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Cloud Computing and the Impact it has had on Traditional Hardware & Software Systems

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Abstract

Cloud computing drives a shift in the way organizations can obtain computing power, create applications and distribute accountability for information systems. This paper reviews these changes by conducting a focused integrative review of five publications, two technical and three scholarly, that have been confirmed, including some published in 2023 and 2024. The analysis links infrastructure ownership, software modernization, economic governance and sustainability without making claims of empirical observations. The synthesis shows that the physical infrastructure is not going away as a result of the cloud, nor are some of the administrative tasks. But some services are becoming dependent and the distributed environment introduces reliance on contractual interfaces. Legacy software doesn't necessarily gain cloud-native features when hosted. The advantages of migration, then, will be based on the characteristics of the workload, how the workload adapts to the architecture, how well the workload performs, and the type of service chosen. A proposed Workload centered assessment framework, that combines technical performance, lifecycle cost, reversibility, security and environmental accountability. The evidence base is limited and diverse so the results only support propositions for analysis rather than statements of overall cost reduction or performance improvement. The paper concludes that the decision principle of selective modernization and hybrid placement offers the better defense than indiscriminate replacement of traditional systems.

Keywords: *cloud computing, legacy systems, hardware infrastructure, software modernization, hybrid architecture,*

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Introduction

Cloud computing is recognized as a way of providing services, not the end of computers. On-demand access, resource pooling, elasticity, network availability, and measured consumption are characteristics identified by National Institute of Standards and Technology (NIST) (Mell & Grance, 2011). It's these features that make cloud services different from outsourcing a dedicated server. They also describe how the adoption of the cloud can change technical architecture and institutional responsibility.

In this paper, traditional systems refer to infrastructure and applications that are under the control of the organization, are mostly located on-premises, and are deployed and procured in more structured ways. This definition has a strong analytical connotation and does not imply that all on-premises environments do not have automation. While an enterprise can run a very automated local infrastructure, a poorly managed cloud deployment can keep the inefficiencies of the older operating model. These must be kept in mind separately, however, because they relate to location, ownership and architectural maturity.

This is the core issue: Migration is sometimes referred to as a replacement decision, but the pace of change for the infrastructure and software is not the same. You can rent virtual machines and instantly change the procurement without changing application coupling, data dependency or release practices. On the other hand, an organization can enhance software modularity prior to shifting workload. Any assessment that is meaningful needs to differentiate between relocation and modernization and must take into account the outcomes throughout the system lifecycle.

The foundations of scholarship place cloud computing at the convergence of changes in hardware procurement and service-based software delivery (Armbrust et al., 2010). More recent studies discuss migration architecture and resource sustainability and highlight the need to consider software with the physical infrastructure (Hasan et al., 2023; Buyya et al., 2024). This paper builds on that connection without asserting unspecific claims about cost reduction, security or emissions resulting from a cloud deployment.

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How is the technical, economic and organizational burden of traditional hardware/software systems shifted by the use of cloud computing? is the guiding research question. The contribution is not a new benchmark or a statistically generalisable causal estimate, but rather a framework of analyses integrated into the contribution.

Literature Review

Service Models and Control

Mell and Grance (2011) categorize infrastructure as a service, platform as a service, and software as a service. This taxonomy is a gradient of consumer control, not just acquiring infrastructure services, but the consumption of an application is a different level of control. Badger et al. (2012) link deployment decisions with deployment opportunities and threats. These standards are meant to be combined to look at the responsibilities that stay with the customer after adoption.

The service model is important because ‘moving to the cloud' is not one intervention. An infrastructure customer can still manage the operating systems and applications, while a software-service customer will mainly manage how the organization accesses, configures and uses the software. Therefore, comparisons that equate all cloud configurations across the board mask the source of benefits and remaining responsibilities. The distinction between services is used throughout this paper.

Software Migration and Architecture

Hasan et al. (2023) note that architectural adaptation and lack of concern for quality after migration are significant issues in the legacy migration field. Through their contribution, they help to distinguish successful transfer from successful modernization. If the internal dependencies and assumptions of a hosted application haven't changed, it can still be a challenge to maintain. The architectural decomposition should be evaluated in the context of certain quality requirements and should not be considered a Goal.

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Infrastructure and Sustainability

Buyya et al. (2024) highlight the importance of integrated management of servers, networks, and cooling in sustainable cloud infrastructure. This view defies the notion of cloud computing as a "physical-less" product. Even if hardware is no longer in sight for the customer, it is never forgotten for the software developer. The infrastructure of a service must therefore precede environmental evaluation, and not end at the "boundary" of the adopting organisation.

Literature is complementary, but methodologically heterogeneous. Standards define concepts and responsibilities, an architectural review is a synthesis of migration research, and a sustainability contribution is an overview of directions of resource management. But these can not be associated in a proper way to a number and averaged out together. The utility of their value here is their ability to clarify mechanisms and the dimensions of decision that can be examined together.

Research Gap

This paper does not claim that there is no prior integrated research, rather it fills a gap that is a bounded integration problem in the selected evidence base. The standards offer the service and risk classifications while the architectural research focuses on migration and sustainability research focuses on infrastructure operation. These streams seem to indicate a need for a single decision structure that connects changes in enterprise hardware ownership to changes in enterprise software architecture, and enterprise accountability over time.

The second one is related to the evaluating boundary. An infrastructure assessment might not include application refactoring or organizational retraining, whereas a software-based assessment might not include networking, recovery capacity or physical resources utilization. Likewise, a purchase comparison can overestimate the upfront costs and underestimate the exit costs. The intended model then moves away from adoption as an onetime hosting transaction to an ongoing allocation decision.

Research Objectives

The first goal is to differentiate between hardware relocation and hardware elimination, and understand the effects of service models on the distribution of

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operational control. The second is to know why migration is not enough to address legacy software issues. The third is to incorporate economic, security, performance and sustainability factors into workload-placement decisions. The fourth is to state propositions which may be tested in the future, but which should not be presumed to have been tested in the present review.

Analytical Propositions

Proposition 1 is that the benefits of cloud are not limited to where you deploy the service, but rather depend on how well your workload matches the service. Proposition 2 is that moving an application that has legacy (but not limiting) dependencies will not remove crucial sources of technical debt. In Proposition 3, the authors argue that more centralized ownership of local infrastructure makes service observability, contractual governance and exit planning more important. Proposition 4 - Improving the environment is not equated with taking equipment outside the enterprise boundary. They are hypotheses that are made based on synthesis, not causal findings.

Methodology

The design and selection of sources.Design and source selection.

This study adopts focused integrative review of literature with a qualitative conceptual synthesis method. Known scholarly and standards-based records were discovered using public web search. These terms were used in the search phrases: cloud computing impact traditional hardware software systems, legacy systems cloud migration architectural review, cloud computing sustainability energy data centers. On October 26, 2026, Discovery was completed. No export to a subscription database or full search was done.

Five publications were retained purposively: Mell and Grance (2011), Badger et al. (2012), Armbrust et al. (2010), Hasan et al. (2023), and Buyya et al. (2024). It was necessary that the authorship of the article be identifiable, that the article be published by a scholarly agency or an established standards publisher, that there be verifiable bibliographic metadata, and that the article be directly relevant to the research question. There was no use of commercial surveys or unverifiable

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claims, duplicate records, and tangential material. Older publications set concepts, recent publications tackle issues of architecture and sustainability.

Extraction and Synthesis

The extraction framework took into account the type of publication, system layer, proposed mechanism, affected responsibility and qualification of the claim. Evidence consisted of verified publication records and abstracts, and available indexed descriptions, not a comprehensive full-text appraisal. The findings were grouped in four themes: infrastructure control, software architecture, software lifecycle governance and sustainability. Themes were then linked together by explicit conceptual reasoning. There are no inter-rater reliability statistics or screening-flow counts reported, nor is there any numerical effect estimate.

Quality and Ethical Safeguards

Selection was based on source authority, but no formal risk-of-bias tool was used. Technical standards used as a means of definition rather than experimental evidence, and observations made at the review level were not translated into causal estimates. No individuals, proprietary data or identifiable personal records were involved. The small purposive sample, the discovery of English language text, and the limited access to full texts limit coverage and reproducibility. The method is designed to facilitate an open-ended exploratory paper, rather than a systematic review or meta analysis.

Results

Results are the author's qualitative synthesis of the literature selected. They're not survey, deployment or financial data measurements. Four patterns came to the fore after applying the analytical framework. The responsibilities of hardware are reorganised. The first pattern is about shifting the control of hardware, not eliminating hardware dependency. Resource pooling lets customers use the capacity as services, but makes the underlying processing, storage, and networking physical (Mell & Grance, 2011). The organisational consequence is that procurement and capacity planning have to be aligned with service levels, connectivity and recovery. This implication is not a measured decrease in equipment costs, it is an implication of the service model.

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Relocation Differs From Modernization

The second pattern is a separation of hosting transition and application improvement. Quality requirements are at the core of assessing legacy transformation in architectural migration literature (Hasan et al., 2023). Therefore, clear application results like maintainability and recoverability should be the measure of success and not whether the application begins to run on infrastructures outside the local area. Certain workloads may be worth refactoring, others may be worth some adaptation, or holding on to them.

Governance Follows Abstraction

The third pattern is about the "relationship between abstraction and accountability". The NIST service taxonomy shows that various arrangements reveal varying degrees of customer control (Mell & Grance, 2011). This paper assumes that governance needs to align with the layers that the organization retains. It does not mean that you can't define access rights, track service commitments or ensure that business continuity is preserved if you don't have direct control. There is a sharing of responsibility, but not a complete sharing.

The boundaries of the environment must be expanded.

The fourth pattern is enterprise level infrastructure reduction is not a comprehensive environmental indicator. It is still required to have integrated infrastructure management in cloud data centers (Buyya et al., 2024). The analytical outcome is that sustainability evaluation should be extended to a service delivery out of the enterprise premises. The evidence chosen does not provide an overall carbon benefit for cloud or traditional systems.

Discussion

Economic and Operational Interpretation

The results do not support the ownership versus rental storyline. A subscription or usage-based bill is a different bill structure, but it's not necessarily a sign of reduced lifecycle cost. Migration work, retained infrastructure, personnel effort, connectivity, data movement, recovery testing, and eventual exit should all be part of an assessment. The categories are an example of an evaluation checklist; this paper does not assign any invented prices or savings percentages to these

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categories. The wider context of consideration of opportunities as well as risks is outlined by Badger et al (2012).

Elasticity can be useful only if a workload and how it's used can leverage it. Additional virtual machines may not necessarily provide a system with tightly coupled components with a scalable degree of effectiveness. Along with application bottlenecks and data dependencies, application capacity flexibility should be considered. The takeaway from the case is that it is better to do technical assessment before committing to procurement, particularly if the cost of modernization exceeds infrastructure savings in the short-term.

Software Engineering Implications

Unresolved architectural assumptions can emerge when adopting cloud. Examples of local filesystem dependencies, synchronous interactions and deployment coupling are examples of things that a migration assessment should look at, but are NOT defects in a new dataset. The literature on migration has justified an explicit evaluation of the target architecture and the quality of the post-migration experience (Hasan et al., 2023). Therefore, the sensible engineering choice is to alter the architecture only if the anticipated operational advantage is consistent with the extra development and coordination involved.

Microservices are not an all-seeing eye. Decomposition adds interfaces and coordination needs that need to be addressed at run time. In cases where independent scaling is not needed, a managed infrastructure application will be considered appropriate. This is a design suggestion based on the concept of workload fit and not a comparative performance outcome. The paper thus opts for the concept of architectural change over for uniformity driven by technology.

Security and Resilience Implications

In the cloud evaluation, each control layer must be assessed to determine who is responsible for it and what evidence will show that the control is working, from a security perspective. Effective recovery isn't just a matter of service contracts. Identity administration, restoration processes and failure communication need to be tested against the requirements of the organization. These are recommendations that build on the risk-aware implementation perspective of

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Badger et al. (2012), but do not mean that a single deployment model is necessarily more secure.

Integrated Assessment Framework

The proposed framework is based on five decision dimensions given into a workload-level assessment. It is a creative, original piece of critical thinking, and has not been tested empirically. It is designed to make it difficult to remember that a good outcome in one dimension is masking a poor outcome in another dimension – e.g., provisioning time obscuring recovery capability.

Performance and Architectural Fit

The first step is to document workload demand, response time requirements, integration dependencies, and toleration for interruptions at the organization. Candidate environments should then be tested against representative workloads and not against generic vendor benchmarks. The preferred environment is the one that meets the application's requirements in a satisfactory complexity. This step distinguishes between requirements that do not require software redesign but can be addressed by hosting changes and those that do.

LCE and Reversibility

The second step is to compare options on an equal basis for a specified duration and to bring transition and exit activities to the fore. Analysts should carefully separate unavoidable costs from costs that are actually different because of migration. The third step involves an evaluation of reversibility (capability to move data, configurations and necessary application functions within acceptable operational limits). These are proposed procedures, not conclusions made that all cloud services are too costly or difficult to abandon.

Governance and Environmental Accountability

The fourth step allocates operational duties to roles and names in an organization and/or provider. The fifth one assesses infrastructure-related environmental impacts based on known system boundaries and analogous service outputs. Buyya et al. (2024) set the ground for the significance of coordinated physical-resource management, and the current framework is interested in enterprise placement decisions. In absence of credible environmental information, a state of

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uncertainty should be communicated, not replaced with a presumed sustainability benefit.

Illustrative Application

Think of an application that is tightly coupled with the local equipment, and its public portal is variable. The framework would not mandate that these workloads all have a common destination. Consideration of a cloud-hosted portal coupled with local applications may make a viable candidate architecture (to be tested). This example is based on decision logic only and it is not a case study, it is not based on observations made, and it does not provide evidence of savings or performance improvements.

Limitations and Future Research

The biggest constraint is the evidence base – five publications were selected for being purposeful and representative of the whole cloud-computing literature is a big challenge. Only two sources of scholarship are recent, and no attempt is made to include all developments to 2026. Adoption outcomes can't be determined by standards-based reasoning, but it is useful for clarifying concepts. It is possible that the issues that were addressed were influenced by search-engine indexing, incomplete full-text access, and the lack of independent screening.

The analysis is not comparative, does not measure the number of licensing changes, the hardware markets, or security incident rates. It also cannot conclude if it is associated with a decrease in employment, spending or emissions in industries. This result will depend on the quality of the longitudinal data and the need to explicitly model the confounding factors. These boundaries are relevant as the paper's conclusions are about mechanisms and decision criteria, not about effects at the population level.

Future studies need to be conducted with the same workloads before and after the migration, noting architectural change, demand, service quality, expenditure and recovery performance. Researchers need to differentiate rehosting from substantive redesign and include organizations that are keeping or bringing back workloads. Energy and emissions boundaries should be indicated in environmental studies, including local infrastructure retained. Another possible

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test of the proposed framework would be prospective validation of whether the framework would increase the transparency of decisions and minimise unexpected transition costs.

Conclusion

However, the fundamentals of how capacity is accessed and responsibility is allocated are the primary ways that cloud computing impacts traditional systems. But what it does mean is that hardware does not vanish, and legacy software doesn't necessarily move to the modern frontier. The synthesis, on the other hand, finds a connection between the abstraction of infrastructure, the adaptation of architecture, and ongoing governance. These relationships can be analyzed together, as described in foundational service definitions (Mell & Grance, 2011), migration scholarship, and sustainability research (Hasan et al., 2023; Buyya et al., 2024).

The main innovation of the paper is a framework that enables a workload-centred assessment of performance, lifecycle economics, reversibility, governance and environmental accountability. In the limits of the foresaid, the most defensible solution is to modernize selectively, according to the need, not to be replaced blindly following the deployment fashion. Cloud, on-premises and mixed solutions should all be considered viable options until there is proof that one is the preferred approach for a specific organization. There is no universal cost, security, performance or sustainability benefit in this review.

Conflict of Interest

The authors declare that they have no financial, professional, technological, commercial, institutional, or personal conflicts of interest that could have influenced the content, interpretation, or conclusions presented in this article.

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Data Availability

No new clinical, experimental, or patient-level datasets were generated or analysed during this study. All information discussed in the review was obtained

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from the published literature and publicly available sources cited in the manuscript. Additional information relating to the review may be obtained from the corresponding author upon reasonable request.

Informed Consent

Not applicable. No patients or other human participants were recruited, and no identifiable personal or clinical information was collected or analysed for this review.

Use of Generative AI

The authors declare that no generative artificial intelligence tools were used to conduct the literature review, generate the scholarly content, interpret the evidence, or formulate the conclusions presented in this article. The discussion of generative AI, artificial intelligence, and machine-learning technologies in the manuscript relates solely to their applications in healthcare resource optimization and does not constitute their use in preparing the article.

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