Best Practices for Deployments with Large Data Volumes

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@salesforcedocs

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CONTENTS

BEST PRACTICES FOR DEPLOYMENTS WITH LARGE DATA VOLUMES

Introduction

Who Should Read This

This paper is for experienced application architects who work with Salesforce deployments that contain *large data volumes*.

A "large data volume" is an imprecise, elastic term, but if your deployment has tens of thousands of users, tens of millions of records, or hundreds of gigabytes of total record storage, then you can use the information in this paper. A lot of that information also applies to smaller deployments, and if you work with those, you might still learn something from this document and its best practices.

To understand the parts of this paper that deal with details of Salesforce implementation, read https://developer.salesforce.com/page/Multi_Tenant_Architecture.

Overview

Salesforce enables customers to easily scale their applications up from small to large amounts of data. This scaling usually happens automatically, but as data sets get larger, the time required for certain operations might grow. The ways in which architects design and configure data structures and operations can increase or decrease those operation times by several orders of magnitude.

The main processes affected by differing architectures and configurations are the:

- Loading or updating of large numbers of records, either directly or with integrations
- Extraction of data through reports and queries, or through views

The strategies for optimizing those main processes are:

- Following industry-standard practices for accommodating schema changes and operations in database-enabled applications
- Deferring or bypassing business rule and sharing processing
- Choosing the most efficient operation for accomplishing a task

What's in This Paper

- Techniques for improving the performance of applications with large data volumes
- Salesforce mechanisms and implementations that affect performance in less-than-obvious ways
- Salesforce mechanisms designed to support the performance of systems with large data volumes

Underlying Concepts

This section outlines two key concepts, multitenancy and search architecture, to explain how Salesforce:

- Provides its application to customers' instances and organizations
- Keeps supported customizations secure, self contained, and high performing
- Tracks and stores application data
- Indexes that data to optimize searching

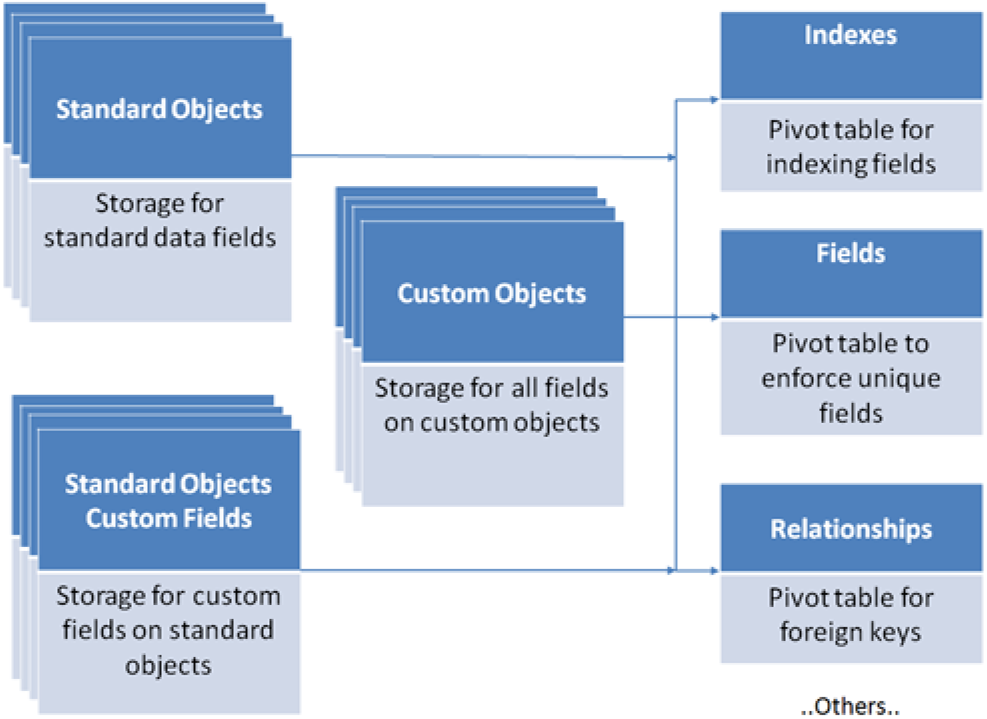
IN THIS SECTION:

Multitenancy and Metadata Overview

Multitenancy is a means of providing a single application to multiple organizations, such as different companies or departments within a company, from a single hardware-software stack. Instead of providing a complete set of hardware and software resources to each organization, Salesforce inserts a layer of software between the single instance and each organization's deployment. This layer is invisible to the organizations, which see only their own data and schemas while Salesforce reorganizes the data behind the scenes to perform efficient operations.

Multitenancy requires that applications behave reliably, even when architects are making Salesforce-supported customizations, which include creating custom data objects, changing the interface, and defining business rules. To ensure that tenant-specific customizations do not breach the security of other tenants or affect their performance, Salesforce uses a runtime engine that generates application components from those customizations. By maintaining boundaries between the architecture of the underlying application and that of each tenant, Salesforce protects the integrity of each tenant's data and operations.

When organizations create custom objects, the platform tracks metadata about the objects and their fields, relationships, and other object definition characteristics. Salesforce stores the application data for all virtual tables in a few large database tables, which are partitioned by tenant and serve as heap storage. The platform's engine then materializes virtual table data at runtime by considering the corresponding metadata.


Standard Objects
Storage for standard data fields
Custom Objects
Storage for all fields on custom objects
Standard Objects Custom Fields
Storage for custom fields on standard objects
Indexes
Pivot table for indexing fields
Fields
Pivot table to enforce unique fields
Relationships
Pivot table for foreign keys
..Others..

Instead of attempting to manage a vast, ever-changing set of actual database structures for each application and tenant, the platform storage model manages virtual database structures using a set of metadata, data, and pivot tables. Thus, if you apply traditional performance-tuning techniques based on the data and schema of your organization, you might not see the effect you expect on the actual, underlying data structures.

Note: As a customer, you also cannot optimize the SQL underlying many application operations because it is generated by the system, not written by each tenant.

Search Architecture

Search is the capability to query records based on free-form text. The Salesforce search architecture is based on its own data store, which is optimized for searching for that text.

Salesforce provides search capabilities in many areas of the application, including:

- The sidebar
- Advanced and global searches
- Find boxes and lookup fields
- Suggested Solutions and Knowledge Base
- Web-to-Lead and Web-to-Case
- Duplicate lead processing
- Salesforce Object Search Language (SOSL) for Apex and the API

For data to be searched, it must first be indexed. The indexes are created using the search indexing servers, which also generate and asynchronously process queue entries of newly created or modified data. After a searchable object's record is created or updated, it could take about 15 minutes or more for the updated text to become searchable.

Salesforce performs indexed searches by first searching the indexes for appropriate records, then narrowing down the results based on access permissions, search limits, and other filters. This process creates a *result set*, which typically contains the most relevant results. After the result set reaches a predetermined size, the remaining records are discarded. The result set is then used to query the records from the database to retrieve the fields that a user sees.

Tip: Search can also be accessed with SOSL, which in turn can be invoked using the API or Apex.

Infrastructure for Systems with Large Data Volumes

This section outlines:

- Salesforce components and capabilities that directly support the performance of systems with large data volumes
- Situations in which Salesforce uses those components and capabilities
- Methods of maximizing the benefits you get from the Salesforce infrastructure

IN THIS SECTION:

Force.com Query Optimizer

Because Salesforce's multitenant architecture uses the underlying database in unusual ways, the database system's optimizer cannot effectively optimize Salesforce queries unaided. The Force.com query optimizer helps the database system's optimizer produce effective execution plans for Salesforce queries, and it is a major factor in providing efficient data access in Salesforce.

The Force.com query optimizer works on the queries that are automatically generated to handle reports, list views, and both SOQL queries and the other queries that piggyback on them.

The Force.com query optimizer:

1. Determines the best index from which to drive the query, if possible, based on filters in the query
2. Determines the best table to drive the query from if no good index is available
3. Determines how to order the remaining tables to minimize cost
4. Injects custom foreign key value tables as needed to create efficient join paths
5. Influences the execution plan for the remaining joins, including sharing joins, to minimize database input/output (I/O)
6. Updates statistics

Database Statistics

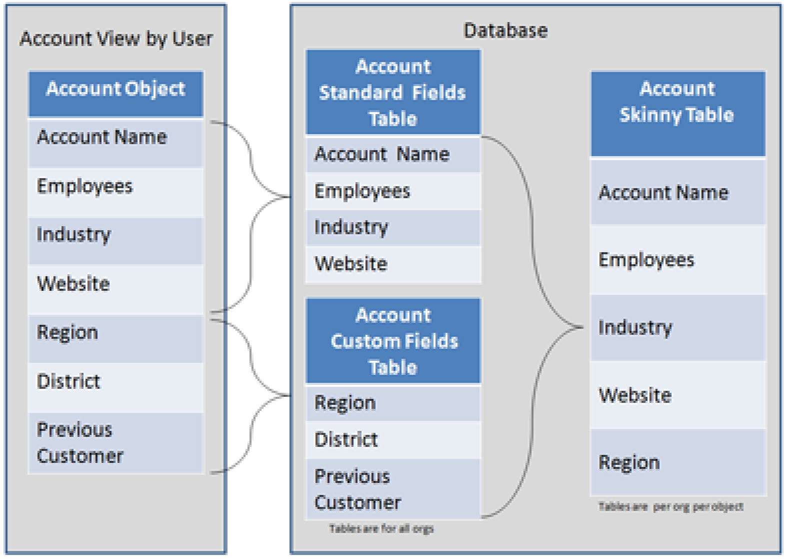
Modern databases gather statistics on the amount and types of data stored inside of them, and they use this information to execute queries efficiently. Because of Salesforce's multitenant approach to software architecture, the platform must keep its own set of statistical information to help the database understand the best way to access the data. As a result, when large amounts of data are created, updated, or deleted using the API, the database must gather statistics before the application can efficiently access data. Currently, this statistics-gathering process runs on a nightly basis.

Skinny Tables

Salesforce creates *skinny tables* to contain frequently used fields and to avoid joins, and it keeps the skinny tables in sync with their source tables when the source tables are modified. To enable skinny tables, contact Salesforce Customer Support.

For each object table, Salesforce maintains other, separate tables at the database level for standard and custom fields. This separation ordinarily necessitates a join when a query contains both kinds of fields. A skinny table contains both kinds of fields and does not include soft-deleted records.

This table shows an Account view, a corresponding database table, and a skinny table that would speed up Account queries.



Skinny tables are most useful with tables containing millions of records. They can be created on custom objects, and on Account, Contact, Opportunity, Lead, and Case objects. In addition, they can enhance performance for reports, list views, and SOQL.

Skinny tables can contain the following types of fields.

- Checkbox
- Date
- Date and time
- Email
- Number
- Percent
- Phone picklist
- Picklist (multi-select)
- Text
- Text area
- Text area (long)
- URL

Here is an example of how a skinny table can speed up queries. Instead of using a date range like *01/01/11* to *12/31/11*—which entails an expensive, repeated computation to create an annual or year-to-date report—you can use a skinny table to include a `Year` field and to filter on *Year = '2011'*.

Considerations

- Skinny tables can contain a maximum of 100 columns.
- Skinny tables cannot contain fields from other objects.
- For Full sandboxes: Skinny tables are copied to your Full sandbox organizations, as of the Summer '15 release. Previously, they were not.

  For other types of sandboxes: Skinny tables are still not copied to your sandbox organizations. To have production skinny tables activated for sandbox types other than Full sandboxes, contact Salesforce Customer Support.

Indexes

Salesforce supports custom indexes to speed up queries, and you can create custom indexes by contacting Salesforce Customer Support.

Note: The custom indexes that Salesforce Customer Support creates in your production environment are copied to all sandboxes that you create from that production environment.

The platform maintains indexes on the following fields for most objects.

- `RecordTypeId`
- `Division`
- `CreatedDate`
- `Systemmodstamp` (`LastModifiedDate`)
- `Name`
- `Email` (for contacts and leads)
- Foreign key relationships (lookups and master-detail)
- The unique Salesforce record ID, which is the primary key for each object

Salesforce also supports custom indexes on custom fields, except for multi-select picklists, text areas (long), text areas (rich), non-deterministic formula fields, and encrypted text fields.

External IDs cause an index to be created on that field, which is then considered by the Force.com query optimizer.

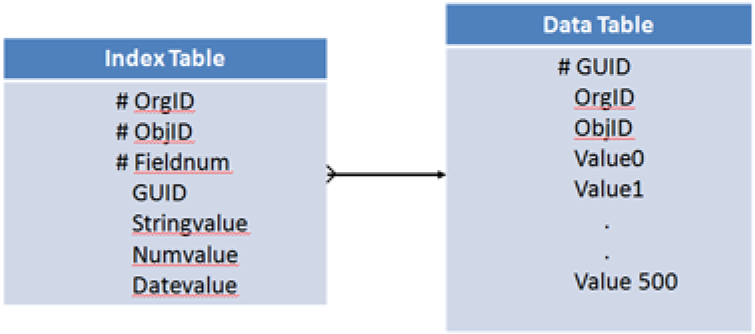
You can create External IDs only on the following fields.

- `Auto Number`
- `Email`
- `Number`
- `Text`

To create custom indexes for other field types, including standard fields, contact Salesforce Customer Support.

Index Tables

The Salesforce multitenant architecture makes the underlying data table for custom fields unsuitable for indexing. To overcome this limitation, the platform creates an index table that contains a copy of the data, along with information about the data types.



The platform builds a standard database index on this index table, which places upper limits on the number of records that can be returned more effectively by an indexed search.

By default, the index tables do not include records that are null (records with empty values). You can work with Salesforce Customer Support to create custom indexes that include null rows. Even if you already have custom indexes on your custom fields, you must explicitly enable and rebuild them to get the empty-value rows indexed.

Standard and Custom Indexed Fields

The Force.com query optimizer maintains a table containing statistics about the distribution of data in each index. It uses this table to perform pre-queries to determine whether using the index can speed up the query.

For example, assume that the Account object has a field called `Account_Type`—which can take the value `Large`, `Medium`, or `Small`—and that the field has a custom index.

For example, Salesforce generates a query like:

```
SELECT *
FROM Account
WHERE Account_Type__c = 'Large'
```

The Force.com query optimizer performs a pre-query to its internal statistics table to determine the number of records with `Large` in the `Account_Type` field. If this number exceeds 10% of the object's total records or 333,333 records, the query does not use the custom index.

The Force.com query optimizer determines what an index is used with.

Standard Indexed Fields

Used if the filter matches less than 30% of the first million records and less than 15% of additional records, up to a maximum of one million records.

For example, a standard index is used if:

- A query is executed against a table with 2 million records, and the filter matches 450,000 or fewer records.
- A query is executed against a table with 5 million records, and the filter matches one million or fewer records.

Custom Indexed Fields

Used if the filter matches less than 10% of the total records, up to a maximum of 333,333 records.

For example, a custom index is used if:

- A query is executed against a table with 500,000 records, and the filter matches 50,000 or fewer records.
- A query is executed against a table with 5 million records, and the filter matches 333,333 or fewer records.

If the criteria for an indexed field are not met, only that index is excluded from the query. Sometimes other indexes are still used if they are in the `WHERE` clause and meet the thresholds for records.

The Force.com query optimizer uses similar considerations to determine whether to use indexes when the `WHERE` clause contains `AND`, `OR`, or `LIKE`.

- For `AND`, the Force.com query optimizer uses the indexes unless one of them returns more than 20% of the object's records or 666,666 total records.
- For `OR`, the Force.com query optimizer uses the indexes unless they all return more than 10% of the object's records or 333,333 total records.

  Note: All fields in the `OR` clause must be indexed for any index to be used.

- For `LIKE`, the Force.com query optimizer does not use its internal statistics table. Instead, it samples up to 100,000 records of actual data to decide whether to use the custom index.

Custom indexes can be created on a formula field if the formula field is deterministic. Because some values vary over time or change when a transaction updates a related entity, the platform cannot index non-deterministic formulas.

Here are examples of things that make formula fields non-deterministic.

Non-deterministic Force.com formula fields can:

- Reference other entities (like fields accessible through lookup fields)
- Include other formula fields that span over other entities
- Use dynamic date and time functions (for example, `TODAY` and `NOW`)

A formula field is also considered non-deterministic if it includes:

- Owner, autonumber, divisions, or audit fields (except for `CreatedDate` and `CreatedByID` fields
  - References to fields that Force.com cannot index
  - Multi-select picklists
  - Currency fields in a multicurrency organization
  - Long text area fields
  - Binary fields (blob, file, or encrypted text)
- Standard fields with special functionalities
  - Opportunity: `Amount`, `TotalOpportunityQuantity`, `ExpectedRevenue`, `IsClosed`, `IsWon`
  - Case: `ClosedDate`, `IsClosed`
  - Product: `ProductFamily`, `IsActive`, `IsArchived`
  - Solution: `Status`
  - Lead: `Status`
  - Activity: `Subject`, `TaskStatus`, `TaskPriority`

Note: If the formula is modified after the index is created, the index is disabled. To re-enable an index, contact Salesforce Customer Support.

Cross-object indexes are typically used if specified using the cross-object notation, as they are in the following example.

```
SELECT Id
FROM Score__c
WHERE CrossObject1__r.CrossObject2__r.IndexedField__c
```

You can use this approach to replace formula fields that cannot be custom-indexed because they reference other objects. As long as the referenced field is indexed, the cross-object notation can have multiple levels.

Two-Column Custom Indexes

Two-column custom indexes are a specialized feature of the Salesforce platform. They are useful for list views and situations where you want to use one field to select records to display and another field to sort them. For example, an Account list view that selects by `State` and sorts by `City` can use a two-column index with `State` in the first column and `City` in the second.

When a combination of two fields is a common filter in the query string, two-column indexes typically help you sort and display records. For example, for the following SOQL, which appears in pseudo code, a two-column index on `f1__c,f2__c` is more efficient than single indexes on `f1__c and f2__c`.

```
SELECT Name
FROM Account
```

```
WHERE f1__c = 'foo'
     AND f2__c = 'bar'
```

Note: Two-column indexes are subject to the same restrictions as single-column indexes, with one exception. Two-column indexes can have nulls in the second column by default, whereas single-column indexes cannot, unless Salesforce Customer Support has explicitly enabled the option to include nulls.

Divisions

Divisions are a means of partitioning the data of large deployments to reduce the number of records returned by queries and reports. For example, a deployment with many customer records might create divisions called `US`, `EMEA`, and `APAC` to separate the customers into smaller groups that are likely to have few interrelationships.

Salesforce provides special support for partitioning data by divisions, which you can enable by contacting Salesforce Customer Support.

Techniques for Optimizing Performance

This section outlines:

- Techniques for optimizing Salesforce performance
- The arrangements, features, mechanisms, and options underpinning those techniques
- Circumstances in which you should use those techniques and tailor them to your needs

IN THIS SECTION:

Using Mashups

One approach to reducing the amount of data in Salesforce is to maintain large data sets in a different application, and then make that application available to Salesforce as needed. Salesforce refers to such an arrangement as a *mashup* because it provides a quick, loosely coupled integration of the two applications. Mashups use Salesforce presentation to display Salesforce-hosted data and externally hosted data.

Salesforce supports the following mashup designs.

External Website

The Salesforce UI displays an external website, and passes information and requests to it. With this design, you can make the website look like part of the Salesforce UI.

Callouts

Apex code allows Salesforce to use Web services to exchange information with external systems in real time.

Because of their real-time restrictions, mashups are limited to short interactions and small amounts of data.

See the *Force.com Apex Code Developer's Guide*.

Advantages of Using Mashups

- Data is never stale.
- No proprietary method needs to be developed to integrate the two systems.

Disadvantages of Using Mashups

- Accessing data takes more time.
- Functionality is reduced. For example, reporting and workflow do not work on the external data.

Defer Sharing Calculation

In some circumstances, it might be appropriate to use a feature called *defer sharing calculation*, which allows users to defer the processing of sharing rules until after new users, rules, and other content have been loaded.

An organization’s administrator can use a defer sharing calculation permission to suspend and resume sharing calculations, and to manage two processes: group membership calculation and sharing rule calculation. The administrator can suspend these calculations when performing a large number of configuration changes, which might lead to very long sharing rule evaluations or timeouts, and resume calculations during an organization’s maintenance period. This deferral can help users process a large number of sharing-related configuration changes quickly during working hours, and then let the recalculation process run overnight between business days or over a weekend.

Using SOQL and SOSL

A SOQL query is the equivalent of a `SELECT` SQL statement, and a SOSL query is a programmatic way of performing a text-based search.

	SOQL	**SOSL**
Executes with	Database	Search indexes
Uses the	`query()` call	`search()` call

Use SOQL when:

- You know in which objects or fields the data resides.
- You want to:
  - Retrieve data from a single object or from multiple objects that are related to one another
  - Count the number of records that meet specified criteria
  - Sort results as part of the query
  - Retrieve data from number, date, or checkbox fields

Use SOSL when:

- You don’t know in which object or field the data resides, and you want to find it in the most efficient way possible.
- You want to:
  - Retrieve multiple objects and fields efficiently, and the objects might or might not be related to one another

  - Retrieve data for a particular division in an organization using the divisions feature, and you want to find it in the most efficient way possible

Consider the following when using SOQL or SOSL.

- Both SOQL `WHERE` filters and SOSL search queries can specify text you should look for. When a given search can use either language, SOSL is generally faster than SOQL if the search expression uses a `CONTAINS` term.
- SOSL can tokenize multiple terms within a field (for example, multiple words separated by spaces) and builds a search index off this. If you're searching for a specific distinct term that you know exists within a field, you might find SOSL is faster than SOQL for these searches. For example, you might use SOSL if you were searching for "John" against fields that contained values like "Paul and John Company".
- In some cases, when multiple `WHERE` filters are being used in SOQL, indexes cannot be used even though the fields in the `WHERE` clause can be indexed. In this situation, decompose the single query into multiple queries, each of which should have one `WHERE` filter, and then combine the results.
- Executing a query with a `WHERE` filter that has null values for picklists or foreign key fields doesn't use the index, and should be avoided.

  For example, the following customer query performs poorly.

  ```
  SELECT Contact__c, Max_Score__c, CategoryName__c, Category__Team_Name__c
  FROM Interest__c
  WHERE Contact__c != null
       AND Contact__c IN :contacts
       AND override__c != 0
       AND ((override__c != null AND override__c > 0)
            OR  (score__c != null AND score__c > 0))
       AND Category__c != null
       AND ((Category_Team_IsActive__c = true OR CategoryName__c IN :selectvalues)
            AND (Category_Team_Name__c != null AND Category_Team_Name__c IN
  :selectTeamValues))
  ```

  `Nulls` in the criteria prevented the use of indexes, and some of the criteria was redundant and extended execution time. Design the data model so that it does not rely on `nulls` as valid field values.

  The query can be rewritten as:

  ```
  SELECT Contact__c, Max_Score__c, CategoryName__c, Category_Team_Name__c
  FROM Interest__c
  WHERE Contact__c IN :contacts
       AND (override__c > 0 OR score__c > 0)
       AND Category__c != 'Default'
       AND ((Category_Team_Name__c IN :selectvalues AND Category_Team_IsActive__c = true)

            OR  CategoryName__c IN :selectvalues)
  ```

  For field `Category__c`, a value is substituted for `NULL`, allowing an index to be used for that field.

  As another example, if dynamic values are being used for the `WHERE` field, and null values can be passed in, don't let the query run to determine there are no records; instead, check for nulls and avoid the query, if possible.

  A query to retrieve an account by its foreign key account number can look like this (in pseudo code).

  ```
  SELECT Name
    FROM Account
  ```

```
 WHERE Account_ID___c = :acctid;

if (rows found == 0) return "Not Found"
```

If `acctid` is `null`, the entire Account table is scanned row by row until all data is examined.

It's better to rewrite the code as:

```
if (acctid != null) {
    SELECT Name
      FROM Account
     WHERE Account_Id___c = :acctid
}
else {
    return "Not Found"
}
```

- When designing custom query-search user interfaces, it's important to:
  - Keep the number of fields to be searched or queried to a minimum. Using a large number of fields leads to a large number of permutations, which can be difficult to tune.
  - Determine whether SOQL , SOSL, or a combination of the two is appropriate for the search.

Deleting Data

The Salesforce data deletion mechanism can have a profound effect on the performance of large data volumes. Salesforce uses a *Recycle Bin* metaphor for data that users delete. Instead of removing the data, Salesforce flags the data as deleted and makes it visible through the Recycle Bin. This process is called *soft deletion*. While the data is soft deleted, it still affects database performance because the data is still resident, and deleted records have to be excluded from any queries.

The data stays in the Recycle Bin for 15 days, or until the Recycle Bin grows to a specific size. The data is then physically deleted from the database after 15 days; when the size limit is reached; or when the Recycle Bin is emptied using the UI, the API, or Apex. See View and Purge the Recycle Bin.

In addition, the Bulk API supports a *hard delete* (physical delete) option, which allows records to bypass the Recycle Bin and become immediately available for deletion. We recommend that you use the Bulk API's hard delete function to delete large data volumes.

If you want to delete records in a sandbox organization's custom objects immediately, you can try to *truncate* those custom objects. You can contact Salesforce Customer Support for assistance with this task.

Search

When large volumes of data are added or changed, the search system must index that information before it becomes available for search by all users, and this process might take a long time.

See Search Architecture on page 3.

Best Practices

This section lists best practices for achieving good performance in deployments with large data volumes.

The main approaches to performance tuning in large Salesforce deployments rely on reducing the number of records that the system must process. If the number of retrieved records is sufficiently small, the platform might use standard database constructs like indexes or de-normalization to speed up the retrieval of data.

Approaches for reducing the number of records include:

- Reducing scope by writing queries that are narrow or selective

  For example, if the Account object contains accounts distributed evenly across all states, then a report that summarizes accounts by cities in a single state is much broader—and takes longer to execute—than a report that summarizes accounts by a single city in a single state.

- Reducing the amount of data kept active

  For example, if your volume of data is increasing, performance can degrade as time goes by. A policy of archiving or discarding data at the same rate at which it comes into the system can prevent this effect.

These tables feature major goals and the best practices to follow to achieve those goals.

IN THIS SECTION:

Reporting

Goal	Best Practice
Maximizing reporting performance by: • Partitioning data to match its likely use • Minimizing the number of records per object	Reduce the number of records to query—use a value in the data to segment the query. For example, query for only a single state instead of for all states. (See Divisions on page 9.)
Reducing the number of joins	• Minimize the number of: – Objects queried in the report – Relationships used to generate the report • De-normalize data when practical—"over de-normalizing" the data results in more overhead. Use summarized data stored on the parent record for the report. This practice is more efficient than having the report summarize the child records.
Reducing the amount of data returned	Reduce the number of fields queried—only add fields to a report, list view, or SOQL query that is required.

Goal	Best Practice
Reducing the number of records to query	• Reduce the amount of data by archiving unused records—move unused records to a custom object table to reduce the size of the report object. • Use report filters that emphasize the use of standard or custom indexed fields. Use index fields in report filters, whenever possible.

Loading Data from the API

Goal	Best Practice
Improving performance	Use the Salesforce Bulk API when you have more than a few hundred thousand records.
Using the most efficient operations	• Use the fastest operation possible—`insert()` is fastest, `update()` is next, and `upsert()` is next after that. If possible, also break `upsert()` into two operations: `create()` and `update()`. • Ensure that data is clean before loading when using the Bulk API. Errors in batches trigger single-row processing for that batch, and that processing heavily impacts performance.
Reducing data to transfer and process	When updating, send only fields that have changed (delta-only loads).
Reducing transmission time and interruptions	For custom integrations: • Authenticate once per load, not on each record. • Use GZIP compression and HTTP keep-alive to avoid drops during lengthy save operations.
Avoiding unnecessary overhead	For custom integrations, authenticate once per load, not on each record.
Avoiding computations	Use Public Read/Write security during initial load to avoid sharing calculation overhead
Reducing computations	• If possible for initial loads, populate roles before populating sharing rules. 1. Load users into roles. 2. Load record data with owners, triggering calculations in the role hierarchy. 3. Configure public groups and queues, and let those computations propagate.

Goal	Best Practice
	4. Add sharing rules one at a time, letting computations for each rule finish before adding the next one. • If possible, add people and data before creating and assigning groups and queues. 1. Load the new users and new record data. 2. Optionally, load new public groups and queues. 3. Add sharing rules one at a time, letting computations for each rule finish before adding the next one.
Deferring computations and speeding up load throughput	Disable Apex triggers, workflow rules, and validations during loads; investigate the use of batch Apex to process records after the load is complete.
Balancing efficient batch sizes against potential timeouts	When using the SOAP API, use as many batches as possible—up to 200—that still avoid network timeouts if: • Records are large. • Save operations entail a lot of processing that cannot be deferred.
Optimizing the Force.com Web Service Connector (WSC) to work with Salesforce	Use WSC instead of other Java API clients, like Axis.
Minimizing parent record-locking conflicts	When changing child records, group them by parent—group records by the field `ParentId` in the same batch to minimize locking conflicts.
Deferring sharing calculations	Use the defer sharing calculation permission to defer sharing calculations until after all data has been loaded. (See Defer Sharing Calculation on page 10.)
Avoiding loading data into Salesforce	Use mashups to create coupled integrations of applications. (See Using Mashups on page 9.)

Extracting Data from the API

Goal	Best Practice
Using the most efficient operations	• Use the `getUpdated()` and `getDeleted()` SOAP API to sync an external system with Salesforce at intervals greater than 5 minutes. Use the outbound messaging feature for more frequent syncing. • When using a query that can return more than one million results, consider using the query capability of the Bulk API, which might be more suitable.

Searching

Goal	Best Practice
Reducing the number of records to return	Keep searches specific and avoid using wildcards, if possible. For example, search with `Michael` instead of `Mi*`.
Reducing the number of joins	Use single-object searches for greater speed and accuracy.
Improving efficiency	Use the setup area for searching to enable language optimizations, and turn on enhanced lookups and auto-complete for better performance on lookup fields.
Improving search performance	In some cases, partition data with divisions. (See Divisions on page 9.)
Reducing the time it takes to index inserts and updates for large data volumes	See Search Architecture on page 3.

SOQL and SOSL

Goal	Best Practice
Allowing indexed searches when SOQL queries with multiple `WHERE` filters cannot use indexes	Decompose the query—if you are using two indexed fields joined by an `OR` in the `WHERE` clause, and your search has exceeded the index threshold, break the query into two queries and join the results.
Avoiding querying on formula fields, which are computed in real time	If querying on formula fields is required, make sure that they are deterministic formulas. Avoid filtering with formula fields that contain dynamic, non-deterministic references. See Standard and Custom Indexed Fields on page 7.
Using the most appropriate language, SOQL or SOSL, for a given search	See Using SOQL and SOSL on page 10.
Executing queries with null values in a `WHERE` filter for picklists or foreign key fields	Use values such as `NA` to replace `NULLS` options. (See Using SOQL and SOSL on page 10.)
Designing custom query and search user interfaces according to best practices	Use SOQL and SOSL where appropriate, keep queries focused, and minimize the amount of data being queried or searched. (See Using SOQL and SOSL on page 10.)
Avoiding timeouts on large SOQL queries	Tune the SOQL query, reducing query scope, and using selective filters. Consider using Bulk API with bulk query. If you've used the previous suggestions and still get timeouts, consider adding a LIMIT clause (starting with 100,000 records) to your queries. If using batch Apex for your queries, use chaining to get sets of records (using LIMIT) or consider moving filter logic to the execute method.

Deleting Data

Goal	Best Practice
Deleting large volumes of data	When deleting large volumes of data, a process that involves deleting one million or more records, use the hard delete option of the Bulk API. Deleting large volumes of data might take significant time due to the complexity of the deletion process. (See Deleting Data on page 17.)
Making the data deletion process more efficient	When deleting records that have many children, delete the children first.

General

Goal	Best Practice
Avoiding sharing computations	Avoid having any user own more than 10,000 records.
Improving performance	Use a data-tiering strategy that spreads data across multiple objects, and brings in data on demand from another object or external store.
Reducing the time it takes to create full copies of production sandboxes with large data volumes	When creating copies of production sandboxes, exclude field history if it isn't required, and don't change a lot of data until the sandbox copy is created.
Making deployments more efficient	Distribute child records so that no parent has more than 10,000 child records. For example, in a deployment that has many contacts but does not use accounts, set up several dummy accounts and distribute the contacts among them.

Large Data Volumes Case Studies

This section contains:

- Large data volume-related problems that customers have had
- Solutions that customers used—or could have used—to fix those problems

To recognize and solve similar issues, read the following case studies:

IN THIS SECTION:

Sort Optimization on a Query

Multi-Join Report Performance

Data Aggregation

Situation

The customer needed to aggregate monthly and yearly metrics using standard reports. The customer's monthly and yearly details were stored in custom objects with four million and nine million records, respectively. The reports were aggregating across millions of records across the two objects, and performance was less than optimal.

Solution

The solution was to create an aggregation custom object that summarized the monthly and yearly values into the required format for the required reports. The reports were then executed from the aggregated custom object. The summarization object was populated using batch Apex.

Custom Search Functionality

Situation

The customer needed to search in large data volumes across multiple objects using specific values and wildcards. The customer created a custom Visualforce page that would allow the user to enter 1–20 different fields, and then search using SOQL on those combinations of fields.

Search optimization became difficult because:

- When many values were entered, the `WHERE` clause was large and difficult to tune. When wildcards were introduced, the queries took longer.
- Querying across multiple objects was sometimes required to satisfy the overall search query. This practice resulted in multiple queries occurring, which extended the search.
- SOQL is not always appropriate for all query types.

Solutions

The solutions were to:

- Use only essential search fields to reduce the number of fields that could be searched. Restricting the number of simultaneous fields that could be used during a single search to the common use cases allowed Salesforce to tune with indexes.
- De-normalize the data from the multiple objects into a single custom object to avoid having to make multiple querying calls.
- Dynamically determine the use of SOQL or SOSL to perform the search based on both the number of fields searched and the types of values entered. For example, very specific values (i.e., no wild cards) used SOQL to query, which allowed indexes to enhance performance.

Indexing with Nulls

Situation

The customer needed to allow nulls in a field and be able to query against them. Because single-column indexes for picklists and foreign key fields exclude rows in which the index column is equal to null, an index could not have been used for the null queries.

Solution

The best practice would have been to not use null values initially. If you find yourself in a similar situation, use some other string, such as N/A, in place of NULL. If you cannot do that, possibly because records already exist in the object with null values, create a formula field that displays text for nulls, and then index that formula field.

For example, assume the Status field is indexed and contains nulls.

Issuing a SOQL query similar to the following prevents the index from being used.

```
SELECT Name
FROM Object
WHERE Status__c = ''
```

Instead, you can create a formula called Status_Value.

```
Status_Value__c = IF(ISBLANK(Status__c), "blank", Status__c)
```

This formula field can be indexed and used when you query for a null value.

```
SELECT Name
FROM Object
WHERE Status_Value__c = 'blank'
```

This concept can be extended to encompass multiple fields.

```
SELECT Name
FROM Object
WHERE Status_Value__c = '' OR Email = ''
```

Rendering Related Lists with Large Data Volumes

Situation

The customer had hundreds of thousands of account records and 15 million invoices, which were within a custom object in a master-detail relationship with the account. Each account record took a long time to display because of the Invoices related list's lengthy rendering time.

Solution

The delay in displaying the Invoices related list was related to data skew. While most account records had few invoice records, there were some records that had thousands of them.

To reduce the delay, the customer tried to reduce the number of invoice records for those parents and keep data skew to a minimum in child objects. Using the Enable Separate Loading of Related Lists setting allowed the account detail to render while the customer was waiting for the related list query to complete. See User Interface Settings.

API Performance

Situation

The customer designed a custom integration to synchronize Salesforce data with external customer applications.

The integration process involved:

- Querying Salesforce for all data in a given object
- Loading this data into the external systems
- Querying Salesforce again to get IDs of all the data, so the integration process could determine what data had been deleted from Salesforce

The objects contained several million records. The integration also used a specific API user that was part of the sharing hierarchy to limit the records retrieved. The queries were taking minutes to complete.

In Salesforce, sharing is a very powerful mechanism for making certain records visible to a certain user, and it works very well for UI interactions. However, when used as a high-volume data filter in a SOQL query, performance can suffer because data access is more complex and difficult to process when you use sharing as a filter, especially if you are trying to filter out records in a large data volume situation.

Solution

The solution was to give the query access to all the data, and then to use selective filters to get the appropriate records. For example, using an administrator as the API user would have provided access to all of the data and prevented sharing from being considered in the query.

An additional solution would have been to create a delta extraction, lowering the volume of data that needed to be processed.

You can find more information about how sharing can affect performance in *A Guide to Sharing Architecture*.

Sort Optimization on a Query

Situation

The customer had the following query.

```
SELECT Id,Product_Code__c
FROM Customer_Product__c
WHERE CreatedDate = Last_N_Days:3
```

The query was looking for all the records created in the last three days, but the amount of data in the object exceeded the threshold for standard indexes: 30% of the total records up to one million records. The query performed poorly.

Solution

The query was rewritten as:

```
SELECT Id,Product_Code__c
FROM Customer_Product__c
WHERE CreatedDate = Last_N_Days:3
ORDER BY CreatedDate LIMIT 99999
```

In this query, the threshold checks were not done, and the `CreatedDate` index was used to find the records. This kind of query returns a maximum of 99,999 records in the order that they were created within the last three days, assuming that 99,999 or fewer records were created during the last three days.

Note: In general, when querying for data that has been added over the `Last_N_Days`, if you specify an `ORDER BY` query on an indexed field with a limit of fewer than 100,000 records, the `ORDER BY` index is used to do the query.

Multi-Join Report Performance

Situation

The customer created a report that used four related objects: Accounts (314,000), Sales Orders (769,000), Sales Details (2.3 million), and Account Ownership (1.2 million). The report had very little filtering and needed to be optimized.

Solution

To optimize the report, the customer:

- Added additional filters to make the query more selective and ensured that as many filters as possible were indexable
- Reduced the amount of data in each object, whenever possible
- Kept the Recycle Bin empty. Data in the Recycle Bin affects query performance.
- Ensured that no complex sharing rules existed for the four related objects. Complex sharing rules can have a noticeable impact on performance.

Summary

The Salesforce platform is a robust environment in which native and custom applications can scale to large volumes of data very quickly while continuing to perform well.

You can maximize the benefits of these capabilities by:

- Making queries selective—ensure that reports, list views, and SOQL are using appropriate filters.
- Reducing the amount of active data—use archiving, mashups, and other techniques to reduce the amount of data stored in Salesforce.

Following these two broad principles and the best practices that support them can reduce the impact of large data volumes on Salesforce application performance.