation changes (due to the Oracle database upgrade) along with planned/ongoing application initiatives/changes.

**Best Practices**

The following are some of the important best practices to be considered while executing enterprise- wide database upgrade programs:

- Baseline the existing inventory prior to the start of the ‘Build and Test’ phase
- Review and sign-off of the discovery elements should be done by all the relevant stakeholders by the end of the ‘Discovery and Planning’ phase
- Ensure that proper change control mechanisms are in place to address any scope changes that are encountered after the ‘Discovery and Planning’ phase
- Establish weekly or fortnightly reviews by the program steering group
- Establish forums (intranet portal or a recurring meeting or knowledge management portal) to discuss issues faced and lessons learned
- Ensure participation from all application teams in the knowledge sharing mechanism
- Maintain a technical issue register which describes the issues faced, symptoms, analysis performed, root cause, solution and so on.
**Conclusion**

A large and complex enterprise-wide Oracle database upgrade strategy may seem daunting at first, but the enterprise should take incremental steps to get started on implementing the strategy and overcoming the obstacles by utilizing new technologies readily available in the market. The following key factors need to be considered for a successful Enterprise-wide database upgrade program:

- Establish a Program Steering Group (PSG)
- Define clear roles and responsibilities for the upgrade teams and stakeholders
- Define appropriate upgrade strategy and “run-book” for each and every database
- Ensure participation and commitment from all stakeholders
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