Scalable Cloud-Based API for Financial Risk Analysis and Trading Strategy Optimization Using Monte Carlo Simulations

Nimisha Rajesh, URN : 6829882, nimisha99rajesh@gmail.com

https://clouddeployment-423818.ue.r.appspot.com/

***Abstract*— This project develops a cloud-based API that employs Monte Carlo simulations to offer financial risk assessment and trading strategy optimization. Utilizing the elastic and scalable properties of cloud computing, as outlined in NIST SP 800-145, our system integrates services such as AWS Lambda and EC2 to efficiently manage large-scale data processing and computational tasks. This architecture supports rapid scalability and real-time analytics, crucial for adapting to the volatile nature of financial markets. By leveraging cloud technology, the API enhances the accuracy and speed of financial analyses, providing traders with robust tools to evaluate trading signals and potential risks effectively. Overall, the project exemplifies the transformative potential of applying cloud computing principles to complex financial analyses, leading to more informed and strategic trading decisions.**

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

I. Introduction

Our cloud-based financial risk assessment platform effectively combines Google Cloud Platform (GCP) and Amazon Web Services (AWS) to align with NIST SP 800-145 cloud computing guidelines. Utilizing GCP's Google App Engine, the system offers a scalable interface for users under the Software as a Service (SaaS) model, allowing access from any internet-connected device without backend management. For backend processing, it employs AWS services like EC2 and Lambda for serverless operations and for intensive Google data computations, showcasing resource pooling and rapid elasticity. This hybrid approach ensures efficient scaling and data processing capabilities, providing a robust, secure, and user-friendly environment for real-time financial analysis with cost and trading strategy optimization:

A. Developer

The architecture and execution of this API system are in compliance with the definitions and guidelines of cloud computing as outlined in NIST SP 800-145, detailing how each characteristic and model enhances functionality and user experience.

In NIST SP800-145	Developer uses and/or experiences
Essential Characteristics	
On-demand Self Service	Developers deploy code to cloud services like Google App Engine (GAE), AWS Lambda, and EC2 without managing underlying infrastructure such as networking and servers, automating the operational aspects of deployment and scaling.
Broad Network Access	The system is accessible over the internet using standard platforms, enhancing flexibility and operational efficiency through a hybrid cloud approach utilizing both GCP and AWS, optimizing the capabilities of each platform.
Resource Pooling	Cloud resources from multiple providers are pooled to ensure optimal distribution of workload, enabling dynamic resource allocation without manual intervention, supporting scale and performance optimization.
Measured Service	Utilizes a pay-as-you-go model where resource usage is monitored and optimized, ensuring cost efficiency by billing for actual compute time and resources used, thus enabling precise cost management and planning.
Service Model	
Platform as a Service (PaaS)	Developers focus on the deployment and management of applications rather than infrastructure, utilizing PaaS capabilities of GCP and AWS to streamline development workflows and accelerate time-to-market.
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 API system's utilization is also consistent with the definitions provided by NIST SP 800-145 in the following aspects:

In NIST SP800-145	User uses and/or experiences
Essential Characteristics	
On-demand Self Service	Users can access applications and services from any internet-connected device without needing to manage or install software, enhancing accessibility and convenience.
Broad Network Access	Applications are accessible from any location over the internet, ensuring users are not limited by their geographical location or the device they are using.
Resource Pooling	High availability and scalability are achieved through the virtualization of resources, which users utilize without needing to understand or manage the physical allocation of resources.
Measured Service	Billing is transparent and based on the actual resources used, providing users with cost-effective solutions and ensuring they only pay for what they consume.

In NIST SP800-145	User uses and/or experiences
Rapid elasticity	Users experience minimal delays and receive timely results as resources scale automatically with increasing demand, ensuring efficient service even during peak loads.
Service Model	
SaaS	Users can access risk analysis and profit/loss reports through a web service available on-demand, eliminating the need for software installation or management
Deployment Model	
Public Cloud	Capabilities are provided freely over the public internet, requiring no additional credentials or detailed access permissions

II. Final Architecture

The system architecture seamlessly integrates components from AWS and Google Cloud to deliver a robust cloud computing solution tailored to efficient risk analysis and resource management. Here is a streamlined overview of the system architecture:

1.Google App Engine (GAE):

a) GAE hosts the API endpoints and user interface, facilitating a scalable and cost-effective platform for API management and interaction.

b) Automatically scales to accommodate user demand without manual intervention, ensuring responsive access to API functionalities.

2. Amazon Web Services (AWS):

a) Elastic Compute Cloud – EC2 :

- Provides scalable computational resources for conducting parallel risk analyses, capable of adjusting to workload demands dynamically.
- EC2 instances are initiated and managed via AWS Lambda during the /warmup phase, supporting fault tolerance by spreading across multiple Availability Zones.

b) AWS Lambda:

- Facilitates the warm-up of EC2 instances, executes risk computations during the analyse phase in case selected, and manages data interactions with AWS S3.

c) AWS Simple Storage Service – S3:

- Acts as a central repository for storing and auditing data, including input data and analysis results which are logged for each session.

d) AWS API Gateway:

- Serves as the conduit for routing HTTP requests from GAE to the appropriate AWS Lambda functions, simplifying interactions and enhancing security.

Architectural Workflow Explanation:

- The system architecture utilizes Google Cloud Platform (GCP) and Amazon Web Services (AWS) to create a robust and scalable workflow.
- Users interact through a user interface hosted on Google App Engine (GAE), which also serves API endpoints for initiating analysis and managing resources.
- User requests are managed by Amazon API Gateway, which routes these to the appropriate services like AWS Lambda or Amazon EC2 for compute-intensive tasks based on the user's request.
- AWS Lambda and EC2 interacts with Amazon S3 for data storage, leveraging auto-scaling capabilities to enhance performance and efficiency.
- Results from analyses stored in S3 are then presented to users via the GAE interface, ensuring an efficient, scalable, and user-friendly experience.

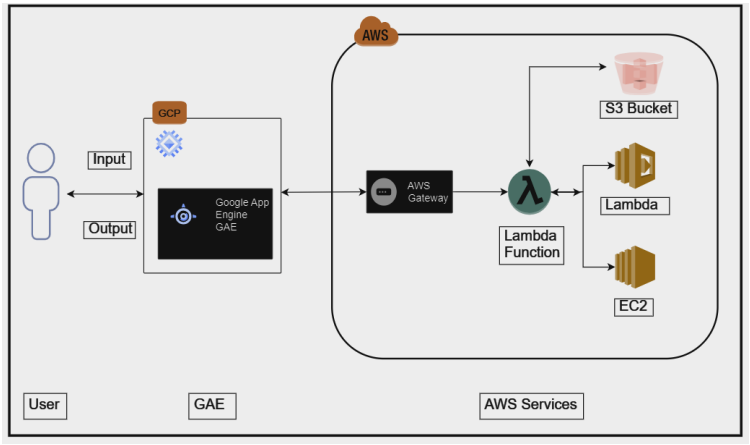


Figure: System Architecture

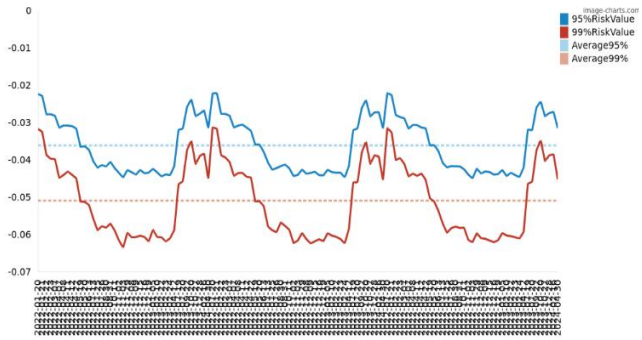
III. Satisfaction of Requirements

Requirement	*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

S	R	H	D	T	P	Avg_95	Avg_99	Cost	Time
lambda	1	102	10000	Buy	7	-0.033211	-0.047322	0.005808 18	26.006776 5
lambda	3	134	20000	Sell	5	-0.036057	-0.050837	0.008473 36	37.940454 00
lambda	4	190	15000	Buy	4	-0.034029 1	-0.048315 38	0.008095 162	36.246997 8
Ec2	3	150	10000	Buy	4	-0.035238 29	-0.050003 49	0.000799 970	79.997088 43
EC2	1	150	20000	Sell	5	-0.036711 22	-0.051757 0	0.000125 48	37.644881 2
EC2	4	180	15000	Sell	3	-0.037050 0	-0.052140 8	0.001362 484	102.18632

This graph depicts the 95% and 99% Value at Risk (VaR) metrics over time, represented by the red and blue lines, respectively. The dotted lines show the average VaR values for each confidence level. The graph illustrates fluctuations in risk, with significant dips indicating increased financial risk or volatility within the observed period, useful for analyzing potential loss thresholds.



V. Costs

Assumptions:

i. Consider there are 1000 active users at any moment
ii. Each user has an average session length of 30 minutes.
iii.60% of usage is directed towards AWS Lambda and 40% towards AWS EC2
iv.Each user stores 1GB of data on AWS S3.

Cost Calculation for AWS Lambda:

a) Consider each user session triggers 10 Lambda function and each execution lasts for 150 milliseconds
b)Cost: $0.0000002 per request
c)Monthly Request : 1000 (users) × 30 (sessions/user) × 10 (invocations/session) = 300,000 invocations per month
d) Total Time: 300,000 (invocations) × 150 (ms) = 45,000 seconds.
e)Monthly Compute Cost : 45,000 (seconds) × $0.00001667(second) = $750
f) Invocation Costs: 300,000 (invocations) × $0.0000002 = $60
g) Total Lambda Cost: $750 (compute) + $60 (invocations) = $810.

Cost calculation for aws ec2:

a)Consider a minimum of 10 instances per hour , costing $0.0464 per hour
b)Total EC2 Cost : 10 instances × 720 hours × $0.0464= $334

Cost Calculation for AWS S3:

a)Consider 1 GB per user is required and is $0.023/GB
b)Storage Cost : 1000(users) × 1(GB/user) ×$0.023/GB = $23 per month

cost calculation for aws Network;

a)Considering each user makes 50 API calls/day and cost per 1 million API calls is $3.50
b) Total API Cost = 1,000 (users) * 50 (calls/user/day) * 30 (days)/ 1,000,000 * $3.50(cost) = $5.25

Total Cost: Cost of (Lambda+EC2+S3+Network) = **$ 1172 /month**

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