

# **Snowflake Data Cloud: Distinctive potential for your data architecture**





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## Introduction

Data fuels businesses, shaping decisions and spurring growth. Amid rising volumes, firms seek more insights. Yet, traditional methods stumble under this data deluge. There is a visible need for a scalable, advanced solution—a platform to handle, process, and analyze vast data efficiently.

In the dynamic realm of data, scalable warehousing is paramount. Enterprises seek adaptable solutions that harmonize with expanding data, ensuring seamless performance. Amidst cloud offerings, challenges like complexity, expenses, and constrained scalability loom. The pursuit of a solution that transcends these barriers, ushering in unmatched performance and scalability, is crystal clear.



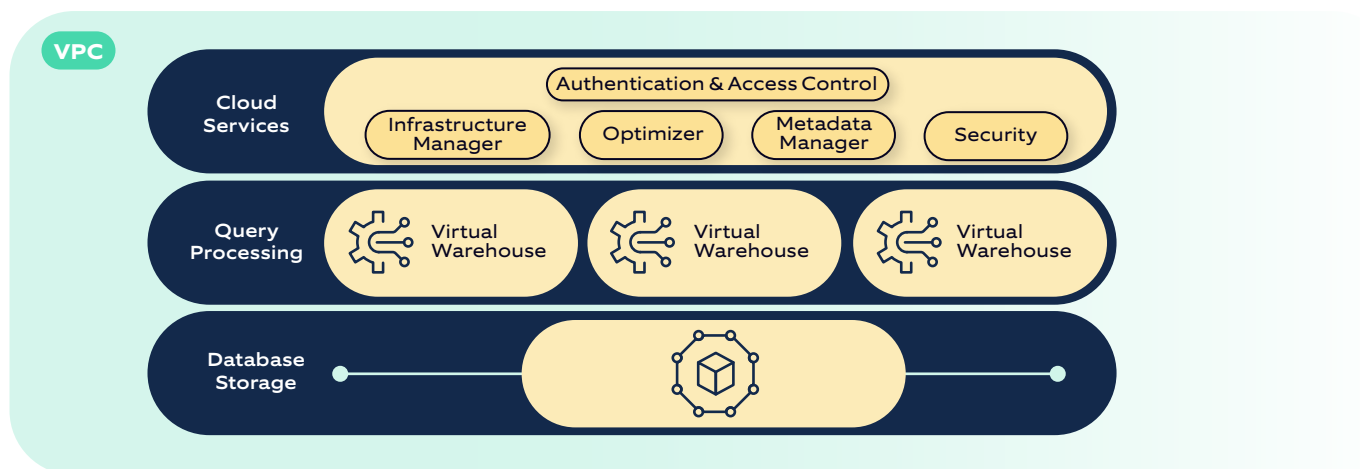


# Snowflake's architecture and reasons behind its technical dominance

Snowflake's architecture revolutionizes data warehousing and analytics. Let's dive in, exploring its inner workings and technical prowess. Understanding Snowflake's core empowers efficient data management and insightful analysis. Join us on this journey to uncover its unique advantages, setting it apart from traditional solutions.

## 1. Key components of Snowflake architecture

The architecture is designed with a logical separation into three distinct layers: this layered approach ensures efficient data management and processing capabilities. This elegant breakdown allows for optimal performance, scalability, and flexibility in handling data.



- **Storage layer**

At the foundation of the architecture lies the Storage Layer. Snowflake leverages cloud-based object storage to store data in a columnar format. This design optimizes query performance, enables efficient compression, and facilitates handling of massive volumes of structured and semi-structured data.

- **Processing layer**

Situated above the Storage Layer is the Processing Layer, which encompasses Snowflake's unique virtual warehouses. These virtual warehouses provide scalable and parallel execution of queries and analytics workloads. Snowflake achieves optimal resource utilization and elastic scaling by decoupling compute from storage to meet workload demands.

- **Cloud Service layer**

The topmost layer of Snowflake's architecture is the Cloud Service Layer, serving as the control plane. It manages user queries, security, metadata, and resource allocation. The Cloud Service Layer provides a unified interface for users to interact with Snowflake, ensuring seamless integration with various cloud providers. This includes Metadata management, query parsing and optimization, data movement and storage, security, and access controls.



The layers blend independently, a symphony of architecture. Foundation-up, Snowflake empowers data warehousing's marvel—scalability, elasticity, efficiency. Cloud scalability, seemingly limitless, chains storage and CPU. Snowflake innovates, uncoupling these, choreographing CPU's ascent without storage's pull. Precision, cost mastery, true elasticity emerge.

## 2. Data storage and organization in Snowflake

The architecture of Snowflake separates storage and compute, offering a unique data organization. The database resides in the storage layer, housing schemas, tables, and metadata. Snowflake's distinctiveness lies in how it stores actual data. Data ingestion stores it in Amazon S3 as small files, optimizing storage and access efficiency. Each file holds a data portion, managed by Snowflake's intelligent storage layer. Using Amazon S3 brings cost-effectiveness as storage and compute are distinct, allowing resource allocation, cost control, and scalability tailored to storage needs.

## 3. Introduction to virtual warehouses

Snowflake's virtual warehouses are cost-effective, with no extra charges for creation beyond metadata. This unique model separates compute cost from metadata, allowing resource optimization without added expenses. Multiple instances can be set up effortlessly, optimizing resource use, scalability, and costs. Automation features ensure seamless query execution, while auto-scaling adjusts compute resources as workload varies, boosting efficiency and cost savings.

## 4. Redefining performance: Snowflake's optimized execution and scalability

Amidst the dynamic data landscape, Snowflake shines as a cloud luminary. Advanced query optimization crafts lean plans through metadata, rewrites, and filters. Speed reigns with parallel prowess, nodes empowered by partitioning. Elastic scaling and multi-cluster finesse allow seamless adjustments. Snowflake's synergy embodies refined queries, distributed might, and limitless expansion—an ode to data mastery.

This extends to query optimization, embracing Snowflake's techniques for potent performance. Parsing and compilation ensure swift data retrieval. Optimized execution intelligently employs metadata, while caching ensures rapid responses. Adaptive intelligence refines plans, and automatic parallelization optimizes resources. Snowflake's compass navigates to insights, redefining business analysis.



## 5. Benefits of columnar storage

Snowflake's architecture champions columnar storage, a game-changer for data warehousing and analytics. Unlike rows, it stacks data in vertical columns, bringing manifold benefits for streamlined analysis.

Column-wise retrieval zooms in on essential data, speeding queries for quick insights. Uniformity enhances compression, cutting storage needs and costs. Column-level processing suits analytics, accelerating statistical calculations. Snowflake's selective approach trims I/O operations, boosting performance for extensive tasks.

Crucially, its schema evolution shines. It adds columns seamlessly, no data structure overhaul. This innovative design transforms data storage, access, and processing, offering efficiency, cost-effectiveness, and agility in data warehousing.

## 6. Data partitioning and clustering strategies in Snowflake

Snowflake's data strategies drive efficient organization, delivering peak performance and cost-effective processing. Partitioning divides datasets into smaller parts based on keys, evenly distributing across nodes. This boosts parallel processing and minimizes data movement during queries. Smart key selection improves query performance. Combined with dynamic pruning, it accelerates query responses.

Clustering complements partitioning, ordering data for compact, efficient retrieval. In clustered column queries, Snowflake omits irrelevant blocks, reducing I/O and enhancing filtering and aggregating.

Leveraging partitioning and clustering optimizes storage and access, empowering high-performance analytics. These strategies harness data potential, enabling informed decisions.





## 7. Unlocking Snowflake's uniqueness: A symphony of storage and compute brilliance

What sets Snowflake's architecture apart is its distinct separation of storage and compute, combined with its utilization of S3, Azure Blob, or GCS for data storage.

Snowflake's architecture stands out through its innovative division of storage and computation, leveraging S3, Azure Blob, or GCS for data storage. Although these storage options might not match the speed of modern SSDs, the paradox is intriguing. Snowflake, a database focused on data changes, adopts immutable storage. Imagine a database prioritizing query performance while using seemingly slower storage. The outcome is a captivating story that defies norms and sparks curiosity. Quite fascinating, don't you think?

This choice catapults Snowflake miles ahead of its rivals! Piqued your interest? Let's dive into the mechanics behind this with S3:

- A. High availability
- B. Durability
- C. API call is supported to read parts of files

These elements form Snowflake's ballet of resilience and agility, weaving a narrative of enhanced database prowess.

Let's delve into the intricacies. On one hand, the unwavering High Availability of S3/blob/GCS guarantees uptime, making your database a reliable partner. On the other hand, the durability of this storage grants your data a timeless existence. Once stored, your data remains impervious to time. In the database realm, these twin pillars exude confidence, fostering unshakable trust.

But there's more to uncover. Brace yourself for an exceptional feature. Within S3/blob/GCS storage resides a remarkable ability: retrieving any part of a stored file via API calls. Imagine the impact of this performance booster, surpassing even today's advanced SSDs.



As we've seen, Snowflake stores data in small files, partitioned by suitable keys, and in a columnar format. For example,

**The data:**

Transaction ID	Date	Customer ID	Product A	Quantity	Price
1	01-01-2023	C1001	Product A	3	\$50
2	02-01-2023	C1002	Product B	2	\$70
3	03-01-2023	C1001	Product A	1	\$50
4	03-01-2023	C1003	Product C	5	\$30
5	04-01-2023	C1002	Product A	2	\$50
6	04-01-2023	C1004	Product B	3	\$75
7	05-01-2023	C1001	Product C	1	\$30
8	05-01-2023	C1005	Product A	4	\$50
9	06-01-2023	C1003	Product B	2	\$75
10	06-01-2023	C1002	Product A	1	\$50
11	07-01-2023	C1001	Product C	3	\$30
12	07-01-2023	C1006	Product B	4	\$75
13	08-01-2023	C1003	Product A	2	\$50
14	08-01-2023	C1007	Product B	1	\$75
15	09-01-2023	C1001	Product C	5	\$30
16	09-01-2023	C1008	Product A	3	\$50
17	10-01-2023	C1002	Product B	2	\$75
18	10-01-2023	C1003	Product A	1	\$50
19	11-01-2023	C1001	Product C	4	\$30
20	11-01-2023	C1004	Product B	3	\$75
21	12-01-2023	C1003	Product A	1	\$50
22	12-01-2023	C1005	Product B	2	\$75
23	13-01-2023	C1006	Product C	5	\$30
24	13-01-2023	C1007	Product A	3	\$50
25	14-01-2023	C1008	Product B	2	\$75
26	14-01-2023	C1009	Product A	1	\$50
27	15-01-2023	C1010	Product C	4	\$30
28	15-01-2023	C1011	Product B	3	\$75
29	16-01-2023	C1002	Product A	1	\$50
30	16-01-2023	C1003	Product B	2	\$75





**The micro partition organized:**

Mirco Partition 1			Mirco Partition 2			Mirco Partition 3		
<b>Transaction ID</b>			<b>Transaction ID</b>			<b>Transaction ID</b>		
1	2	3	11	12	13	21	22	23
4	5	6	14	15	16	24	25	26
7	8	9	17	18	19	27	28	29
10			20			30		
<b>Date</b>			<b>Date</b>			<b>Date</b>		
01-01-2023	02-01-2023	03-01-2023	07-01-2023	07-01-2023	08-01-2023	12-01-2023	12-01-2023	13-01-2023
03-01-2023	04-01-2023	04-01-2023	08-01-2023	09-01-2023	09-01-2023	13-01-2023	14-01-2023	14-01-2023
05-01-2023	05-01-2023	06-01-2023	10-01-2023	10-01-2023	11-01-2023	15-01-2023	15-01-2023	16-01-2023
06-01-2023			11-01-2023			16-01-2023		
<b>Customer ID</b>			<b>Customer ID</b>			<b>Customer ID</b>		
C1001	C1002	C1001	C1001	C1006	C1003	C1003	C1005	C1006
C1003	C1002	C1004	C1007	C1001	C1008	C1007	C1008	C1009
C1001	C1005	C1003	C1002	C1003	C1001	C1010	C1011	C1002
C1002			C1004			C1013		
<b>Product</b>			<b>Product</b>			<b>Product</b>		
Product A	Product B	Product A	Product C	Product B	Product A	Product A	Product B	Product C
Product C	Product A	Product B	Product B	Product C	Product A	Product A	Product B	Product A
Product C	Product A	Product B	Product B	Product A	Product C	Product C	Product B	Product A
Product A			Product B			Product B		
<b>Quantity</b>			<b>Quantity</b>			<b>Quantity</b>		
3	2	1	3	4	2	1	2	5
5	2	3	1	5	3	3	2	1
1	4	2	2	1	4	4	3	1
1			3			2		
<b>Price</b>			<b>Price</b>			<b>Price</b>		
\$50	\$75	\$50	\$30	\$75	\$50	\$50	\$75	\$30
\$30	\$50	\$75	\$75	\$30	\$50	\$50	\$75	\$50
\$30	\$50	\$75	\$75	\$50	\$30	\$30	\$75	\$50
\$50			\$75			\$75		



The scene is set: Snowflake conducts a data storage symphony. Envision this: data elegantly divided into compact files, 50 to 500 MB each. Yet, that's just the beginning. The magic unfolds as data is partitioned artfully with the ideal keys. The stage brightens, data stands columnar, boosting performance and unleashing analytics' potential.

Stats in the Service layer guide micro partition selection. Once chosen, it fetches data – a database's "Range scan". But wait, micro partitions are those small S3/blob/GCS files. Locating them? A feat, accessing only needed portions, intricate, isn't it?

The magic unfolds with chosen storage. Slow yet impactful, this immutable storage enables Snowflake's exceptional range scan through a dedicated API. This API precisely accesses the required line, showcasing its brilliance. Thus, Snowflake's preference for S3/blob/GCS becomes evident.

Prepare to witness the heart of Snowflake's orchestration, where each note is harmoniously played. Behold the marvel: from the statistics stored within the Service layer, a decision is swiftly conjured – a micro partition is to be summoned. And then, in a breathtaking performance, Snowflake directs its focus to the chosen micro partition, conjuring the data with a mere whisper. A dance known as the Range scan unfolds, akin to a masterful stroke on a canvas of databases.

But here's where the enchantment deepens. Enter the micro partition, a realm of petite files nestling within S3/blob/GCS. To reach the very core of these diminutive files, a delicate maneuver is required – a touch, a precise connection to a segment of that file, and nothing more. A challenge beckons, doesn't it?

But wait, here's where the magic takes center stage – the chosen storage, seemingly plodding and unchanging, transforms into a remarkable guiding force for Snowflake. It unveils a special secret: an open pathway, a gateway unlocked by the cloud provider's API. This API acts like a GPS, leading directly to the specific data point waiting to be read. It's as if the technology harmonizes into a grand performance, a crescendo of awe-inspiring brilliance.

And now, we unveil the inner workings of Snowflake's decision-making process – the why, the how, and the symbiotic connection with S3/blob/GCS. As these puzzle pieces slot into position, a fabric of knowledge begins to materialize before us.



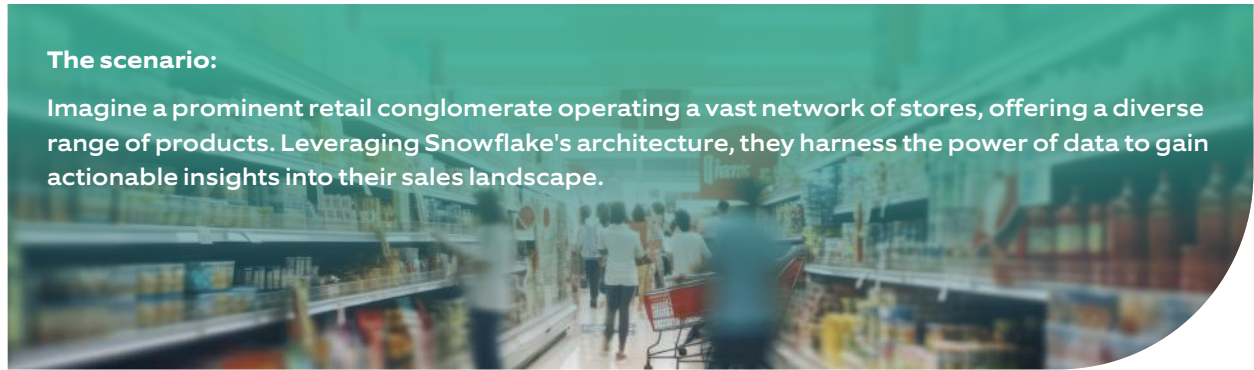
# Real-world use cases and best practices

## 1. Unlocking near-real-time data processing and insights in retail

In today's hyper-competitive retail landscape, the ability to swiftly respond to market shifts and consumer preferences is a strategic imperative. Snowflake's architecture emerges as a catalyst, empowering retailers to process and analyze sales data in near-real time, revolutionizing decision-making and propelling overall business performance.

### The scenario:

Imagine a prominent retail conglomerate operating a vast network of stores, offering a diverse range of products. Leveraging Snowflake's architecture, they harness the power of data to gain actionable insights into their sales landscape.



### How Snowflake drives near-real-time-insights

- **SEAMLESS DATA INGESTION**

Sales data from various stores and locations is effortlessly funneled into Snowflake's cloud-based data warehouse. The data is meticulously organized within Snowflake's framework, ensuring streamlined querying and analysis.

- **RESOURCE ALLOCATION**

The retailer strategically allocates dedicated compute resources by leveraging Snowflake's dynamic virtual warehouses. This precise allocation ensures that analytical operations proceed smoothly, without impeding concurrent processes.

- **REAL-TIME DATA PROCESSING**

Fresh sales transactions are promptly processed and seamlessly integrated into Snowflake's data storage in near-real time. The architecture's robust parallel processing capability expedites insights from substantial data volumes.

- **EFFORTLESS QUERYING**

Retail analysts and decision-makers effortlessly query the data, extracting invaluable insights. Snowflake's architecture adeptly executes complex queries, facilitating the extraction of meaningful patterns and trends.

- **DYNAMIC DASHBOARDS**

Real-time insights come to life through interactive, intuitive dashboards. Executives gain proactive visibility into sales data, enabling agile strategies that respond swiftly to shifting market dynamics.



### Impactful outcomes:

- **AGILE DECISION-MAKING**

Armed with near-real-time insights, the retailer promptly identifies top-performing products and adjusts inventory levels. This proactive approach nimbly prevents stockouts and eliminates overstock situations.

- **TREND DISCOVERY**

Leveraging Snowflake's prowess, the retailer uncovers emerging consumer trends and preferences. Timely detection facilitates the strategic introduction of new products and finely tuned-marketing campaigns.

- **OPTIMIZED INVENTORY MANAGEMENT**

By discerning consumption patterns, the retailer optimizes inventory control. Precise inventory management, driven by insights, results in streamlined procurement processes and reduced storage costs.

- **EFFORTLESS QUERYING**

Retail analysts and decision-makers effortlessly query the data, extracting invaluable insights. Snowflake's architecture adeptly executes complex queries, facilitating the extraction of meaningful patterns and trends.

- **ENHANCED CUSTOMER EXPERIENCE**

Timely insights enable personalized customer experiences, tailoring promotions and offerings to individual preferences. This elevates the retail experience, cultivating lasting customer loyalty.

The Retail industry's transformative journey with Snowflake's architectural brilliance illustrates a paradigm shift in processing and comprehending sales data in near-real time. The results are profound—enhanced decision-making agility, meticulous inventory control, and a retail journey that's anchored in data-driven excellence. This transformative capability extends its promise beyond retail, offering data-driven success across diverse sectors.



## 2. Seamlessly scaling with Snowflake's elastic infrastructure

In the ever-evolving landscape of healthcare, agility and scalability are paramount. Snowflake's architecture emerges as a game-changer, empowering healthcare institutions to scale their data infrastructure, unlocking unparalleled insights and propelling medical innovation.

### The scenario:

Imagine a large healthcare consortium responsible for managing a vast volume of patient data across multiple facilities. Leveraging Snowflake's architecture, they harness the power of elastic scalability to handle surges in data influx and ensure uninterrupted analysis.

### How Snowflake facilitates elastic scalability?

- **DATA INGESTION MASTERY**

Patient data from numerous healthcare facilities seamlessly flows into Snowflake's cloud-based data warehouse. The architecture's sophisticated data organization ensures that diverse data sources are managed effortlessly.

- **ELASTIC COMPUTE RESOURCES**

Snowflake's elastic infrastructure dynamically allocates additional compute resources as data volumes surge. This on-demand scaling ensures consistent performance, even during peak usage periods.

- **RAPID DATA PROCESSING**

The healthcare consortium's researchers and analysts perform complex analyses on massive datasets. Snowflake's architecture accelerates query execution, enabling swift extraction of insights without compromising accuracy.

- **REAL-TIME ANALYTICS**

Near-real-time analytics facilitate monitoring patient trends and treatment outcomes. Snowflake's distributed processing capabilities deliver timely insights, aiding healthcare professionals in making informed clinical decisions.

- **ACCELERATED RESEARCH**

The healthcare consortium's researchers delve into extensive genomic datasets to discover new treatments. Snowflake's architecture empowers parallel processing, expediting genomic analysis and accelerating medical breakthroughs.



## Transformational outcomes:

- **SWIFT CAPACITY ADAPTATION**

By leveraging Snowflake's elastic scalability, the healthcare consortium seamlessly handles fluctuations in patient data volume. Resource allocation scales harmoniously, ensuring uninterrupted operations during critical times.

- **ENHANCED CLINICAL DECISION-MAKING**

Timely insights from real-time data enable healthcare professionals to make informed clinical decisions. Rapid access to patient histories, treatment outcomes, and diagnostic patterns refines patient care.

- **ACCELERATED RESEARCH AND INNOVATION**

Researchers leverage Snowflake's architecture to dissect vast genomic datasets, uncovering genetic markers and potential treatment pathways. Accelerated research paves the way for groundbreaking medical advancements.

- **IMPROVED RESOURCE UTILIZATION**

Elastic scalability optimizes resource utilization, eliminating over-provisioning and reducing operational costs. Healthcare institutions channel resources precisely where needed, enhancing cost-efficiency.

The healthcare industry's journey with Snowflake's architecture is a testament to scalability's transformative potential. Snowflake's elastic infrastructure empowers healthcare institutions to scale seamlessly, accommodate data surges, and drive medical innovation. As healthcare's reliance on data intensifies, Snowflake's architectural brilliance propels the sector into a future of adaptive, data-driven excellence.





# Ensuring security and compliance in Snowflake architecture

In the realm of contemporary data management, concerns expand beyond scalability, performance, and agility. The safeguarding of data integrity and the adherence to regulatory standards take center stage. This section casts a spotlight on the robust security protocols and compliance mechanisms inherent to Snowflake's architecture.

Amidst the dynamic landscape of regulations, Snowflake remains a steadfast guardian of data, employing cutting-edge technologies and strategies. From encryption protocols to access governance, Snowflake ensures data sanctity and compliance, offering tranquility in an ever-evolving digital sphere. Join us as we journey through the bastion of security and compliance intricately woven into Snowflake's architecture.

## 1. Overview of Snowflake's security features

Security is at the core of Snowflake's architecture, with a multitude of meticulously crafted features seamlessly integrated. These elements form a robust defense, ensuring your data's protection and compliance within a dynamic and ever-evolving cloud environment. These elements are:

- **Advanced Access Control** for precise user permissions and data integrity.
- **Enhanced Authentication** with SSO, MFA, and federated authentication.
- **Robust Encryption** for data at rest and in transit, guarding against breaches.
- **Comprehensive Auditing** for compliance, activity tracking, and anomaly detection.
- **Sensitive Data Protection** via masking and redaction, preventing unauthorized access.
- **Compliance Support** meeting industry standards like SOC 2, GDPR, HIPAA.
- **Secure Data Sharing** for collaborative work without compromising privacy.
- **Real-time Threat Detection** to identify and thwart suspicious activities.
- **Immutable Storage** using cloud-based solutions with built-in immutability.
- **Disaster Recovery** ensuring high availability and data redundancy.

These security features collectively establish a robust defense, ensuring data confidentiality, integrity, and availability within your organization.



## 2. Encryption mechanism for data protection

Within Snowflake's architecture, data protection is fortified through advanced encryption mechanisms. These meticulously designed elements contribute to a comprehensive shield, safeguarding your data's confidentiality and integrity, even in the face of modern security challenges. These mechanisms are:

- **Data at Rest Encryption: AES-256 encryption secures stored data, curtailing unauthorized access.**
- **Data in Transit Encryption: SSL/TLS protocols encrypt data transfers, maintaining confidentiality.**
- **Key Management: Encryption keys are kept separate from data, bolstering security.**
- **Transparent Data Encryption (TDE): Seamless encryption before storage and decryption on retrieval.**
- **Customer-Managed Keys: Compliance-centric option for enhanced encryption control.**

These encryption mechanisms provide a comprehensive shield, safeguarding your data from unauthorized access and ensuring its confidentiality and integrity throughout its lifecycle.

## 3. Access controls and user management in Snowflake

Snowflake places paramount importance on access controls and user management, ensuring that data is only accessible by authorized individuals and actions are meticulously monitored. The platform offers a comprehensive suite of features that empower organizations to manage user access with precision.

- **Granular Access Control: Refine permissions at various levels, adhering to least privilege.**
- **Secure Authentication: SSO, MFA, and external identity providers bolster user verification.**
- **Simplified Management: RBAC facilitates role assignment, simplifying administration.**
- **Robust Monitoring: Audit logs track activities, aiding compliance adherence.**
- **Data Privacy: Masking and redaction secure sensitive data, supporting collaboration.**



#### 4. Achieving regulatory compliance with Snowflake

In today's data-driven landscape, regulatory compliance is paramount for organizations across industries. Snowflake's architecture is designed to meet stringent compliance requirements, offering a secure and reliable platform for managing sensitive data while adhering to various regulations.

- **Data Residency and Sovereignty:** Store data where required for compliance with regulations.
- **Auditing and Monitoring:** Transparently track and review data access and activities.
- **Data Retention and Deletion:** Implement and enforce data retention and deletion policies.
- **Transparent Data Encryption (TDE):** Seamless encryption before storage and decryption on retrieval.
- **Collaborative Compliance:** Tools for documenting and demonstrating adherence to regulations, simplifying audits.



# How Nagarro can help you gain a stronger edge in your architecture with Snowflake

Nagarro is a strategic partner of Snowflake that delivers data solutions across the value chain. We are empowering organizations with modern data platforms, by engineering powerful solutions that navigate challenges in traditional data warehousing, enable data-driven decision-making, and reduce costs. We help businesses uncover a new stream of data insights with a modern and scalable data solution.

Our project frameworks, combined with accelerators, businesses, and technical consulting expertise provide unrivaled time to market. This helps ensure early concept validation, stakeholder trust development, and rapid innovation.

We have enabled commodity brokering companies, FMCG enterprises, and several other businesses to leverage cloud data warehousing for business insights.

We can also help you anchor Snowflake's potential and build a solid data transformation strategy, engineer a future-proof data architecture, utilize self-service business analytics for proactive decision-making, and execute an effective data governance framework for data security and quality.

Explore how you can [build modern data platforms with Snowflake Data Cloud](#) that maximize your business value.

[Drop us an email](#) to get in touch with our team of experts for a consultation.



## Author



### Sanjeeva Kumar

Architect (Database)

Sanjeeva Kumar, a seasoned DBA Architect with over 18 years of experience, excels in Oracle database performance tuning and security. His expertise extends to capacity planning, backup strategies, database migration, and innovative solutions. An avid data enthusiast, he's well-versed in Azure and GCP data engineering, actively exploring the nuances of Snowflake to expand his horizons in the ever-evolving world of data management.

Sanjeeva is also a prolific author, having penned numerous blogs and papers on diverse database topics, including backup strategy, MongoDB, InfluxDB, and more, sharing his deep insights and knowledge with the database community.

### About Nagarro

In a changing and evolving world, challenges are ever more unique and complex. Nagarro helps to transform, adapt, and build new ways into the future through a forward-thinking, agile and caring mindset. We excel at digital product engineering and deliver on our promise of thinking breakthroughs. Today, we are 19,500 experts across 35 countries, forming a Nation of Nagarrians, ready to help our customers succeed.

For more information, visit [www.nagarro.com](http://www.nagarro.com).