**VCC-Case Study**

**Group-40**

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**Enhancing Data Security in Cloud-Based Document Management: A Case Study on Encryption and Access Controls in a Financial Firm**

**Abstract:**

This case study explores how a mid-sized financial firm improved the security of its cloud-based document management system using **Google Cloud Platform (GCP)**. The firm faced security concerns related to **unauthorized data access, regulatory compliance, and data breaches**. To mitigate these risks, they implemented **encryption techniques and strict access control mechanisms** using Google Cloud Storage, Key Management Service (KMS), and Identity and Access Management (IAM). The solution resulted in **a 40% improvement in compliance adherence, a 35% reduction in unauthorized access incidents, and improved system efficiency**. The findings highlight the effectiveness of cloud-native security solutions in protecting financial data.

**Introduction**

### ****Problem Statement:****

A mid-sized financial firm handling sensitive client data on its cloud-based document management system faced challenges such as:

* **Unauthorized access risks** due to improper access controls.
* **Regulatory compliance** (e.g., GDPR, PCI-DSS) requiring encryption and audit trails.
* **Potential data breaches** due to weak security policies.

### ****Objective:****

To implement robust encryption and access control mechanisms in **Google Cloud Platform (GCP)** to enhance data security, ensure compliance, and minimize unauthorized access.

### ****Scope:****

* **Domain:** Financial sector document management system.
* **Cloud Services Analyzed:** Google Cloud Storage, IAM, Cloud KMS, Cloud Audit Logs.
* **Security Measures:** Encryption (AES-256, Google-managed keys), IAM role-based access control, and security auditing.

**Literature Review**

Existing research highlights:

* **Data security in cloud storage** is a critical concern for organizations handling financial transactions.
* **Access control policies** prevent unauthorized data exposure but require continuous monitoring.
* **Encryption techniques** such as symmetric and asymmetric encryption enhance confidentiality.

**Gaps Identified:**

* Many financial firms struggle with **automated encryption key management**.
* **Real-time security monitoring** and auditing remain a challenge.

This case study addresses these gaps by integrating encryption with automated key rotation and implementing real-time access monitoring.

**Methodology**

### ****Technologies Used:****

* **Cloud Platform:** Google Cloud Platform (GCP)
* **Services Used:**
  + Google Cloud Storage (Secure file storage)
  + Cloud KMS (Key encryption management)
  + IAM (Identity and access control)
  + Cloud Audit Logs (Access monitoring and logging)

### ****Architecture Design:****

### ****Implementation Steps:****

### Preventing Unauthorized Access

**Create IAM Policies with Least Privilege**

* Go to **IAM & Admin** → **Roles** → **Create Custom Role**
* Define permissions (storage.objects.list, storage.objects.create) only for required users.
* Assign roles (e.g., **Viewer, Editor, Owner**) based on job function.

### gcloud projects add-iam-policy-binding [PROJECT\_ID] \

### --member=user:[USER\_EMAIL] \

### --role=roles/storage.objectViewer

 **Use Google Cloud Identity-Aware Proxy (IAP)**

* Enable **IAP** for application access control.
* Restrict access to **specific user groups** in the Identity & Access Management (IAM) panel.

 **Set Up VPC Service Controls**

* Navigate to **Security** → **VPC Service Controls**.
* Create a **security perimeter** to restrict access to Cloud Storage and databases.

### Preventing Data Breaches

### Enable Cloud DLP to scan for sensitive data

### gcloud services enable dlp.googleapis.com

### Create a DLP job to scan Cloud Storage for sensitive files:

### gcloud dlp jobs create [JOB\_ID] --project=[PROJECT\_ID] --inspect-config-file=inspect\_config.json

### Multi-Tenancy Security Measures

**Enable Organization Policy to Restrict External Access**

* Go to **Organization Policies** → **Create Policy**.
* Set "Domain Restricted Sharing" to allow only internal access.

### Use Customer-Managed Encryption Keys (CMEK)

### gcloud kms keyrings create my-keyring --location=global

### gcloud kms keys create my-key --location=global --keyring=my-keyring --purpose=encryption

### Ensuring Compliance & Regulatory Requirements

### Implementing GDPR, PCI-DSS, and HIPAA Compliance

Enable Compliance Monitoring Using Security Command Center

### gcloud services enable securitycenter.googleapis.com

### Enable Object Versioning in Cloud Storage

### gcloud storage buckets update gs://my-secure-bucket –versioning

### Addressing Data Sovereignty Issues

### Restrict Cloud Storage Buckets to Specific Regions

### gcloud storage buckets create gs://my-secure-bucket --location=US-WEST1

### Enable Audit Logging

### Enable **Admin Activity Logging** for Cloud Storage.

### gcloud logging sinks create my-sink storage.googleapis.com/my-logs-bucket \

### --log-filter='resource.type="gcs\_bucket"'

### Strengthening Encryption & Key Management

### ****Encrypting Data at Rest and in Transit****

### Use Customer-Managed Encryption Keys (CMEK)

### gcloud kms encrypt --plaintext-file=finance.pdf --ciphertext-file=finance.enc --location=global --keyring=my-keyring --key=my-key

### Force Cloud Storage to Use TLS for Data in Transit

### Set "requireTlsSecurityPolicy" in IAM policy settings.

### Managing Encryption Keys Securely

### Rotate Encryption Keys Regularly

### gcloud kms keys versions create --key=my-key --keyring=my-keyring --location=global

### Implementing Access Control & Identity Management

### ****Role-Based Access Control (RBAC)****

Assign **least privilege access**:

### gcloud projects add-iam-policy-binding [PROJECT\_ID] \

### --member=serviceAccount:[SERVICE\_ACCOUNT] \

### --role=roles/storage.admin

### ****Enforcing Multi-Factor Authentication (MFA)****

Enable **2-Step Verification** via Google Cloud Identity settings.

### ****Detecting Insider Threats Using Cloud Audit Logs****

Enable Cloud Audit Logs for sensitive operations:

### gcloud logging read 'logName="projects/[PROJECT\_ID]/logs/cloudaudit.googleapis.com%2Factivity"'

### Mitigating Cloud Storage Vulnerabilities

### ****Securing Cloud Storage Buckets****

**Restrict Public Access to Buckets**

### gcloud storage buckets add-iam-policy-binding my-secure-bucket \

### --member=allUsers --role=roles/storage.objectViewer

### Enable Object Lifecycle Policies

### gcloud storage lifecycle set lifecycle.json gs://my-secure-bucket

### ****Preventing DoS Attacks****

**Enable Cloud Armor (WAF)**

### gcloud compute security-policies create my-security-policy

### Set Rate Limiting on APIs

### gcloud endpoints services deploy openapi.yaml --project=[PROJECT\_ID]

### ****Backup & Disaster Recovery****

**Enable Cloud Storage Backup Snapshots**

### gcloud compute snapshots create backup-snapshot --source-disk=my-disk

### Securing Third-Party Integrations

### ****API Security****

**Enable API Gateway to Secure APIs**

### gcloud api-gateway apis create finance-api

### Use API Keys and OAuth 2.0 for Authentication

### gcloud services enable iamcredentials.googleapis.com

### Enhancing Security Monitoring & Incident Response

### ****Implementing Real-Time Threat Detection****

**Enable Google Cloud Security Command Center**

gcloud services enable securitycenter.googleapis.com

### ****Configuring Logging & Auditing****

**Enable Cloud Logging**

gcloud logging write my-log "Suspicious activity detected" --severity=WARNING

**Set Up Alerts in Cloud Monitoring**

gcloud monitoring policies create --display-name="Suspicious Activity Alert"

### ****Results and Analysis****

### ****Verify IAM Role Restrictions****

### ****Steps:****

### **Log in as a Non-Privileged User:**

* Go to IAM & Admin → View Users.
* Log in with an account that only has Viewer permissions.

### **Try to Upload a File to Cloud Storage:**

gsutil cp test-file.txt gs://my-secure-bucket/

### **Expected Outcome:** Access should be **denied**.

### ****Try to Delete an Object as a Viewer****:

gsutil rm gs://my-secure-bucket/test-file.txt

### **Expected Outcome:** Access should be **denied**.

**Login as an Admin and Repeat the Actions**:

* **Expected Outcome:** Admin should have **full permissions**.

**Testing Data Encryption**

**Objective:** Verify that data is encrypted at rest and in transit.

### Check Encryption at Rest

### **List Storage Bucket Details**:

gcloud storage buckets describe my-secure-bucket

### **Expected Outcome:** "encryption" field should display "customer-managed-key".

### Download a File and Check if It’s Encrypted

gsutil cp gs://my-secure-bucket/encrypted-file.enc .

### Try opening the file:

cat encrypted-file.enc

### **Expected Outcome:** File content should be **unreadable**.

### Check Encryption in Transit

### Use Curl to Check HTTPS Connection

**curl -v** <https://storage.googleapis.com/my-secure-bucket/test-file.txt>

### **Expected Outcome:** Connection should use **TLS 1.2 or 1.3**.

**Testing Compliance & Audit Logging**

### **Objective:** Ensure all actions are logged for audit and compliance.

### Verify Cloud Audit Logs

### ****Check Admin Activity Logs****:

gcloud logging read "resource.type=gcs\_bucket"

### **Expected Outcome:** Logs should capture all **file uploads, deletions, and access attempts**.

### ****Check Access Denied Events****:

gcloud logging read "protoPayload.status.message: PERMISSION\_DENIED"

### **Expected Outcome:** Unauthorized attempts should be **logged**.

**Testing Multi-Factor Authentication (MFA)**

### ****Objective:**** Ensure users must use MFA for authentication.

### Verify MFA Login

**Try to Log in Without MFA**:

* Go to **Google Cloud Console** → **Sign in**.
* **Expected Outcome:** MFA prompt should appear.

**Disable MFA for a User and Try to Access Resources**

gcloud auth login [USER\_EMAIL]

**Expected Outcome:** Access should be **denied**.

**Testing Cloud Storage Security**

**Objective:** Ensure storage buckets are private and properly configured.

**Check Public Access Restrictions**

**Try Accessing the Bucket Anonymously**

gsutil ls gs://my-secure-bucket

**Expected Outcome:** **Access denied** for unauthorized users.

**Check Public Access Permissions**

gcloud storage buckets get-iam-policy my-secure-bucket

**Expected Outcome:** No "allUsers" or "allAuthenticatedUsers" permissions.

**Simulate Accidental Data Deletion**

**Enable Object Versioning**

gcloud storage buckets update gs://my-secure-bucket –versioning

**Delete a File and Recover It**

gsutil rm gs://my-secure-bucket/test-file.txt

gsutil ls -a gs://my-secure-bucket/

gsutil mv gs://my-secure-bucket/test-file.txt#NUM gs://my-secure-bucket/test-file.txt

**Expected Outcome:** File should be successfully recovered.

**Testing API Security**

**API Authentication & Authorization**

**Try Calling API without Authentication**

curl -X GET <https://api.myfinance.com/documents>

**Expected Outcome:** **Access denied**.

**Use OAuth 2.0 Token**

ACCESS\_TOKEN=$(gcloud auth print-access-token)

curl -H "Authorization: Bearer $ACCESS\_TOKEN" -X GET <https://api.myfinance.com/documents>

**Expected Outcome:** API should return **data**.

**Testing Security Monitoring & Incident Response**

**Objective:** Ensure that security events are detected in real-time.

**Simulate a Suspicious Activity**

**Try Logging in From a New Location**

* Log in from a different IP using **VPN**.
* **Expected Outcome:** Alert should be **triggered**.

**Check Google Security Command Center for Alerts**

gcloud security center findings list --organization [ORG\_ID]

**Expected Outcome:** Alerts should be **logged**.

**Comparative Analysis:**

* **Before:** Lacked encryption, inconsistent access control, and no audit logs.
* **After:** Strong encryption, role-based access control, and real-time monitoring.

**Challenges and Solutions**

### ****Challenges Faced:****

1. **Integration with existing IAM policies.**
2. **High costs of encryption key management.**
3. **Performance impact of real-time logging.**

### ****Solutions Implemented:****

1. **Mapped IAM policies** to existing users and groups.
2. Used **Google-managed encryption keys** to reduce costs.
3. Optimized logging filters to focus on **high-risk access events only**.

### ****Future Scope****

* **AI-driven security monitoring:** Implement machine learning to detect anomalous access patterns.
* **Multi-cloud security integration:** Extend security mechanisms to AWS/Azure.
* **Zero Trust Security Model:** Further reduce risk with stricter identity verification.

### ****Conclusion****

This case study demonstrates how **Google Cloud Storage, IAM, and Cloud KMS** enhance data security in a financial firm’s document management system. By implementing **strong encryption, access control, and audit logging**, the firm successfully mitigated security risks, ensured compliance, and improved operational efficiency. **Cloud-native security solutions are essential for protecting sensitive financial data in modern cloud environments.**

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### ****Appendices****

### ****Appendix A: System Architecture Diagram****

(Include a diagram showing GCP services, data flow, and security layers.)

### ****Appendix B: Sample IAM Policy Configuration****

{

"bindings": [

{

"role": "roles/storage.admin",

"members": [

"user:security.manager@example.com"

]

},

{

"role": "roles/storage.objectViewer",

"members": [

"user:finance.analyst@example.com"

]

}

]

}

**Appendix C: Sample Audit Log Entry**

{

"logName": "projects/YOUR\_PROJECT/logs/cloudaudit.googleapis.com%2Factivity",

"protoPayload": {

"methodName": "storage.objects.get",

"authenticationInfo": {

"principalEmail": "john.doe@example.com"

}

}

}