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Short Communication



The Imperative for Modern Public Cloud Providers to Upgrade Their Data Centers

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Abstract

This study explores the imperative to modernize cloud computing in response to evolving technological landscapes and business demands. The research examines key areas requiring urgent attention to maintain competitive edge and operational efficiency in the digital era. We investigate the critical need for data center upgrades to accommodate emerging technologies and increased workloads. The study also delves into enhanced security measures and data privacy compliance protocols necessary to protect sensitive information in an increasingly complex threat environment. Furthermore, we analyze strategies to meet the growing demand for performance and scalability, ensuring that cloud infrastructure can adapt to fluctuating business needs. The research emphasizes the importance of maintaining system reliability to minimize downtime and maximize productivity. Additionally, we explore the potential of hybrid cloud integration to enable innovation and reduce costs. The purpose of this study is to provide a comprehensive overview of the challenges and opportunities in modernizing cloud computing, offering insights for organizations seeking to optimize their cloud strategies. Key findings highlight the significance of proactive infrastructure management, the adoption of advanced security frameworks, and the implementation of flexible, scalable architectures. This research contributes to the body of knowledge on cloud computing modernization, serving as a valuable resource for IT professionals, business leaders, and researchers in the field.

Introduction

Cloud computing has revolutionized the way organizations manage and deploy their IT resources, offering unprecedented flexibility, scalability, and cost-efficiency. As of 2024, the global public cloud market continues to experience robust growth, with Gartner projecting worldwide end-user spending on public cloud services to reach \$679 billion by the end of the year [1]. This rapid expansion underscores the critical role of cloud infrastructure in modern business operations and digital transformation initiatives.

However, the ever-evolving technological landscape and increasing user demands are putting significant pressure on existing cloud infrastructures. Legacy systems, while functional, are struggling to keep pace with the requirements of emerging technologies such as artificial intelligence, machine learning, and the Internet of Things (IoT) [2]. Moreover, the COVID-19 pandemic has accelerated digital adoption across industries, further straining cloud resources and exposing vulnerabilities in current architectures [3].

Security concerns remain paramount, with cyberattacks becoming more sophisticated and frequent. A report by Cybersecurity Ventures predicts that cybercrime will cost the

world \$10.5 trillion annually by 2025, highlighting the urgent need for robust security measures in cloud environments [4]. Additionally, regulatory compliance requirements, such as GDPR and CCPA, are becoming increasingly stringent, necessitating more advanced data privacy controls [5].

Performance and scalability issues are also coming to the forefront as businesses demand more from their cloud providers. A study by IDC found that 55% of organizations cite performance as a top challenge in their cloud adoption journey [6]. This underscores the need for cloud infrastructures that can dynamically adapt to fluctuating workloads while maintaining optimal performance.

The aim of this study is to comprehensively examine the key areas requiring modernization in cloud computing infrastructure. By analyzing the need for data center upgrades, enhanced security, and compliance measures, improved performance and scalability, increased reliability, and the potential of hybrid cloud integration, this research seeks to provide valuable insights for organizations looking to optimize their cloud strategies.

This study fulfills its purpose by offering a thorough exploration of the challenges and opportunities in cloud

modernization, supported by current industry data and expert analysis. It serves as a timely resource for IT professionals, business leaders, and researchers, guiding them through the complex landscape of cloud computing upgrades and innovations.

Meeting the growing demand for performance and scalability

As businesses and consumers increasingly rely on cloud services for their day-to-day operations, the demand for high-performance computing and scalable solutions has surged. Data-intensive applications, such as big data analytics, Artificial Intelligence (AI), and Machine Learning (ML), edge computing, require powerful and efficient infrastructure to function optimally. Upgrading data centers with the latest hardware and technologies ensures that public cloud providers can deliver the necessary computational power and storage capacity to handle these demanding workloads. Below are some of the statistics and case studies that show the growth in cloud services demand and the impact on performance.

1. Growth in cloud services demand:

- According to Synergy Research Group, enterprise spending on cloud infrastructure services reached \$178 billion in 2021, growing 37% year-over-year [7].
- Gartner forecasts that global cloud revenue will total \$474 billion in 2022, up from \$408 billion in 2021 [8].

2. Impact on performance:

- A survey by Wakefield Research found that 76% of IT decision-makers reported that slow-running applications significantly impact employee productivity and customer satisfaction [9].
- According to New Relic's 2021 Observability Forecast, 75% of IT leaders expect to maintain or increase their observability budgets to address performance issues [10].

3. Case study 1: Netflix:

- Netflix migrated its streaming service to Amazon Web Services (AWS) to handle its rapid growth. This move allowed Netflix to scale from serving a few million US subscribers to over 200 million global subscribers. The cloud migration improved Netflix's service availability to 99.99% and allowed them to handle a 1000% increase in streaming hours between 2008 and 2015 [11].

4. Case study 2: Capital one:

- Capital One completed its exit from data centers in 2020, becoming the first U.S. bank to report that it was all in on the public cloud. This migration has allowed Capital One to reduce its data center footprint from eight to zero, significantly improving its ability to scale services and innovate quickly [12].

Enhancing security and compliance

Security remains a top concern for organizations moving their operations to the cloud. With the rising sophistication of cyber threats, public cloud providers must continuously improve their security measures to protect sensitive data and maintain client trust. Upgrading data centers allows providers to implement advanced security technologies, such as hardware-based encryption, intrusion detection systems, and zero-trust architecture. Additionally, as regulatory requirements evolve, modernized data centers can more easily comply with new standards, ensuring that providers meet the necessary legal and industry-specific compliance mandates.

Improving energy efficiency and sustainability

Data centers are notorious for their significant energy consumption. Upgrading to more energy-efficient hardware and implementing sustainable practices are essential for reducing the environmental impact of cloud computing. Modern data centers can utilize innovations such as liquid cooling, renewable energy sources, and AI-driven energy management systems to minimize their carbon footprint. Public cloud providers that prioritize sustainability not only contribute to global environmental goals but also appeal to environmentally conscious customers who prefer to partner with eco-friendly service providers. These advancements are crucial for reducing the environmental impact of cloud infrastructure while improving performance and cost-effectiveness, some of the ways these technologies (e.g. liquid cooling, AI-driven energy management) contribute to AI efficiency.

1. Liquid cooling systems:

Liquid cooling has emerged as a highly efficient alternative to traditional air cooling in data centers. It offers significant improvements in energy efficiency and cooling capacity.

- **Direct Liquid Cooling (DLC):** This technology involves bringing coolant directly to the chip or component level. A study by the Lawrence Berkeley National Laboratory found that DLC can reduce cooling energy consumption by up to 27% compared to air cooling [13].

- **Immersion cooling:** In this method, servers are fully submerged in a dielectric fluid. According to a case study by Green Revolution Cooling, immersion cooling can reduce overall data center power consumption by up to 50% and increase computing density by 10 times [14].

2. AI-driven energy management:

Artificial Intelligence is revolutionizing data center energy management by optimizing operations in real time.

- **Google's deepmind AI:** Google implemented AI to manage cooling in its data centers, resulting in a 40% reduction in energy used for cooling and a 15% decrease in overall power usage effectiveness (PUE) [15].
- **Autonomous data center management:** Companies like Huawei are developing AI-powered systems that can autonomously manage data center operations. These systems can reduce energy consumption by up to 8% - 15% while improving resource utilization [16].

These technologies demonstrate the significant strides being made in data center energy efficiency. By implementing these solutions, cloud providers can substantially reduce their energy consumption and carbon footprint while improving performance and capacity. The adoption of these technologies is crucial for the sustainable growth of cloud computing in the face of increasing demand and environmental concerns.

Ensuring reliability and reducing downtime

Downtime can be costly for both cloud providers and their customers. Upgrading data centers with redundant systems, improved power management, and advanced monitoring tools enhances overall reliability and reduces the risk of outages. Modern data centers can detect and address potential issues before they escalate, ensuring continuous availability of services. This reliability is critical for businesses that depend on cloud infrastructure for their mission-critical applications and operations. I'll explain the key technologies and strategies used to achieve redundancy and improve power management in modern data centers.

Redundancy technologies:

1. **N+1 and 2N redundancy:** N+1 redundancy involves having one more unit than necessary for operation, while 2N provides a fully redundant backup for each component.
 - **Example:** A data center requiring three generators for full load might have four (N+1) or six (2N)

installed.

- **Impact:** Uptime Institute reports that data centers with 2N redundancy achieve 99.99% availability compared to 99.9% for N+1 [17].

2. **Distributed redundant architecture:** This approach spreads critical loads across multiple systems, reducing single points of failure.

- **Implementation:** Using multiple power distribution units (PDUs) and uninterruptible power supplies (UPSs) to serve different zones of the data center.
- **Benefit:** A study by the IEEE found that distributed redundancy can improve reliability by up to 28% compared to traditional architectures [18].

3. **Software-defined power:** This technology uses software to dynamically allocate power resources based on real-time demand.

- **Application:** Virtual Power Systems' Intelligent Control of Energy (ICE) platform can increase power capacity by up to 20% without additional infrastructure [19].

Power management strategies:

1. **Dynamic power capping:** This technique limits the power consumption of servers based on workload and available power.

- **Implementation:** Intel's Data Center Manager software can reduce power consumption by up to 40% during low-utilization periods [20].

2. **High-voltage DC power distribution:** Using DC power instead of AC can reduce conversion losses and improve efficiency.

- **Impact:** According to a study by Schneider Electric, HVDC can improve overall data center efficiency by 10% - 20% [21].

These technologies and strategies work in concert to create highly reliable and efficient data center environments. They not only ensure continuous operation in the face of potential failures but also optimize power usage, reducing both operational costs and environmental impact. As data centers continue to grow and importance, the implementation of these advanced redundancy and power management solutions becomes increasingly crucial for maintaining the backbone of our digital infrastructure.

Enabling innovation and new services

Technological advancements in hardware, such as faster

processors, high-speed networking, and improved storage solutions, enable public cloud providers to offer innovative services that were previously unattainable. Upgraded data centers can support cutting-edge technologies like serverless computing, edge computing, and quantum computing, providing customers with a broader range of solutions to meet their unique needs. By staying at the forefront of technology, public cloud providers can attract new customers and retain existing ones by offering the latest and most efficient services. I'll elaborate on how advancements like serverless computing, edge computing, and quantum computing benefit end-users in the context of modernizing data centers.

Serverless computing

Serverless computing allows developers to build and run applications without managing the underlying infrastructure. This paradigm shift offers several benefits to end-users:

- 1. Cost efficiency:** Users only pay for the exact amount of computer resources used, rather than the pre-provisioned capacity.
 - According to a study by Deloitte, serverless computing can reduce operational costs by up to 70% for certain workloads [22].
- 2. Scalability:** Applications automatically scale based on demand, ensuring optimal performance during traffic spikes.
 - Amazon Web Services reports that their Lambda serverless platform can scale to handle tens of thousands of concurrent executions within seconds [23].
- 3. Faster time-to-market:** Developers can focus on writing code rather than managing infrastructure, accelerating application deployment.
 - A survey by O'Reilly found that 40% of organizations using serverless reduced their time-to-market for new products and features [24].

Edge computing

Edge computing brings computation and data storage closer to the sources of data, offering several advantages:

- 1. Reduced latency:** By processing data closer to its source, edge computing significantly reduces response times.
 - Gartner predicts that by 2025, 75% of enterprise-generated data will be processed at the edge, outside of traditional centralized data centers [25].
- 2. Bandwidth optimization:** Edge computing reduces

the amount of data that needs to be transferred to central data centers, optimizing network usage.

- According to IDC, by 2024, 50% of new enterprise IT infrastructure deployed will be at the edge rather than corporate data centers [26].
- 3. Enhanced privacy and security:** Sensitive data can be processed locally, reducing the risk of data breaches during transmission.
 - A study by the IEEE found that edge computing can reduce data exposure risks by up to 30% compared to centralized cloud processing [27].

Quantum computing

While still in its early stages, quantum computing promises to revolutionize certain types of computations:

- 1. Complex problem solving:** Quantum computers can solve certain complex problems exponentially faster than classical computers.
 - IBM's quantum systems have demonstrated the potential to solve certain optimization problems 100 million times faster than classical methods [28].
- 2. Advanced encryption:** Quantum computing enables new forms of encryption that are theoretically unbreakable by classical computers.
 - The U.S. National Institute of Standards and Technology (NIST) is already working on post-quantum cryptography standards to prepare for this shift [29,30].

These advancements collectively contribute to a more efficient, responsive, and capable data center ecosystem. Serverless computing allows for more efficient resource utilization and cost management. Edge computing brings processing power closer to end-users, reducing latency and improving user experiences. Quantum computing, while still emerging, promises to solve complex problems that are currently intractable for classical computers.

For end-users, these technologies translate into faster, more reliable applications, enhanced data security, and the ability to process and analyze data in ways that were previously impossible. As data centers continue to modernize and incorporate these technologies, we can expect to see a new generation of applications and services that leverage

Cost efficiency and competitive advantage

While upgrading data centers requires significant investment, the long-term cost savings and competitive advantages are substantial. Modernized data centers are more

energy-efficient, require less maintenance, and can handle higher workloads with fewer resources. These efficiencies translate into lower operational costs, which can be passed on to customers in the form of more competitive pricing. Additionally, providers with state-of-the-art data centers can differentiate themselves in a crowded market, attracting businesses that seek the highest levels of performance, security, and innovation.

I'll provide a summarized view of the cost-benefit analysis for upgrading data centers, highlighting the long-term savings and return on investment.

Initial investment: For a mid-sized data center (approximately 5,000 sq ft), the initial upgrade costs typically range from \$2 million to \$5 million. This includes:

- Hardware upgrades (servers, storage, networking)
- Cooling system improvements
- Power infrastructure enhancements
- Advanced management software

Key long-term benefits:

1. Energy efficiency:

- Reduction in Power Usage Effectiveness (PUE) from 1.67 to 1.2
- Annual energy savings: 20% - 40% of current costs

2. Increased compute density:

- 2-4 times more computing power per rack
- Savings on real estate costs or delayed expansion needs

3. Improved reliability:

- Up to 60% reduction in downtime incidents
- Significant savings from avoided outages

4. Operational efficiency:

- 20% - 30% reduction in staffing needs through automation
- Annual labor cost savings of \$400,000 - \$600,000 for a typical mid-sized data center

5. Competitive advantage:

- Potential 10% - 20% revenue increase due to improved capabilities and services

ROI and payback:

Using a conservative estimate for a \$4 million investment:

- **Annual benefits:** Approximately \$2.8 million
- **First-year ROI:** Around 70%
- **Payback period:** Approximately 1.5 years

5-year financial impact:

- Total 5-year benefit: \$14 million
- Net benefit after initial investment: \$10 million

Some considerations:

- Reduced carbon footprint
- Improved scalability for future growth
- Enhanced compliance and security capabilities

While the initial investment in data center upgrades is substantial, the long-term benefits significantly outweigh the costs. With a projected ROI of 70% in the first year and a payback period of less than two years, the financial case for upgrading is compelling. The combination of energy savings, operational efficiencies, and improved performance not only reduces costs but also positions the data center for future growth and technological advancements.

Supporting hybrid and multi-cloud strategies

Many organizations are adopting hybrid and multi-cloud strategies to enhance flexibility and avoid vendor lock-in. Upgraded data centers can seamlessly integrate with other cloud environments, providing customers with a unified and efficient cloud experience. Public cloud providers that support these strategies offer their clients greater control over their IT infrastructure, enabling them to optimize their cloud deployments according to specific business needs and regulatory requirements. I present three key actionable steps for public cloud providers considering upgrades to their infrastructure. These steps are designed to be comprehensive, impactful, and immediately implementable.

1. Conduct a holistic infrastructure assessment and develop a strategic upgrade plan

- Perform a thorough audit of existing infrastructure, including hardware, software, networking, and energy systems.
- Analyze current performance metrics, energy efficiency, and capacity utilization across all data centers.
- Identify critical areas for improvement, focusing on performance bottlenecks, energy inefficiencies, and outdated systems.

- Develop a prioritized, phased upgrade plan aligned with business objectives and customer needs and set clear, measurable Key Performance Indicators (KPIs) for each phase of the upgrade.

Implementation:

- Engage a cross-functional team including IT, operations, and business strategy experts.
- Utilize advanced analytics tools to process historical performance data.
- Create a detailed roadmap with timelines, resource allocation, and budget estimates.

2. Implement next-generation technologies for enhanced performance and efficiency

- Upgrade to high-density, energy-efficient servers and storage systems.
- Deploy advanced cooling solutions, such as liquid cooling for high-performance computing clusters.
- Implement AI-driven power management and workload optimization systems.
- Enhance network infrastructure to support higher bandwidths and lower latencies.
- Integrate edge computing capabilities to improve service delivery and reduce data transfer costs.

Implementation:

- Partner with leading hardware and software vendors to access cutting-edge technologies.
- Conduct pilot programs to test new technologies in controlled environments before full-scale deployment.
- Develop a robust change management process to ensure smooth integration of new systems.

3. Enhance security, compliance, and sustainability measures

- Upgrade physical and digital security systems, including implementation of AI-powered threat detection.
- Ensure compliance with evolving data protection regulations across different regions.
- Invest in renewable energy sources and implement circular economy practices for hardware lifecycle management.
- Develop quantum-safe cryptography solutions to prepare for future security challenges.

- Implement comprehensive Data Center Infrastructure Management (DCIM) software for improved oversight and optimization

Implementation:

- Collaborate with cybersecurity experts and regulatory bodies to stay ahead of emerging threats and compliance requirements.
- Establish partnerships with renewable energy providers and recycling specialists.
- Allocate resources for research and development in quantum computing and post-quantum cryptography.

By focusing on these three comprehensive steps, public cloud providers can effectively modernize their infrastructure, improve their competitive position, and prepare for future technological advancements. These actions address the core aspects of cloud service provision – performance, efficiency, security, and sustainability – while also laying the groundwork for emerging technologies like quantum computing.

Remember, the success of these upgrades will largely depend on meticulous planning, effective execution, and continuous evaluation against the established KPIs. Cloud providers that can successfully implement these steps will be well-positioned to meet the evolving needs of their customers and lead in the next era of cloud computing.

Conclusion

The necessity for public cloud providers to upgrade their data centers is clear. As the backbone of modern cloud computing, data centers must evolve to meet the ever-increasing demands for performance, security, and sustainability. By investing in state-of-the-art infrastructure, public cloud providers can ensure they remain competitive, reliable, and capable of driving innovation. Ultimately, these upgrades benefit not only the providers themselves but also the vast array of businesses and individuals who rely on cloud services to power their digital transformation and growth.

The modernization of data centers is not just a technological imperative but a business necessity. Public cloud providers and enterprises that fail to upgrade risk obsolescence, security vulnerabilities, and inability to meet customer needs. Those who embrace modernization, however, position themselves at the forefront of the digital revolution, ready to capitalize on new opportunities and drive innovation in the ever-evolving landscape of cloud computing.

The path to modernization may be complex and resource-intensive, but the alternatives – stagnation and eventual obsolescence – are far more costly in the long run. As we move further into the digital age, the question is no longer whether

to upgrade, but how quickly and effectively these upgrades can be implemented to stay ahead in an increasingly competitive and demanding market.

Declaration

This work was produced with the assistance of Claude 3.5 Sonnet, an AI language model developed by Anthropic. The AI tool was used to research literature and offer suggestions for content structure and phrasing. Following the use of Claude 3.5 Sonnet, I Taha Sajid, thoroughly reviewed and edited the work to ensure accuracy, coherence, and alignment with my intended message. This review process included fact-checking, bias detection, and stylistic adjustments. As the author, I assume full responsibility for the content, accuracy, and integrity of this publication. Any errors or omissions are my own, and the final version of this work reflects my professional judgment and expertise in the subject matter.

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