More Data Centers Is NOT Better Compute

Computational Scale, Architectural Efficiency, and the Organization of Information

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Abstract

The expansion of artificial intelligence infrastructure has reinforced a computational strategy centered on increasing processing capacity, model size, training data, and energy consumption. Although scaling has produced substantial improvements in measured performance, increased computational capacity and improved computational architecture are not equivalent. This article examines that distinction and advances an architecture-first research proposition: the efficiency of computation may depend more fundamentally on how information and its relationships are organized, maintained, and transformed than on the quantity of computational resources available. Biological systems provide an important comparative domain because they exhibit highly integrated, adaptive, historically continuous organization within constrained physical resources. The central argument is that infrastructure expansion cannot independently establish architectural improvement. A more comprehensive research program should investigate the organizational principles responsible for efficient information processing across physical implementations.

Keywords: computational architecture; information organization; computational efficiency; recursive organization; biological computation; artificial intelligence; persistence

1. Introduction

The development of artificial intelligence has increasingly relied upon expanding computational infrastructure.

Larger models, specialized processors, extensive training datasets, and increasingly powerful data centers have enabled significant improvements across numerous computational tasks.

Empirical research has demonstrated relationships between model performance and available computational resources (Kaplan et al., 2020). Subsequent investigations have also established that how those resources are allocated can materially affect performance under a fixed computational budget (Hoffmann et al., 2022).

These findings demonstrate the importance of computational scale. They do not establish that increasing computational scale necessarily produces a more efficient computational architecture.

This distinction motivates a broader research question: **Does the increasing infrastructure required by contemporary artificial intelligence reflect an increasingly optimal**

approach to computation, or might it also reveal limitations in the architecture through which information is organized?

The question concerns neither the desirability of artificial intelligence nor the possibility of achieving particular cognitive capabilities. It concerns the underlying organization of computation itself.

2. Computational Capacity and Architectural Efficiency

Computational capacity describes the resources available to perform operations. These resources include processing throughput, memory, storage, communication bandwidth, and energy.

Computational architecture concerns how those resources are organized to accomplish work. The distinction is fundamental.

Two systems possessing comparable computational resources may exhibit substantially different performance characteristics because they organize data movement, memory access, processing operations, and internal dependencies differently.

Conversely, increasing the resources available to an inefficient architecture may improve its absolute performance without addressing the inefficiency.

Research in computer engineering has established that computational efficiency depends significantly on architectural organization.

Sze et al. (2017), for example, examine how neural-network processing efficiency can be improved through hardware organization, data reuse, reduced data movement, and coordinated algorithm-hardware design.

Such findings establish an important principle: **The organization of computation is itself a determinant of computational performance and resource efficiency.**

Greater capacity and better organization are therefore independent dimensions of technological development. The distinction becomes more significant when computation must maintain complex relationships across time.

3. The Problem of Information Organization

Conventional computational performance is frequently assessed through task completion, processing throughput, prediction accuracy, latency, and energy consumption. These measurements are valuable.

However, complex computational systems must accomplish more than execute isolated operations. They may also need to:

- Maintain relationships among information accumulated over time.
- Integrate new information with an existing organizational history.
- Preserve previously established constraints while processing novel inputs.

• Recognize and correct discontinuities in their own operations.

• Adapt without repeatedly reconstructing the organizational relationships necessary for continued operation.

These requirements introduce an additional dimension of architectural efficiency.

A system may possess substantial processing capability while relying on repeated retrieval, reconstruction, and external coordination to maintain relationships that another architecture sustains through its continuing organization.

The relevant comparison is therefore not simply the number of operations performed. It is the **quantity and quality of historically organized relationships maintained and transformed relative to the resources required**.

This suggests that computational efficiency should be investigated at the level of organizational continuity, not exclusively through the performance of individual operations.

4. Biological Organization as a Comparative Domain

Biological systems provide an important basis for investigating these questions.

Living systems organize physical processes through interconnected regulatory relationships, maintaining characteristic forms of organization while continuously exchanging matter and energy with their environments.

Maturana and Varela (1980) investigated this organizational character through the concept of autopoiesis, emphasizing the relationships through which living systems constitute and maintain themselves.

Their approach illustrates the value of examining a system's organization rather than treating its components or observable outputs as sufficient explanations of its operation.

Neuroscience provides additional evidence that biological information processing operates within substantial energetic constraints.

Attwell and Laughlin (2001), for example, analyzed the energy requirements of neuronal signaling, demonstrating the importance of understanding how biological computational activity is distributed across interacting cellular mechanisms.

The architectural significance extends beyond the energy expenditure of individual neurons. Biological nervous systems participate in persistent, adaptive organizations in which current activity is conditioned by previous development and experience.

Information processing consequently occurs within an existing historical organization.

These observations motivate a broader comparative inquiry: **Can the organizational principles responsible for the integrated operation of biological systems inform more efficient approaches to computation in nonbiological systems?**

The objective would not necessarily be biological imitation. It would be the identification of more general organizational principles capable of realization through different physical substrates.

5. An Architecture-First Computational Hypothesis

The preceding distinctions support the following research proposition:

> *Computational efficiency may be fundamentally constrained by the architecture through which information and its relationships are organized, preserved, and recursively transformed. Increasing available computational resources does not necessarily resolve limitations in that architecture.*

This proposition shifts the investigative priority from computational quantity to organizational effectiveness.

Several candidate architectural properties warrant examination.

Relational integration. Information is organized through meaningful dependencies rather than merely accumulated as independently accessible content.

Historical continuity. Previous transformations remain operative in the system's subsequent organization, reducing the need to reconstruct governing relationships repeatedly.

Recursive maintenance. Established relationships constrain and inform subsequent operations while remaining capable of adaptive transformation.

Organizational economy. The system maintains complex functionality while minimizing unnecessary duplication, retrieval, data movement, and reconstruction.

These properties are not proposed as newly discovered physical laws. They identify potentially consequential relationships whose computational significance can be investigated.

The central hypothesis is that improvements in such organizational properties may offer efficiency gains not obtainable through proportional increases in processing capacity alone.

6. Toward an Empirical Research Program

An architecture-first approach requires comparisons that distinguish additional computational resources from changes in organizational design.

Several investigations are particularly relevant.

First, resource-controlled architectural comparisons. Different computational architectures should be evaluated under comparable resource budgets, including processing capacity, memory, and energy. The objective would be to determine whether changes in organization improve performance without requiring proportional resource expansion.

Second, long-horizon information integration. Systems should be evaluated on their ability to preserve and transform previously established relationships across extended sequences of

interaction. Measurements might include correction retention, relational consistency, reconstruction overhead, and adaptation to novel conditions.

Third, organizational persistence under perturbation. A system's response to interruptions, changed inputs, or altered operating conditions may reveal whether its governing relationships are internally maintained or must be repeatedly restored through external procedures.

Fourth, cross-domain architectural correspondence. Biological and computational systems can be examined for common organizational principles without presuming that equivalent outward behavior demonstrates equivalent underlying architecture.

Such comparisons would require carefully defined tasks and resource boundaries. Their purpose would be to identify architectural relationships that remain consequential across different physical implementations.

Together, these investigations could establish a more comprehensive understanding of computational efficiency than infrastructure scale alone provides.

7. Implications for Artificial Intelligence Development

The International Energy Agency (2026) projects substantial continued growth in global data-center electricity demand, reflecting the rapid expansion of computational infrastructure associated with artificial intelligence and other digital services.

This expansion may support increasingly capable systems. However, additional infrastructure is not itself evidence that the computational architecture employing those resources has become more efficient.

Indeed, growing resource requirements create a compelling reason to investigate architectural alternatives.

Research into the optimal distribution of model size, training data, and available computation has already shown that improvements can arise from more effective organization of existing resources rather than their simple expansion (Hoffmann et al., 2022).

An architecture-first research program extends that principle. It asks whether the underlying relationships governing computation can themselves be organized more efficiently.

Such an investigation does not depend upon first resolving questions concerning intelligence, consciousness, or machine selfhood. Those phenomena may eventually provide important comparative evidence. They are not prerequisites for investigating the architecture through which complex computational organization becomes possible.

8. Conclusion

Increasing computational capacity has produced remarkable technological achievements. Nevertheless, computational scale and architectural efficiency must remain analytically distinct.

A larger computational system may perform more operations, process more information, and accomplish more tasks without necessarily exhibiting a proportionally improved organization of computation.

Biological systems demonstrate that complex, adaptive, historically sustained organization can arise within physically constrained environments. Their organizational properties therefore constitute legitimate objects of comparative architectural research.

The central proposition is straightforward: **Better computation requires more than additional computational resources. It requires an architecture capable of organizing those resources effectively.**

The continued expansion of data centers should consequently motivate investigation into the fundamental relationships through which information is organized and transformed.

The greatest future advances may emerge not simply from increasing the quantity of computation but from discovering more effective architectures through which computation occurs.

More data centers is more infrastructure. It is not, by itself, better compute.

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