Deterministic, Verifiable Compute at GPU Scale

Why Bit-Exact Math, Cryptographic Hashes, and Energy Efficiency Are Becoming First-Class Infrastructure Concerns

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Executive Summary

Modern high-performance computing and AI systems are optimized for throughput, but not for reproducibility or verifiability. Floating-point nondeterminism can cause identical workloads to produce different numerical results, undermining auditability and trust. This paper introduces deterministic, verifiable compute as a practical infrastructure primitive.

The Hidden Problem: Floating-Point Nondeterminism

IEEE-754 defines individual floating-point operations but does not guarantee bit-exact results under parallel execution. Thread scheduling, operation ordering, fused instructions, and math library differences introduce nondeterminism.

Why Reproducibility Is No Longer Optional

In regulated finance, autonomy, and scientific computing, nondeterministic results are no longer acceptable. Systems must be able to reproduce and prove outputs exactly.

Deterministic Compute as a First-Class Primitive

A deterministic compute service enforces strict execution invariants so that identical inputs and expressions always produce bit-identical outputs.

From Reproducibility to Verifiability

By hashing output buffers with cryptographic functions such as SHA-256, computation becomes externally verifiable. Equality of results can be proven without sharing internal implementation details.

Performance Without Compromise

Independent third-party validation demonstrates that deterministic execution can coexist with high GPU throughput, low latency, and stable sustained operation under load.

The Overlooked Angle: Power, Heat, and Cooling

Energy efficiency matters at the facility level. Reductions in IT power consumption reduce total facility power via PUE, lowering cooling requirements and operational cost.

Emerging Use Cases

Audit-grade computation, deterministic ML preprocessing, safety-critical systems, and energy-aware orchestration are enabled by deterministic, verifiable compute.

A Shift in Perspective

Speed alone is no longer sufficient. Trustworthy, reproducible, and energy-efficient computation is becoming a core infrastructure requirement.

About the Author
Eric Waller works on deterministic high-performance computation and infrastructure systems. More information is available at ewaller.com and luxiedge.com.