

Optimizing Cloud-Native Data Warehouses: A Comprehensive Analysis Of Amazon Redshift In Modern Multi-Cloud Analytics Environments

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Abstract: The accelerating digitization of economic and social activity has transformed data into a central productive resource, demanding analytical infrastructures capable of storing, integrating, and processing unprecedented volumes of heterogeneous information at scale. Cloud-native data warehousing has emerged as a foundational response to this demand, enabling elastic, distributed, and service-oriented analytical platforms that diverge fundamentally from traditional on-premise data warehouse architectures. Within this rapidly evolving landscape, Amazon Redshift has become one of the most influential and widely deployed systems, shaping both industry practices and academic understandings of cloud data warehousing. This research article develops a comprehensive theoretical and analytical study of cloud-native data warehousing with a particular emphasis on Amazon Redshift, situating it within broader debates about cloud computing, big data platforms, and modern analytics pipelines. Drawing extensively on the technical, architectural, and operational insights articulated in Worlikar, Patel, and Challa's Amazon Redshift Cookbook (2025), the study integrates practitioner-oriented design patterns with scholarly frameworks of distributed systems, service-oriented computing, and data warehousing theory. The article argues that Redshift represents not merely an incremental technological upgrade but a paradigmatic shift toward simplified, managed, and deeply integrated analytical infrastructures that fundamentally alter how organizations conceptualize data storage, query processing, governance, and scalability.

Through a methodologically rigorous synthesis of documentation, scholarly literature, and architectural case studies, the research analyzes Redshift's core design principles, including its columnar storage model, massively parallel processing architecture, decoupled storage and compute layers, concurrency scaling mechanisms, and tight integration with the Amazon Web Services ecosystem. These features are examined comparatively against alternative cloud data warehouse and analytics platforms offered by Microsoft Azure and Google Cloud, as well as against open-source big data frameworks and legacy on-premise data warehouse systems. The analysis demonstrates that Redshift's architectural philosophy reflects broader trends in cloud computing toward abstraction, automation, and elasticity, while also revealing tensions between vendor-specific optimization and multi-cloud interoperability. The results indicate that while Redshift achieves high levels of performance, operational simplicity, and economic efficiency for many workloads, it also raises critical questions about data lock-in, governance complexity, and the long-term sustainability of highly specialized proprietary ecosystems.

The discussion extends these findings by situating Redshift within ongoing theoretical debates about data warehouse as a service, platformization, and the political economy of cloud infrastructure. By critically engaging with both supportive and skeptical perspectives in the literature, the article outlines how Redshift both exemplifies and complicates the promise of cloud-native analytics. It concludes that understanding Redshift's role in modern data ecosystems requires moving beyond purely technical evaluations toward a more holistic appreciation of how cloud data warehouses reshape organizational power, knowledge production, and the future trajectory of digital economies.

Keywords

Cloud data warehousing, Amazon Redshift, big data analytics, cloud computing architecture, data warehouse as a service, multi-cloud platforms

INTRODUCTION: The historical evolution of data warehousing has been inseparable from broader shifts in computing paradigms, organizational information needs, and the political economy of digital infrastructures. Early data warehouses emerged in an era dominated by centralized mainframes and relational database management systems, where analytical processing was constrained by hardware limitations, rigid schemas, and the high capital costs of enterprise-grade servers (Zhang et al., 2010). These traditional systems were designed primarily for structured, slowly changing data, often extracted from transactional systems through batch-oriented extract, transform, and load processes that reflected the temporal rhythms of organizational reporting cycles. Over time, however, the exponential growth of digital data, driven by web platforms, sensor networks, and mobile devices, rendered these architectures increasingly inadequate, both in terms of scale and in terms of their ability to support real-time or near-real-time analytics (Armbrust et al., 2010).

The rise of cloud computing marked a profound rupture in this trajectory. By abstracting physical infrastructure into virtualized, on-demand services, cloud platforms fundamentally altered the economic and technical assumptions underlying information systems design (Jadeja and Modi, 2012). Storage, compute, and networking resources could now be provisioned elastically, allowing organizations to scale their analytical workloads without the long-term capital commitments that had previously constrained innovation. Within this context, the notion of data warehouse as a service gained prominence, promising to deliver enterprise-grade analytical capabilities through managed, cloud-native platforms that minimized operational complexity while maximizing performance and flexibility (Kaur et al., 2012).

Amazon Redshift occupies a central position in this transformation. Introduced as a fully managed, petabyte-scale data warehouse service, Redshift was explicitly designed to bring the performance characteristics of high-end analytical databases into the elastic, pay-as-you-go environment of the cloud (Gupta et al., 2015). The significance of this shift cannot be overstated: it redefined not only how data warehouses are built and operated, but also how they are conceptualized within organizational strategies for data governance, business intelligence, and advanced analytics. The detailed architectural and operational guidance provided in Worlikar, Patel, and Challa's

Amazon Redshift Cookbook (2025) illustrates how Redshift embodies a synthesis of distributed systems engineering, relational database theory, and cloud-native design principles, offering practitioners a rich set of patterns for constructing modern data warehousing solutions.

Despite the widespread adoption of Redshift and similar platforms, the academic literature has struggled to keep pace with the rapid evolution of cloud-native analytics technologies. Much of the existing research on data warehousing remains rooted in pre-cloud paradigms, emphasizing issues such as dimensional modeling, indexing strategies, and on-premise performance tuning (Almeida and Bernardino, 2008). While these concerns remain relevant, they do not fully capture the socio-technical implications of shifting data warehousing into managed cloud environments where many architectural decisions are abstracted away from end users. Similarly, the literature on cloud computing has often focused on infrastructure and platform services, leaving the specific dynamics of cloud-based analytical systems under-theorized (Goutas et al., 2016).

This gap is particularly evident when considering the role of large cloud providers such as Amazon Web Services, Microsoft Azure, and Google Cloud in shaping the future of data analytics. These platforms do not merely host data warehouses; they actively structure the possibilities of data storage, processing, and integration through their proprietary services, pricing models, and governance frameworks (Borra, 2024). Redshift, for example, is deeply integrated with other AWS services such as S3, DynamoDB, and Elastic MapReduce, creating a tightly coupled ecosystem that offers powerful synergies but also raises concerns about vendor lock-in and interoperability (AWS Documentation, 2024).

The present study seeks to address these theoretical and empirical gaps by developing a comprehensive, critical analysis of Amazon Redshift as a paradigmatic example of cloud-native data warehousing. Drawing on a wide range of scholarly and practitioner-oriented sources, including the in-depth architectural recipes presented by Worlikar et al. (2025), the article situates Redshift within the broader historical evolution of data warehousing and cloud computing. It asks not only how Redshift works, but what its design choices reveal about the changing nature of data infrastructures, organizational power, and knowledge production in the digital age.

To achieve this, the introduction develops several interrelated strands of argument. First, it elaborates the theoretical foundations of data warehousing and cloud computing, tracing how ideas about scalability, distribution, and service orientation have reshaped analytical systems. Second, it reviews the existing literature on cloud-based data warehouses, highlighting both areas of consensus and points of contention among scholars and practitioners. Third, it articulates a clear research gap: while Redshift is widely discussed in technical documentation and industry reports, there is a lack of sustained, theoretically informed analysis that situates it within the broader socio-technical landscape of cloud computing. By addressing this gap, the study aims to contribute not only to the technical understanding of Redshift, but also to the emerging field of cloud infrastructure studies.

The significance of this endeavor is underscored by the increasing centrality of data-driven decision-making across sectors. From finance and healthcare to logistics and public administration, organizations rely on large-scale analytical platforms to generate insights that shape strategic choices and social outcomes. As these platforms migrate to the cloud, questions about their design, governance, and implications become matters of public as well as private concern. Understanding the architecture and operation of systems like Amazon Redshift is therefore not merely a technical exercise; it is a critical component of understanding how contemporary societies organize knowledge and power through digital infrastructures (Verna, 2013).

By integrating detailed architectural analysis with broader theoretical reflection, this article positions Amazon Redshift as both a technological artifact and a socio-economic institution. In doing so, it seeks to move beyond narrow evaluations of performance or cost toward a more holistic appreciation of how cloud-native data warehousing is reshaping the terrain of data analytics. The following sections develop this argument through a rigorous methodological framework, an in-depth presentation of results grounded in the literature, and an extensive discussion that situates these findings within ongoing scholarly debates.

METHODOLOGY

The methodological orientation of this research is grounded in a qualitative, interpretive, and comparative framework designed to capture the multifaceted nature of cloud-native data warehousing systems such as Amazon Redshift. Given the complexity and rapid evolution of cloud infrastructures, purely quantitative or experimental approaches are often

insufficient to reveal the underlying architectural logics, organizational practices, and theoretical implications that shape these systems (Zhang et al., 2010). Instead, this study adopts a systematic literature-based methodology that synthesizes technical documentation, scholarly research, and practitioner-oriented analyses into a coherent analytical narrative. This approach allows for both depth and breadth, enabling a detailed examination of Redshift's internal design while situating it within broader debates about cloud computing and data warehousing.

The primary empirical material for the study consists of a carefully curated corpus of sources drawn from the references provided, encompassing academic journal articles, conference proceedings, technical white papers, cloud provider documentation, and authoritative industry publications. Among these, the Amazon Redshift Cookbook by Worlikar, Patel, and Challa (2025) serves as a central anchor, offering a rich and detailed account of Redshift's architecture, operational patterns, and best practices. This text is treated not merely as a technical manual but as a significant artifact of professional knowledge production, reflecting how practitioners conceptualize and operationalize cloud-native data warehousing in real-world contexts. By integrating its insights with more abstract theoretical frameworks from the academic literature, the methodology seeks to bridge the often-observed gap between theory and practice in information systems research.

The first stage of the methodological process involved a thematic coding of the selected sources, focusing on key concepts such as scalability, distributed query processing, storage architectures, elasticity, data governance, and platform integration. These themes were derived inductively from the literature as well as deductively from established theories of data warehousing and cloud computing (Armbrust et al., 2010; Jadeja and Modi, 2012). Each source was analyzed for how it addressed these themes, allowing patterns of convergence and divergence to be identified across different types of texts, from scholarly articles to vendor documentation. This coding process enabled the construction of an analytical framework that could accommodate both the technical specifics of Redshift and the broader conceptual issues at stake.

The second stage involved a comparative analysis of Amazon Redshift with alternative cloud-based and on-premise data warehousing solutions. Drawing on comparative studies of AWS, Azure, and Google Cloud platforms (Borra, 2024), as well as on documentation from each provider (AWS Documentation, 2024; Microsoft Azure Documentation, 2024; Google Cloud

Documentation, 2024), the research examined how different architectural and service design choices reflect varying philosophies of cloud computing. This comparative perspective is crucial for avoiding the implicit bias that can arise from focusing on a single vendor's ecosystem, and it allows the study to critically assess Redshift's strengths and limitations in relation to its competitors.

A third methodological component involved the use of architectural case narratives derived from practitioner literature, including performance tuning guides, concurrency scaling analyses, and integration scenarios (Soe, 2019; Smallcombe, 2021). These narratives provide concrete illustrations of how Redshift is deployed and optimized in practice, revealing the trade-offs and constraints that accompany its design. Rather than treating these accounts as isolated anecdotes, the methodology situates them within the broader theoretical framework developed from the academic literature, allowing their implications to be interpreted in a systematic and critical manner.

The study also explicitly acknowledges the limitations inherent in a literature-based methodology. Without access to proprietary performance benchmarks, internal system metrics, or large-scale empirical datasets, the analysis cannot provide definitive quantitative claims about Redshift's superiority or inferiority in specific scenarios. Instead, it focuses on interpretive depth, seeking to understand how different sources conceptualize and evaluate Redshift within the evolving landscape of cloud-native analytics (Gupta et al., 2015). This emphasis on interpretive rigor is consistent with established approaches in information systems research that prioritize theoretical insight and contextual understanding over narrow performance metrics (Goutas et al., 2016).

Ethical and epistemological considerations also inform the methodological design. Cloud platforms are not neutral technologies; they embody particular economic interests, governance structures, and power relations (Verna, 2013). Vendor documentation and industry publications, while invaluable sources of technical detail, are also shaped by marketing imperatives and strategic positioning. The methodology therefore adopts a critical stance toward all sources, triangulating claims across multiple texts and situating them within broader scholarly debates. For example, performance claims about Redshift's concurrency scaling features are examined alongside independent evaluations and theoretical discussions of distributed query processing to avoid uncritical acceptance of promotional narratives (Soe, 2019; Smallcombe, 2021).

Finally, the methodological framework is iterative

rather than linear. As insights emerged from the analysis of one set of sources, they informed the interpretation of others, allowing the analytical narrative to evolve in response to the material. This reflexive process is particularly important in a field as dynamic as cloud computing, where new services and architectural patterns continually reshape the conceptual terrain (Borra, 2024). By embracing this iterative logic, the study aims to produce a nuanced and coherent account of Amazon Redshift that is both empirically grounded and theoretically informed.

RESULTS

The analytical synthesis of the literature reveals a complex and multifaceted picture of Amazon Redshift as a cloud-native data warehousing platform. Rather than presenting a simple narrative of technological superiority or inevitable adoption, the results indicate that Redshift embodies a distinctive set of architectural, operational, and organizational trade-offs that reflect broader dynamics in cloud computing and data analytics (Gupta et al., 2015). These findings can be organized around several interrelated dimensions: architectural design, performance and scalability, integration within cloud ecosystems, and implications for data governance and organizational practice.

At the architectural level, Redshift is consistently characterized as a massively parallel processing system built on a shared-nothing architecture, in which data is distributed across multiple compute nodes that operate concurrently to execute analytical queries (AWS Documentation, 2024). This design reflects long-standing principles of parallel database systems, but its implementation in a managed cloud service introduces new layers of abstraction and automation. Worlikar et al. (2025) emphasize that Redshift's architecture is deliberately simplified compared to traditional enterprise data warehouses, with many tuning and maintenance tasks handled automatically by the platform. This simplification is not merely a matter of convenience; it represents a strategic design choice aimed at reducing the operational burden on organizations while enabling them to leverage large-scale parallelism.

The results further indicate that Redshift's columnar storage model plays a critical role in its performance characteristics. By storing data in columns rather than rows, Redshift optimizes I/O for analytical workloads that typically involve scanning large datasets but accessing only a subset of attributes (Gupta et al., 2015). This design aligns with broader trends in analytical database research, which have long recognized the advantages of columnar storage for

read-intensive workloads. However, in the context of a cloud-native system, columnar storage also facilitates more efficient data compression and network transfer, contributing to both performance and cost efficiency (Worlikar et al., 2025).

Scalability emerges as another defining feature of Redshift, but the results reveal that it is achieved through a combination of architectural mechanisms rather than through a single technological innovation. The ability to add or remove nodes dynamically allows organizations to scale their data warehouse in response to changing workloads, a capability that is central to the promise of cloud computing (Jadeja and Modi, 2012). At the same time, features such as concurrency scaling, which temporarily allocate additional compute resources to handle spikes in query demand, illustrate how Redshift seeks to balance performance and cost in a pay-as-you-go environment (Soe, 2019). Independent evaluations of these features suggest that while they can significantly improve throughput under heavy load, they also introduce new layers of complexity in cost management and workload planning (Smallcombe, 2021).

Integration within the broader AWS ecosystem is perhaps one of the most significant results of the analysis. Redshift is not designed to operate in isolation; it is deeply interconnected with services such as Amazon S3 for storage, DynamoDB for NoSQL data, and Elastic MapReduce for big data processing (AWS Documentation, 2024). Worlikar et al. (2025) describe numerous architectural patterns in which Redshift functions as the analytical core of a larger data platform, ingesting data from diverse sources and serving as the basis for business intelligence and advanced analytics. This tight integration offers powerful synergies, enabling organizations to construct end-to-end data pipelines entirely within the AWS environment. However, the results also indicate that this integration can reinforce dependency on a single vendor, raising concerns about portability and long-term flexibility (Borra, 2024).

From an organizational and governance perspective, the results suggest that Redshift reshapes how data warehousing is managed and perceived within enterprises. Traditional data warehouses required specialized teams to handle hardware provisioning, database tuning, and performance optimization, creating a clear division between infrastructure management and analytical use (Almeida and Bernardino, 2008). In contrast, Redshift's managed service model collapses many of these distinctions, allowing analysts and data engineers to focus more directly on data modeling and query development (Worlikar et al., 2025). While this shift can increase

agility and reduce operational overhead, it also centralizes control within the cloud provider, altering the balance of power between organizations and their technology vendors (Verna, 2013).

Collectively, these results paint a picture of Amazon Redshift as a platform that exemplifies the broader transition toward cloud-native, service-oriented data warehousing. Its architectural innovations and operational features enable new forms of scalability, performance, and integration, but they also introduce new dependencies and governance challenges. Understanding these dynamics requires not only technical analysis but also a critical appreciation of the socio-technical context in which Redshift operates, a task that is taken up in greater depth in the following discussion.

DISCUSSION

The findings presented above invite a deeper theoretical and critical interpretation of Amazon Redshift's role within the contemporary landscape of cloud-native data warehousing. Rather than treating Redshift as a neutral technological artifact, this discussion situates it within broader debates about the evolution of cloud computing, the political economy of digital platforms, and the changing epistemology of data-driven organizations. By engaging with multiple scholarly perspectives and juxtaposing them with the architectural realities described by Worlikar et al. (2025), the analysis reveals both the transformative potential and the inherent tensions embedded in Redshift's design.

One of the most salient theoretical implications of Redshift's architecture is its embodiment of what Armbrust et al. (2010) describe as the "illusion of infinite resources" that underpins cloud computing. Through elastic scaling and managed services, Redshift presents organizations with a seemingly boundless analytical environment in which storage and compute can be provisioned on demand. This illusion, however, is carefully engineered through sophisticated resource management, virtualization, and pricing mechanisms that remain largely opaque to end users. From a critical perspective, this opacity can be understood as a form of infrastructural power, in which the cloud provider shapes user behavior and organizational decision-making through the design of its services and cost structures (Goutas et al., 2016).

The simplification of data warehouse operations, so prominently emphasized in the Amazon Redshift Cookbook (Worlikar et al., 2025), illustrates this dynamic vividly. By automating tasks such as vacuuming, backup, and performance tuning, Redshift lowers the barrier to entry for advanced analytics,

enabling a wider range of organizations to deploy large-scale data warehouses. At the same time, this automation obscures the underlying mechanisms that govern performance and cost, potentially limiting users' ability to fully understand or control their analytical environments. Critics of cloud computing have long argued that such abstraction can lead to a loss of organizational autonomy, as key decisions about infrastructure are effectively delegated to proprietary platforms (Verna, 2013).

From a comparative standpoint, Redshift's tightly integrated ecosystem contrasts sharply with the more modular architectures promoted by some open-source and multi-cloud advocates. Platforms built around open frameworks such as Hadoop or Spark emphasize interoperability and portability, allowing organizations to mix and match components across different environments (Almeida and Bernardino, 2015). Redshift, by contrast, derives much of its power from its deep integration with AWS services, which can streamline data pipelines but also entrench vendor dependence (Borra, 2024). This tension reflects a broader debate in cloud computing between the efficiency of vertically integrated platforms and the flexibility of open, heterogeneous ecosystems.

Another important dimension of the discussion concerns the epistemological implications of cloud-native data warehousing. Data warehouses have always been more than mere repositories; they are instruments through which organizations construct and legitimize knowledge about their operations, customers, and environments (Almeida and Bernardino, 2008). By centralizing data in a managed cloud service, Redshift reshapes these processes of knowledge production. The ease with which data can be ingested from diverse sources, transformed, and queried encourages more experimental and iterative forms of analysis, aligning with contemporary practices in data science and machine learning (AWS Documentation, 2024). However, it also raises questions about data sovereignty, privacy, and the concentration of sensitive information within a small number of global cloud providers.

Performance and scalability, often treated as purely technical attributes, also acquire new meanings in this context. The concurrency scaling features described by Soe (2019) and evaluated by Smallcombe (2021) demonstrate how Redshift can dynamically adapt to fluctuating workloads, supporting large numbers of simultaneous users. Yet these capabilities are embedded within a pricing model that monetizes bursts of demand, effectively transforming performance into a commodity. Organizations must therefore navigate a complex trade-off between

responsiveness and cost, a challenge that is both technical and managerial (Gupta et al., 2015). Worlikar et al. (2025) provide numerous strategies for optimizing this balance, but the underlying economic logic remains a defining feature of the platform.

The discussion also highlights the implications of Redshift's design for the future of data warehousing research and practice. Traditional theories of data warehouse architecture, which focus on schema design, indexing, and query optimization, are increasingly supplemented by concerns about cloud governance, service integration, and organizational agility (Kaur et al., 2012). Redshift exemplifies this shift, as many classical optimization tasks are handled automatically by the platform, freeing practitioners to focus on higher-level questions of data modeling and business logic. At the same time, this reorientation challenges researchers to develop new conceptual frameworks that account for the role of cloud providers as active participants in the data ecosystem, rather than as passive infrastructure vendors (Borra, 2024).

Finally, it is important to acknowledge the limitations and contestations that surround Redshift. While its proponents emphasize performance, scalability, and ease of use, critics point to issues such as limited cross-region replication, challenges in handling semi-structured data, and the complexities of migrating large datasets out of the AWS ecosystem (AWS Documentation, 2024). These critiques do not negate Redshift's achievements, but they underscore the need for a balanced and critical perspective that recognizes both its strengths and its constraints. By situating Redshift within a broader theoretical and comparative framework, this study seeks to contribute to such a perspective, encouraging scholars and practitioners alike to engage more deeply with the socio-technical realities of cloud-native data warehousing.

CONCLUSION

The analysis presented in this article has demonstrated that Amazon Redshift occupies a pivotal position in the contemporary evolution of cloud-native data warehousing. Through its combination of massively parallel processing, columnar storage, elastic scalability, and deep integration within the AWS ecosystem, Redshift exemplifies a new generation of analytical platforms that depart fundamentally from traditional on-premise data warehouses. Drawing on the detailed architectural and operational insights provided by Worlikar, Patel, and Challa (2025), as well as on a wide range of scholarly and practitioner-oriented sources, the study has shown that Redshift is not merely a technical tool but a socio-technical system that reshapes how organizations store, analyze, and

govern data.

By situating Redshift within broader theoretical debates about cloud computing, platformization, and data governance, the article has highlighted both the opportunities and the tensions inherent in cloud-native analytics. Redshift's managed service model and elastic architecture enable unprecedented levels of agility and performance, lowering barriers to entry for data-driven innovation. At the same time, its proprietary integration and abstraction of infrastructural control raise important questions about vendor dependence, transparency, and the long-term sustainability of cloud-based data ecosystems. These dynamics suggest that future research and practice must move beyond narrow evaluations of cost or speed to engage more deeply with the organizational, economic, and ethical implications of cloud data warehousing.

In this sense, Amazon Redshift serves as both a powerful analytical engine and a lens through which to examine the changing nature of digital infrastructure. Understanding its role in modern data ecosystems is therefore essential not only for technologists and managers, but for anyone concerned with how data shapes contemporary societies. As cloud-native platforms continue to evolve, the critical and theoretically informed approach developed here offers a foundation for ongoing inquiry into the future of data warehousing in the cloud.

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