Cloud- Driven Financial Strategies: Implementing Monte Carlo simulations for Enhanced Risk Analysis

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***Abstract*— This report investigates the design and implementation of a cloud-based platform for conducting Monte Carlo simulations on stock market data. Leveraging NIST SP 800-145 security guidelines, the system integrates AWS Lambda for efficient serverless computations, Amazon EC2 for computationally intensive tasks, and Google App Engine for a user-friendly interface. Key areas of focus include cost-benefit analysis beyond the free tier, performance evaluation, scalability assessment, and a comprehensive delineation of technical and functional requirements. The report concludes with a detailed analysis of system capabilities and limitations, supported by in-depth data and visual representations.**

Keywords: NIST SP 800-145, Monte Carlo Simulation, AWS Lambda, Amazon EC2, Google App Engine, Cost-benefit analysis.

I. Introduction

Cloud computing has revolutionized the landscape of computing resource management and deployment. This study explores the development of a cloud-based financial analysis platform designed to adhere to the NIST SP 800-145 security standard. By leveraging the scalability of Amazon EC2 and the efficiency of AWS Lambda, the system offers a robust computational foundation. A user-friendly interface hosted on Google App Engine enhances accessibility and usability. This study explores the implementation of NIST cloud computing standards to develop a dependable, scalable, and user-friendly platform for executing Monte Carlo simulations in financial analysis.

A. Developer

The architecture and operations of the system are fully aligned with the guidelines set out in NIST SP 800-145 cloud computing framework. This ensures that the platform effectively leverages cloud- based features and service models to enhance both functionality and user experience. Here's an explanation of the way these elements are utilized:

In NIST SP800-145	Developer Engagement and Interaction
Instant Provisioning	By harnessing the power of AWS Lambda and EC2, developers can seamlessly automate application scaling and deployment, eliminating the complexities of infrastructure management. This agile approach accelerates development cycles and reduces time-to-market.
	The integration of GCP and AWS ensures global accessibility, optimizing performance and operational flexibility. Developers can create applications that seamlessly operate across

In NIST SP800-145	Developer uses and/or experiences
Widespread Network Availability	diverse platforms and geographical locations.
Shared Resource Management	Dynamic load distribution across AWS and GCP resources guarantees optimal system performance and scalability without manual intervention. This elasticity is crucial for handling fluctuating workloads and ensuring a consistent user experience.
Usage-Based Service Measurement	The consumption-based billing model provides developers with granular visibility into resource utilization, enabling precise cost management and optimization. This data-driven approach fosters efficient resource allocation.
Cloud Application Platform	Developers are spared the trouble of managing servers, storage, and networks thanks to PaaS (Platform as a Service). Developers may now focus only on creating and maintaining applications. Utilizing PaaS offerings from AWS and GCP streamlines development processes and accelerates time-to-market.
Combined Cloud Deployment	The amalgamation of GCP and AWS offers a variety of application deployment choices. Scalability, cost-effectiveness, and overall performance are improved by using GAE for hosting static material, while AWS Lambda and EC2 handle dynamic workloads.

B. User

API system delivers a consistently optimized and reliable user experience across all interactions, adhering strictly to NIST 800-145 guidelines.

In NIST SP800-145	User interactions and Engagement
Instant Provisioning	U Individual users can freely distribute computing resources according to their needs; service providers do not need to be contacted directly. This independence makes the procedure easier for the user to understand and more convenient.
Widespread Network Availability	Cloud services can be accessed via the internet, allowing users to reach applications and data from a variety of devices and locations. This enhances accessibility and supports remote work.
Shared Resource Management	Cloud providers manage a shared pool of resources, which are dynamically assigned to users according to demand. This approach ensures efficient use of resources and cost savings.
Usage-Based Service Measurement	Cloud resources are highly flexible, allowing them to be adjusted quickly in response to changing demands. When workloads increase, additional computational power, storage or bandwidth can be

In NIST SP800-145	User uses and/or experiences
	allocated to maintain performance.
Scalable Resource Elasticity	Cloud resources can be quickly adjusted, either scaled up or down, to meet changing workload demands. This flexibility ensures optimal performance and cost-effectiveness.
Software Delivery Model (SaaS)	Software as a Service (SaaS) lets consumers access and use software directly over the internet without the need for installation or continuous management. It does this by delivering programs online.
Public Cloud Deployment Approach	Public cloud services are offered over the internet and are available to anyone with an internet connection. This model offers broad accessibility and scalability.

II. Final Architecture

The final architecture of the cloud-based financial analysis system has been carefully crafted to fully utilize the strengths of Amazon Web Services (AWS) and Google Cloud Platform. Built with a focus on robustness, scalability, and efficiency, and aligned with NIST SP 800-145 standards, this platform is perfectly equipped for executing Monte Carlo simulations and performing risk assessments on stock market data.

1. Back-end Components:

Amazon API Gateway: Serving the system's front door, the API Gateway manages incoming client requests, authenticates users, and routes traffic to appropriate backend services. It also handles throttling and rate limiting to protect against overwhelming traffic.

AWS Lambda: This Serverless compute service that excels at handling computationally less intensive tasks within the system. It is ideally suited for data preprocessing, initial calculations, and other functions that don't require significant processing power. Lambda's pay-per-use model eliminates the need for upfront infrastructure costs, making it highly cost-effective. Moreover, its auto-scaling capabilities allow it to dynamically adjust resources based on incoming workload, ensuring optimal performance and cost-efficiency. By offloading these tasks to Lambda, the system can focus the more resource-intensive Monte Carlo simulations on EC2 instances, optimizing overall performance and cost.

Amazon EC2: It provides the computational horsepower necessary for executing complex Monte Carlo simulations. By leveraging EC2's auto-scaling capabilities, the system dynamically adjusts compute resources to align with fluctuating simulation demands. This ensures optimal performance while preventing overprovisioning and associated costs. EC2's robust infrastructure guarantees the reliability and stability required for accurate and consistent simulation results.

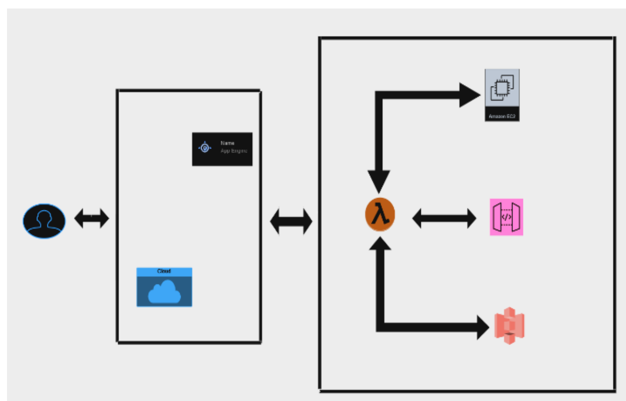
Amazon S3: It serves as the robust, scalable, and secure data repository for the system, storing simulation results, input data, and audit logs. Its object-based storage design efficiently handles large datasets generated by the computationally intensive Monte Carlo simulations. The platform's durability and redundancy features ensure data integrity and availability, even in the face of potential failures or disruptions. Additionally, S3's cost-effective storage options contribute to the overall efficiency of the system.

2. Front-end Components:

Google App Engine (GAE): The system's architecture comprises a robust front-end built on Google App Engine, providing a user-friendly interface for interacting with the Monto Carlo simulation platform. Users can input parameters, visualize results and manage simulations through this intuitive platform. On the backend, a combination of AWS services, including Lambda, EC2, and S3, work in concert to process computations, store data, and manage API requests, ensuring efficient, scalable, and secure operations for the Monto Carlo simulations.

Component Interactions:

Users initiate Monte Carlo simulations by inputting parameters through the Google App Engine-based interface. The API Gateway routes these requests to AWS Lambda for less demanding computations or to Amazon EC2 for more resource-intensive operations. The results of the simulations are then saved in Amazon S3 for later use. Processed data is transformed into actionable insights, including risk metrics and visualizations. These outputs are presented back to the user via the Google App Engine interface. This integrated system ensures efficient processing, scalability, and a seamless user experience.



Architectural Workflow Explanation:

The system functions as an integrated whole, where each component is vital for producing efficient and precise Monte Carlo simulations. Users begin by entering essential parameters—such as the simulation duration, data points, type of trading signal, and profit/loss evaluation period—through a user-friendly web interface hosted on Google App Engine (GAE). These inputs are then channeled through the Amazon API Gateway, which acts as a traffic manager, directing requests to either AWS Lambda for less computationally intensive tasks or Amazon EC2 for more complex simulations. EC2's robust processing capabilities are ideal for handling large-scale Monte Carlo simulations, while Lambda's serverless architecture offers cost-effective scalability for smaller computational needs. Once the simulations are complete, the results, including intermediate calculations and final outputs, are securely stored in Amazon S3 for future reference and analysis. The processed data is then retrieved and presented to the user in a comprehensible format, including risk metrics, profit/loss estimates, and visual representations, via the GAE interface.

III. Satisfaction of Requirements

	MET	*PARTIALLY MET*	*NOT MET*
Requirements	i.	iv.	ii. iii
Endpoints	/warmup /resources_ready /get_warmup_cost /get_endpoints /analyse /get_sig_vars9599 /get_avg_vars9599 /get_sig_profit_loss /get_tot_profit_loss /get_chart_url /get_time_cost /get_audit /reset /terminate /resources_terminated		

IV. Results

S	R	H	D	T	P	Avg_95	Avg_99	Cost	Time
Lambda	1	250	600	Buy	2	-0.0285140	-0.0408020	0.0024587	11.0092267
Lambda	3	67	800	Sell	5	-0.0293679	-0.0417675	0.00556511	24.9184131
EC2	2	198	400	Sell	4	-0.0348993	-0.0491720	0.00038540	57.8110602
EC2	4	78	700	Buy	6	-0.0359382	-0.0437775	0.001342677	100.700824
EC2	3	234	900	Sell	5	-0.0351311	-0.0501591	0.00079028	79.0289183

V. Costs

Assumptions: Active Users: 1200, Session Duration: 50 minutes, Utilization Distribution: 55% AWS Lambda, 45% AWS EC2, Data Storage: 2.5GB/user on AWS S3

AWS Lambda Expenses: Execution Count per Session: 18 executions, 300 ms each, Monthly Execution Volume: 6840,000 (1,200 users * 18 executions * 30 days). Execution Cost: $0.00001800 per invocation, Request Cost: $0.19 per million invocations. Execution Cost : $11.66, Request Cost :$0.12, Aggregate Lambda Cost: $11.78

AWS EC2 Expenses: Instances Necessary:12 instances/hour, Monthly Instance Usage: 8,640 (12 instances * 24 hours * 30 days). Instance Price: $0.070 per hour. Instance Cost : $604.80, Overall EC2 Cost : $604.80

AWS S3 Expenses: Storage Needed: 2.5GB/user, Monthly Storage Volume: 3,000GB (1,200 users * 2.5GB), Storage Fee: $0.030 per GB, Total S3 Cost : $90.00

AWS Network Expenses: API Request/User/Day: 60, Monthly API Requests: 1,800,000 (1,200 users * 60 requests * 30 days). Network Fee: $0.10 per GB for outbound data.
Total Network Expenses : $6.00

Overall Monthly Cost: AWS Lambda: $11.78, AWS EC2 : $604.80, AWS S3 : $90.00, AWS Network : $6.00,
Grand Total : $712.58

VI. References

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