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

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***Abstract*—This paper introduces a sophisticated cloud-native application programming interface (API) designed for financial risk analysis and trading strategy optimization using Monte Carlo simulations. The system exploits the scalable and elastic features of cloud computing, adhering to the NIST SP 800-145 framework, to handle extensive computational tasks across multiple cloud services, including AWS Lambda, EC2, and Google Cloud Platform. By processing real-time data and employing advanced analytics, the API efficiently evaluates trading signals derived from technical indicators and performs risk assessments on trading strategies. Key components such as Amazon S3 for data storage, AWS Lambda for task distribution, and Google App Engine for deploying interactive applications ensure a robust infrastructure that supports rapid scalability and high availability. This integration allows for dynamic resource provisioning and cost-effective scalability, essential for adapting to the financial market's volatility. The API demonstrates a transformative approach to leveraging cloud technologies for enhanced financial decision-making, offering significant improvements in the accuracy and timeliness of risk assessments.**

Keywords— AWS Lambda, EC2, S3, GAE, Financial Risk Assessment, Monte Carlo Simulations, NIST

I. INTRODUCTION

This report introduces a cloud-based financial analysis system that leverages the robust capabilities of both Amazon Web Services (AWS) and Google Cloud Platform (GCP) to deliver a comprehensive trading strategy optimization and risk assessment solution. Adhering to the NIST SP 800-145 standards for cloud computing, our platform utilizes AWS Lambda and EC2 for backend computations and serverless data processing, while providing a user-friendly interface through Google App Engine under the Software as a Service (SaaS) model. This dual-platform approach ensures rapid scalability and resource pooling, enabling efficient real-time Microsoft data analysis with cost and management with minimal overhead. By integrating advanced cloud services, the system offers a secure and dynamic environment for users to execute and assess financial trading strategies directly from any internet-connected device, aligning technical functionality with strategic financial insights.

A. Developer

The architecture and operations of our API system are fully aligned with the NIST SP 800-145 cloud computing framework, enhancing both functionality and user experience through its structured use of cloud characteristics and service models. Below is a breakdown of how these elements are incorporated:

In NIST SP800-145	Developer uses and/or experiences
Essential Characteristics	
On-demand Self Service	Developers can seamlessly deploy applications to cloud platforms such as Google App Engine, AWS Lambda, and EC2, managing application scalability and deployment without the need to handle the underlying infrastructure directly.
Broad Network Access	The API is accessible globally via the internet, utilizing a blend of services from both GCP and AWS to optimize each platform's strengths, thereby enhancing operational flexibility and efficiency.
Resource Pooling	Resources from AWS and Google Cloud are pooled together, allowing for an elastic distribution of computing load. This dynamic allocation supports scalability and enhances overall system performance without manual intervention.
Measured Service	The system adheres to a consumption-based model, where the use of computing resources is metered and billed accordingly. This ensures that costs are directly correlated with actual usage, allowing for more precise budget management and cost-effective operations.
Service Model	
Platform as a Service (PaaS)	This model allows developers to concentrate on application management and development without the complexities of managing servers, storage, or network components. Utilizing PaaS capabilities from GCP and AWS simplifies development processes and significantly reduces the time-to-market for new features..
Deployment Model	
Hybrid Cloud	Combines the flexibility of using both GCP and AWS to deploy applications. For instance, static content is hosted on GAE, while dynamic processing like risk analysis is handled by AWS Lambda and EC2, providing a balance between performance, cost, and scalability.

B. User

The deployment and utilization of our API system are meticulously designed to conform to the NIST SP 800-145 guidelines for cloud computing, ensuring a seamless and efficient user experience across various aspects:

In NIST SP800-145	User uses and/or experiences
Essential Characteristics	
On-demand Self Service	Users enjoy hassle-free access to applications from any internet-connected device, allowing them to utilize services like financial risk analysis without the complexities of software management or installation.
Broad Network Access	The system is engineered to be accessible globally over the internet, offering users the convenience to operate from any location and on any device, enhancing user flexibility and engagement.

In NIST SP800-145	User uses and/or experiences
Essential Characteristics	
Resource Pooling	Through the effective virtualization of resources, the system provides high availability and scalability. This feature allows users to leverage pooled cloud resources for their computational needs without being bogged down by the underlying technicalities of resource allocation.
Measured Service	Billing is straightforward and user-friendly, based solely on resource consumption. This ensures that users pay only for the resources they use, making the service cost-effective.
Rapid elasticity	The system is designed to handle varying load demands efficiently. It automatically scales up during peak usage times and scales down when the demand decreases, ensuring consistent performance and speed.
Service Model	
SaaS	The platform operates under the SaaS model, providing users with on-demand, web-based access to our financial risk assessment tools. This eliminates the need for users to manage software installations or updates, streamlining their interaction with the service.
Deployment Model	
Public Cloud	The services are delivered over the public internet, making them easily accessible to a broad audience without specialized credentials or configurations. This approach ensures that our tools are available to anyone with internet access, promoting inclusivity and ease of use.

II. Final Architecture

The system's architecture effectively integrates essential components from both Amazon Web Services (AWS) and Google Cloud Platform (GCP) to establish a robust and scalable cloud computing solution tailored for advanced risk analysis and resource management. This setup allows for a seamless operation that caters to both developers and end-users with high efficiency and minimal management overhead.

1.Google App Engine (GAE):

a) Utilizes GAE to host the API endpoints along with the user interface, ensuring a scalable and cost-effective environment for user interactions and API management.

b) Configured to automatically adjust its scale based on user demand, GAE enhances system responsiveness without the need for manual scaling interventions.

2. Amazon Web Services (AWS):

2.1 Elastic Compute Cloud – EC2:

a) Provides the necessary computational power to perform parallel risk analyses, dynamically adjusting resources according to workload variations.

b) Managed through AWS Lambda to initiate and configure EC2 instances during high-demand phases, ensuring optimized performance across multiple Availability Zones.

2.2 AWS Lambda:

a) Handles serverless computing tasks, including the orchestration of EC2 for computing demands and interacting with AWS S3 for data management.

2.3 AWS Simple Storage Service – S3:

a) Serves as the central repository for all analytical data and results, offering secure and scalable storage solutions that support extensive data auditing and retrieval..

2.4 AWS API Gateway:

a) Facilitates secure and efficient interactions between the Google App Engine frontend and AWS backend services.

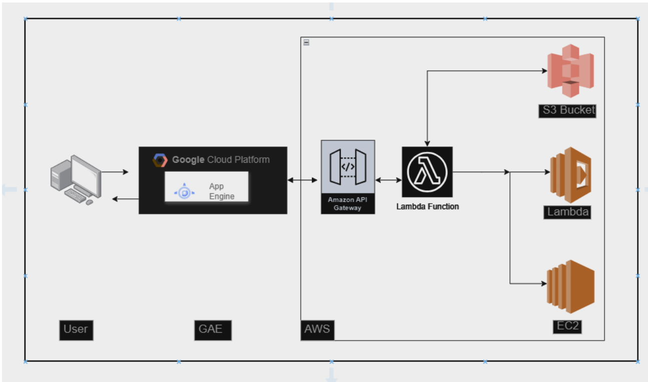


Figure: System Architecture

Architectural Workflow Explanation:

The discussion will focus on user interactions with the implemented API for risk assessment and analysis, utilizing a robust and scalable system architecture that combines Google Cloud Platform (GCP) and Amazon Web Services (AWS).

a) Users access the system through a web interface, where they can initiate analyses by setting parameters and choosing services.

b) The web interface is hosted on Google App Engine (GAE). Users interact with the GAE-hosted interface to input parameters for their analyses and select desired services.

c) When users submit a request via the GAE interface, the request is sent to the Amazon API Gateway.

d) The API Gateway triggers an AWS Lambda function. This function either warms up Amazon EC2 instances or directly handles the analysis if Lambda is chosen for execution.

e) Both AWS Lambda and EC2 instances use Amazon S3 for storing data. S3 provides a scalable and secure storage solution.

f) Once the analysis is complete, the results are stored in Amazon S3.

g) The GAE interface retrieves the analytical results from AWS S3 and displays them to the user. This provides insights and risk assessments derived from the cloud-based computations.

III. Satisfaction of Requirements

This table outlines the satisfaction of various requirements for the cloud-based financial risk analysis system, categorizing each requirement as either met, partially met, or not met.

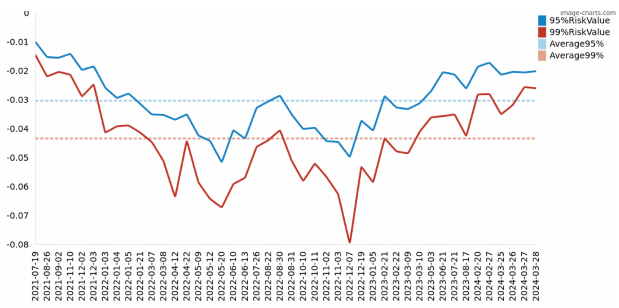
TABLE I.

	MET	*PARTIALLY MET*	*NOT MET*
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

TABLE 2

S	R	H	D	T	P	Avg_95	Avg_99	Cost	Time
Lambda	1	100	500	Sell	2	-0.0294533	-0.042720	0.0023477	10.51218
Lambda	2	120	1000	Buy	4	-0.0301621	-0.042841	0.0039160	17.53436
Lambda	3	140	1500	Sell	6	-0.0297994	-0.0424699	0.0054523	24.41369
EC2	1	160	2000	Buy	2	-0.0342694	0.04865553	0.0001254	37.62740
EC2	2	180	2500	Sell	4	-0.03346156	-0.04727483	0.0003819	57.29396
EC2	3	200	3000	Buy	6	-0.0343936	-0.04870188	0.0007960	79.60896



V. Costs

Assumptions:

Active Users*: 500*

Session Length*: 30 minutes*

Usage Distribution*: 70% AWS Lambda, 30% AWS EC2*

Data Storage*: 2GB/user on AWS S3*

AWS Lambda Costs:

12 executions/session, 200 ms each

180,000 requests/month

Total Cost: *$0.60(compute)+$0.09(invocations) = $0.69*

AWS EC2 Costs:

8 instances/hour

Total Cost: 5,760 instance hours/month × $0.052 = $299.52

AWS S3 Costs:

2GB/user

Total Cost*: 500 users × 2GB × $0.025 = $25.00*

AWS Network Costs:

40 API calls/user/day

Total Cost: 600,000 calls/month × $4.00/million = $2.40

Total Monthly Cost:

Grand Total: $0.69 (Lambda) + $299.52 (EC2) + $25.00 (S3) + $2.40 (Network) = $327.61 per month

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