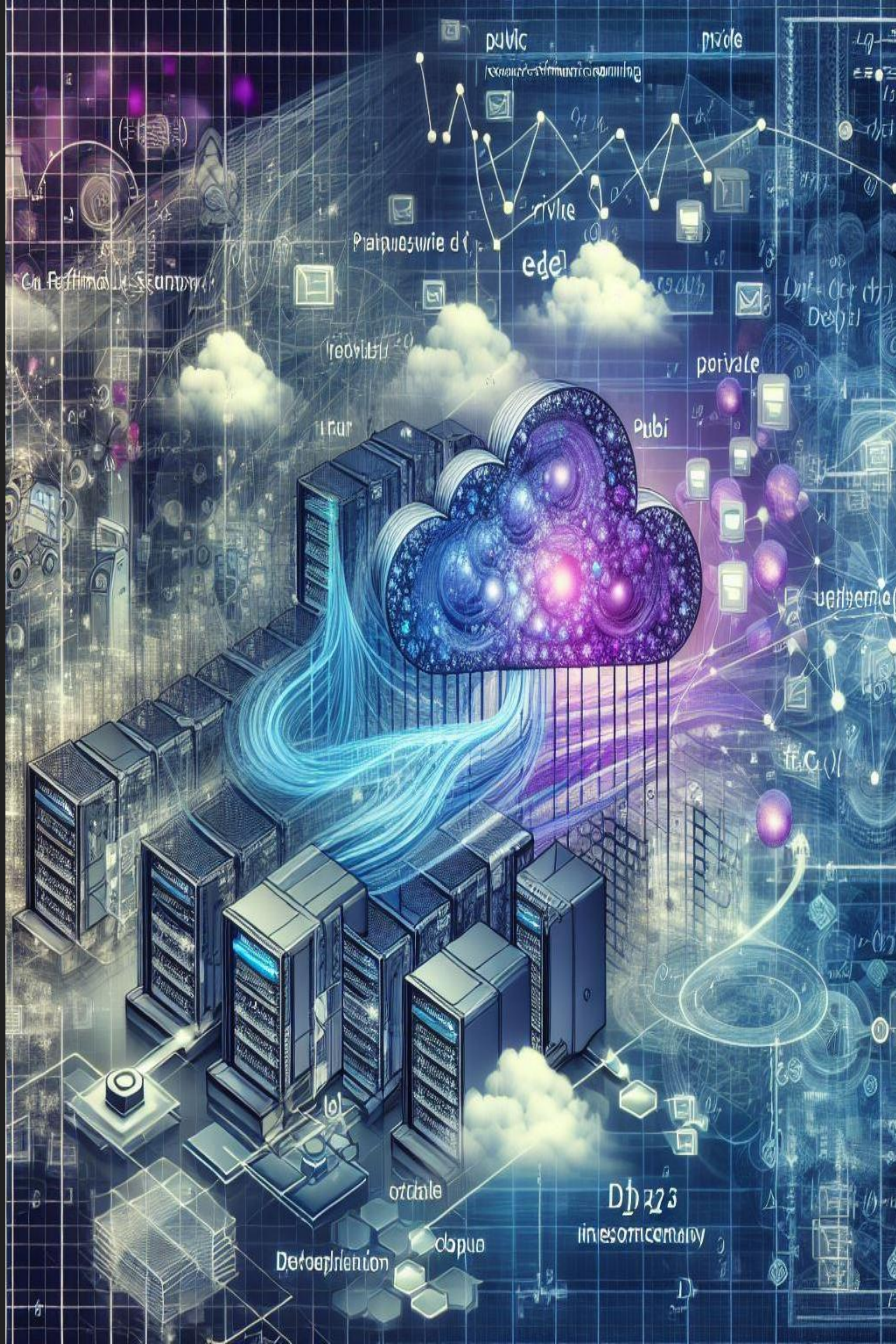
Simon Kuznets Kharkiv National University of Economics

Mathematical modeling of data transfer for resource-intensive tasks in heterogeneous cloud systems:

performance indicators and methodological approaches



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The Imperative of Modeling

Systemic Volatility

Modern systems operate under constant volatility and uncertainty.

Random Elements

Successful management requires accounting for inherent random factors.

Beyond Determinism

Purely deterministic models fail to predict performance with stochastic inputs.

Achieving Operational Improvements

Enhanced Efficiency

Streamline complex processes.

Cost Reduction

Substantially lower operational costs.

Systems Automation

Critical for comprehensive managerial oversight.

Improved Service

Measurably enhance customer service quality.

Core Concepts & Methodologies

1

Stochastic models

Manages high-volume flow processes and resource allocation.

2

Markov Processes

Stochastic modeling for time-dependent system state changes.

3

Simulation Modeling

Experimental verification and optimization under uncertainty.

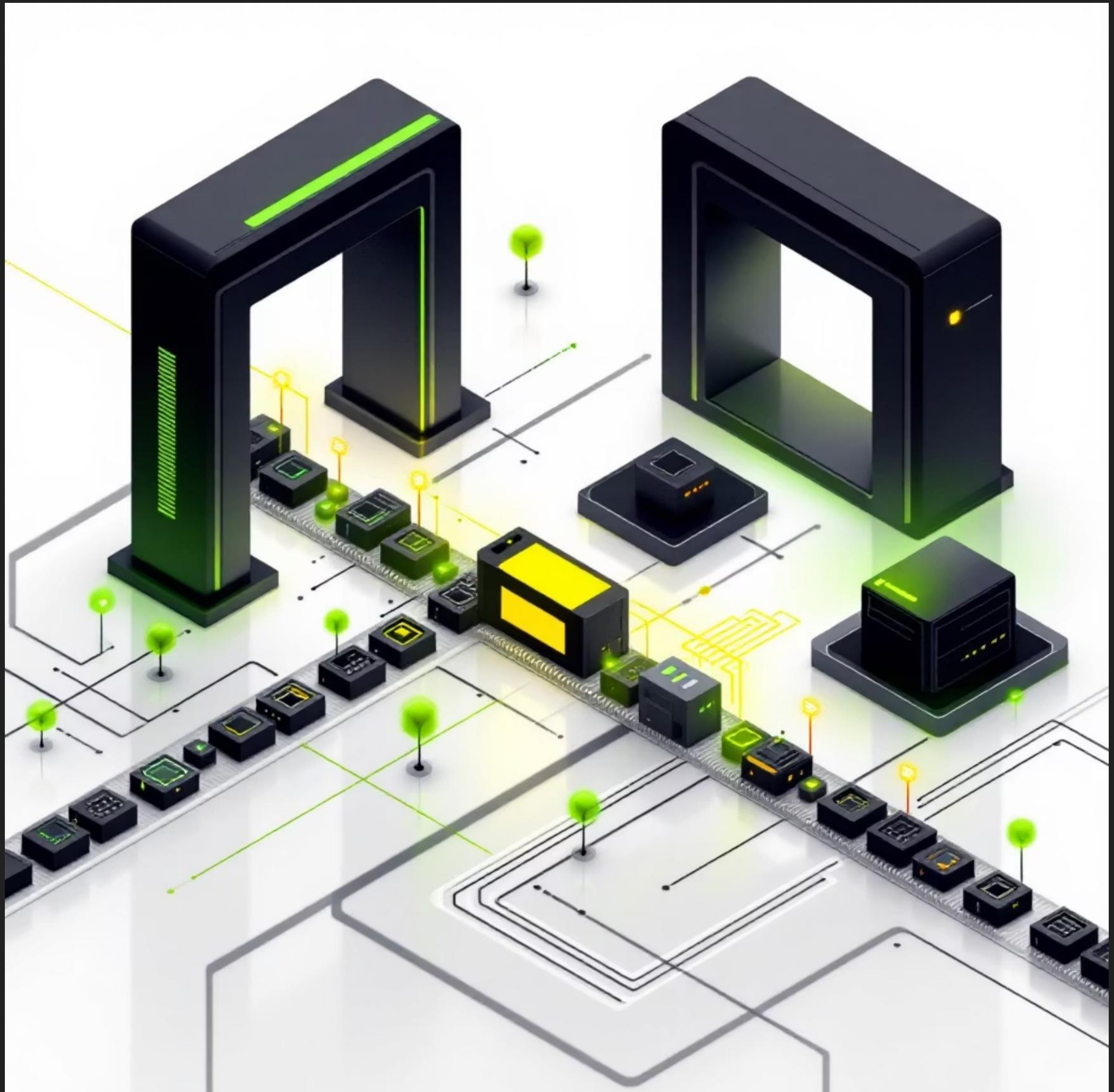
4

Digital Twins

Virtual replicas for risk-free scenario testing.

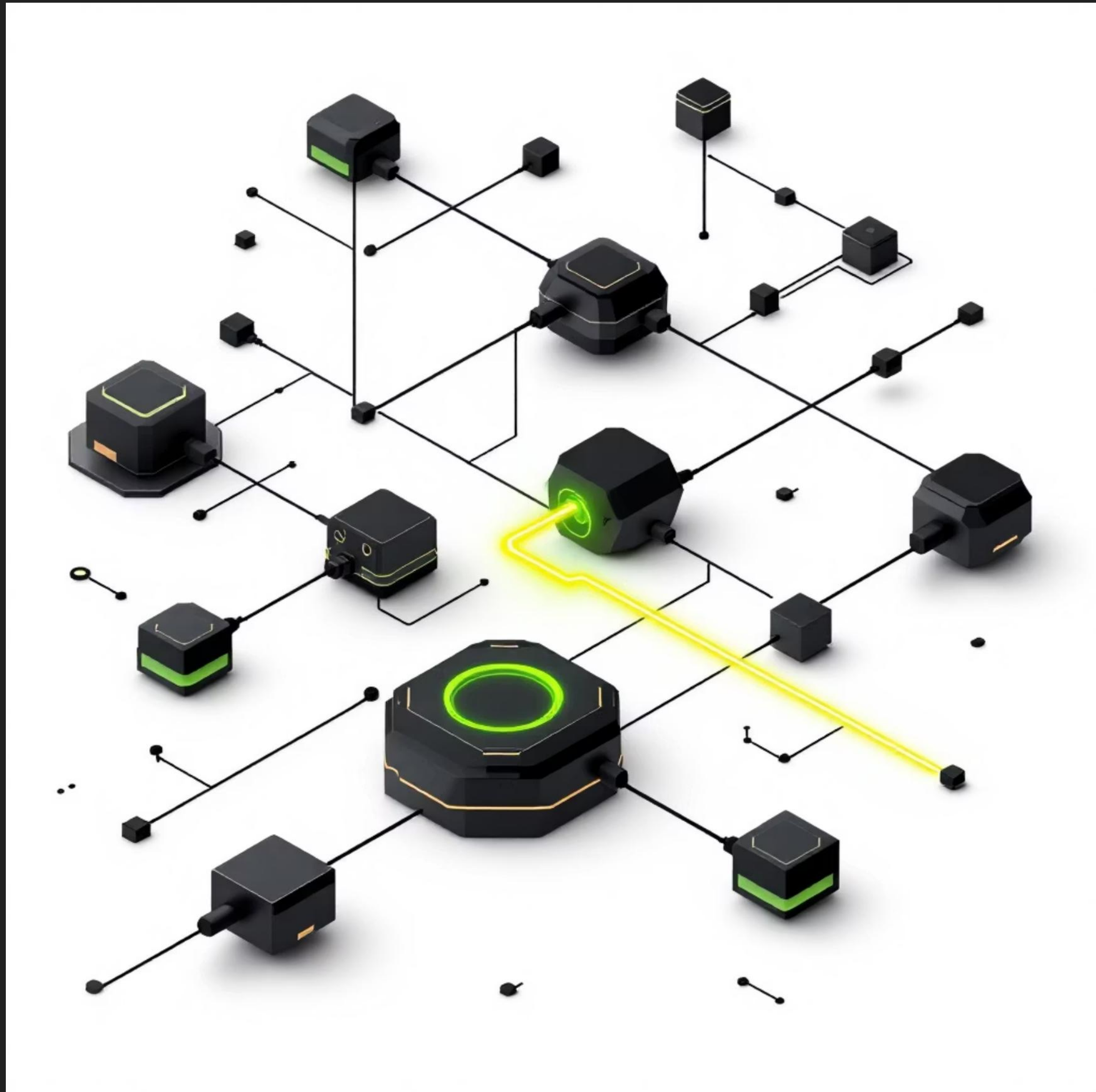
Queuing Theory: The Analytical Prerequisite

Queuing Theory quantifies performance in systems where requests compete for limited resources. It establishes analytical bounds for waiting times, queue length, and resource utilization.



Markov Processes

Integrates Markov processes, assuming a "memoryless" property where system evolution depends only on its current state. This simplifies mathematical complexity, allowing for analytical solutions in models like M/M/c.



Discrete-Event Simulation Modeling

Simulation is the primary research tool for complex systems operating under uncertainty, offering experimental flexibility beyond analytical solutions.

01

Model Definition & Construction

Translate the system into a virtual representation (Digital Twin), defining entities, attributes, flow logic, and input data.

02

Experimentation & Optimization

Conduct numerous simulation runs, analyze results, and calculate confidence intervals. Test alternative scenarios risk-free.

Digital Twin Integration & Dynamic Optimization

Real-Time Management

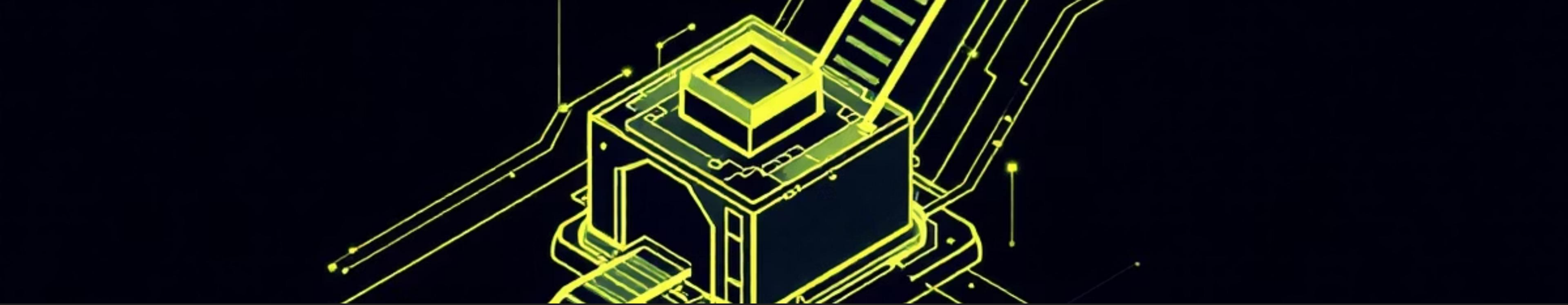
Enables adaptive management and dynamic correction of routes.

System Adaptability

Increases flexibility to absorb unforeseen shocks.

Predictive Analytics

Leverages stochastic forecasting to anticipate future events.



Optimization Outcomes & Economic Efficiency

1

Cost Reduction

Lowering cost basis and controlling expenditures.

2

Resource Utilization

Maximizing resource use and minimizing waste.

3

Inventory Management

Precise control to minimize surplus or deficit.

Strategic Benefits of Modeling Automation

Efficiency & Service Quality	Increased efficiency, cost reduction, improved customer service	Enhanced operational throughput and QoS
Dynamic Resource Control	Automated transport management; dynamic route correction	Adaptive load balancing, fault tolerance
Capacity Planning	Optimization of inventory management; predictive analytics	Optimized capacity provisioning
System Mapping	Creation of a complete functional picture	Unified visibility, accurate Digital Twin construction

Synthesizing Stochastic Modeling for Future Systems

Foundational Methods

Queuing Theory & Markov processes for analytical rigor.

Applied Methods

Simulation Modeling for experimental flexibility.

Future Directions

Modular platforms and AI integration for autonomous optimization.

Cloud Relevance

Principles directly apply to heterogeneous cloud architectures.

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Thank You!