



# EHR HEALTHCARE

**6M22 Project – Group 4  
(Phase II)**



Source: [https://services.google.com/fh/files/blogs/master\\_case\\_study\\_ehr\\_healthcare.pdf](https://services.google.com/fh/files/blogs/master_case_study_ehr_healthcare.pdf)

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## CLOUD ARCHITECTURE

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# EHR PHASE I - REVIEW

## **EHR Background:**

- ❖ Electronic Health record software to the medical industry.
- ❖ Provides software as a service to multi-national medical offices, hospitals and insurance providers.

## **Use Case Statement:**

- ❖ EHR Healthcare's business has been growing exponentially year over year
- ❖ Need to scale environments, adapt disaster recovery plan, roll out new CD capabilities.
- ❖ Google Cloud has been chosen to replace their current colocation facilities

## **EHR Current State**

### **Environment:**

- ❖ Multiple colocation facilities, The lease on one of the data centers is about to expire.

### **Application:**

- ❖ Web-based application, many of them run on a group of Kubernetes clusters.
- ❖ Data is stored in MySQL, MS SQL Server, Redis and MongoDB.
- ❖ EHR is hosting several legacy file and API-based integrations with insurance providers on-premises. (to be replaced over next several years)
- ❖ Monitoring is done via open source tools and email alerts are often ignored.



# EHR PHASE I - REVIEW

## ADOPTION OF GOOGLE CLOUD:



- ❖ Infrastructure as a code (IAC) is the managing and provisioning of infrastructure through code instead of using a manual process to configure devices or systems



- ❖ Deploying application using CI/CD methodolog



- ❖ Building applications on the scalable architecture

Operational  
excellence



Security,  
privacy, and  
compliance



Reliability



Cost  
optimization



Performance  
optimization



# CLOUD MIGRATION

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Cloud migration is the process of moving a company's digital assets, services, databases, IT resources, and applications either partially, or wholly, into the cloud. Cloud migration is also about moving from one cloud to another.

## BENEFITS OF CLOUD MIGRATION:

- ❖ Increased agility and flexibility
- ❖ Ability to innovate faster
- ❖ Easing of increasing resource demands
- ❖ Better managing of increased customer expectations
- ❖ Reduction in costs
- ❖ Deliver immediate business results
- ❖ Simplify IT
- ❖ Shift to everything-as-a-service
- ❖ Better consumption management
- ❖ Cloud scalability
- ❖ Improved performance

## CHALLENGES IN CLOUD MIGRATION:

- ❖ Legacy application
- ❖ Application modernization
- ❖ Cloud management
- ❖ Complexity of migrating
- ❖ Key dependencies
- ❖ Business support

# CLOUD MIGRATION STRATEGIES

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## **GCP Cloud Migration Strategies “5Rs”:**

- ❖ Rehost ("lift and shift")
- ❖ Refactor
- ❖ Revise
- ❖ Rebuild
- ❖ Replace



# CLOUD MIGRATION STRATEGIES

## Rehost ("lift and shift")

One of the easiest and least expensive ways to migrate an existing workload to the cloud is to take the workload as-is and run it on cloud-native resources: this is known as the "Lift & Shift" approach.

### Advantages of the Lift and Shift approach:

- The [lift and shift cloud migration](#) approach does not demand any application-level changes as it is merely being rehosted on the cloud.
- Workloads that demand specialized hardware, say, for example, graphical cards or HPC, can be directly moved to specialized VMs in the cloud, which will provide similar capabilities.
- A lift and shift allow you to migrate our on-premises identity services components such as Active Directory to the cloud along with the application.
- Security and compliance management in a lift and shift cloud migration is relatively simple as you can translate the requirements to controls that should be implemented against compute, storage, and network resources.
- The lift and shift approach uses the same architecture constructs even after the migration to the cloud takes place.

# BUSINESS EVOLUTION



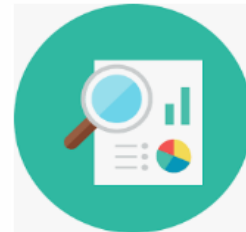
Rapid Scaling



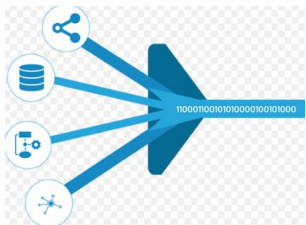
99.9% availability  
Uptime



Latency



Data Analytics



Ingest & process data  
from new providers



Regulatory compliance



Monitoring



Cost Efficiency



# RAPID SCALING



Load Balancer



GKE Cluster



Instance group



Auto Scale Policy Prioritization:

- CPU Utilization
- HTTP(s) Load Balancer capacity
- Cloud Monitoring Metrics

## Business Objective



Less CAPEX



Effective Business decision making



Reliable solutions due to SLA



Flexible budget

# AVAILABILITY AND LATENCY



## Network



- LB with Multi Zone Deployment
- Cloud Interconnect
- Dedicated Interconnect

## Services and Operations



- Auto Heal MIG (VM running services)
- Auto Repair GKE
- Pub/Sub
- Cloud FireStore
- Cloud MemoryStore
- Cloud CDN

## Business Objective



Reduced Downtime



Increased Customer Satisfaction



Increased Customer Engagement

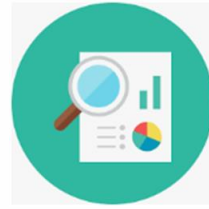
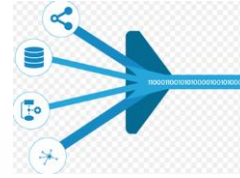


Smooth UI/UX Interaction



Improved Services/App Rating

# DATA INGEST PROCESS AND DATA ANALYTICS



Data Flow



Cloud SQL



Big Query



DataProc

- Fully managed & serverless data processing flow
- Managed query data
- Large read only data analytic
- Batch processing

## Business Objective



Reduced onsite storage cost and space



Faster data interaction



Reliable back up



Bigger data storage



- Wider analytic scope
- Smarter modelling and prediction that can be used for biz forecasting

# MONITORING, LOGGING AND ALERTING



Cloud  
Monitoring



Cloud  
Logging

- Alerts and Notifications, Charts and Dashboards
- Automatically ingest audit and platform logs, manage retention and policies

## **Business Objective:**



Improve audit  
performances

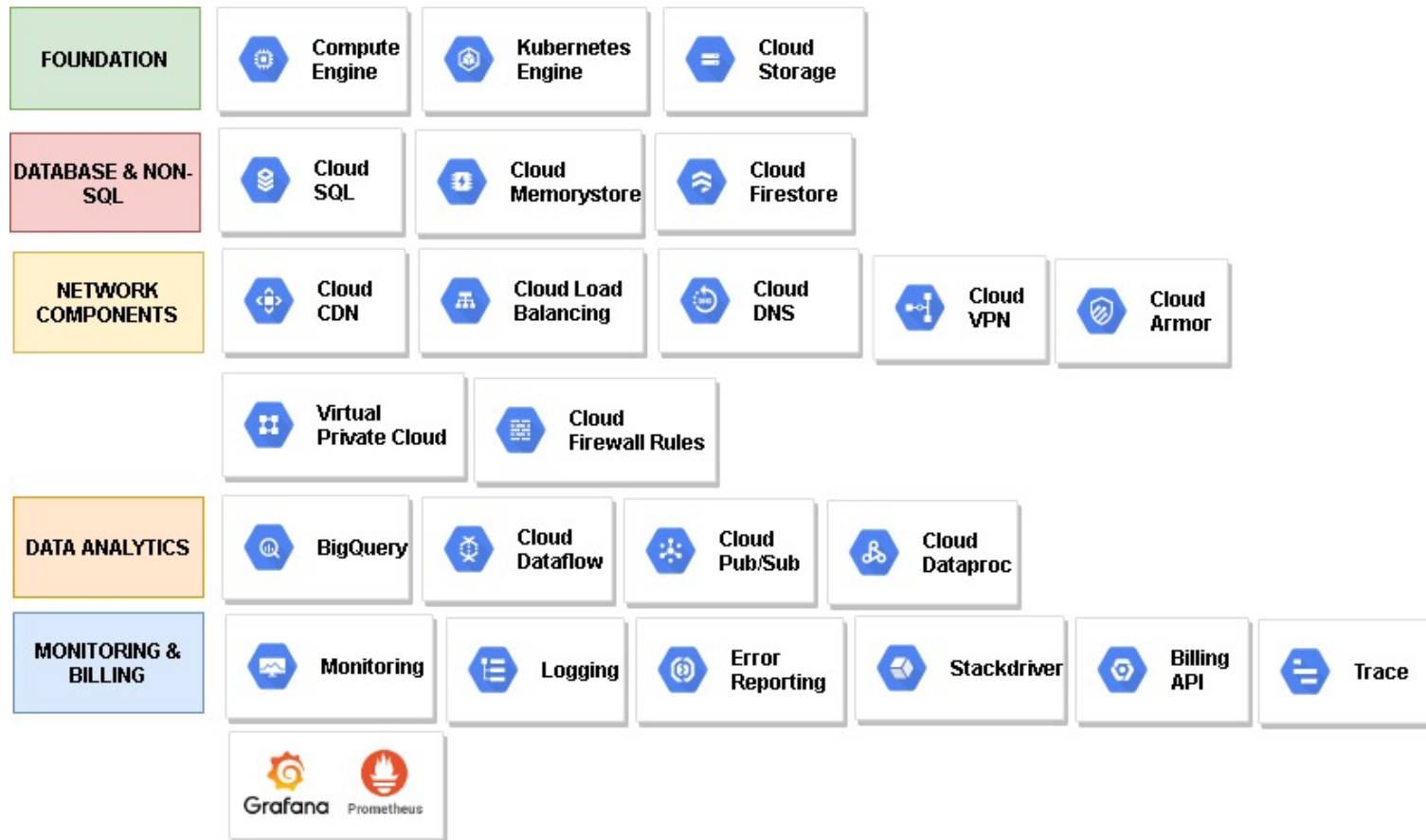


Easier and faster biz  
decisions



Reduce error repair time

# GOOGLE SERVICES ADOPTED



# DEVOPS TOOLS ADOPTED



**JFROG is an artifact repository for storing software packages**



**STASH is a tool for managing, sharing and tracking changes in source code files**



**JENKINS is an automation server for running software build and testing jobs and etc**

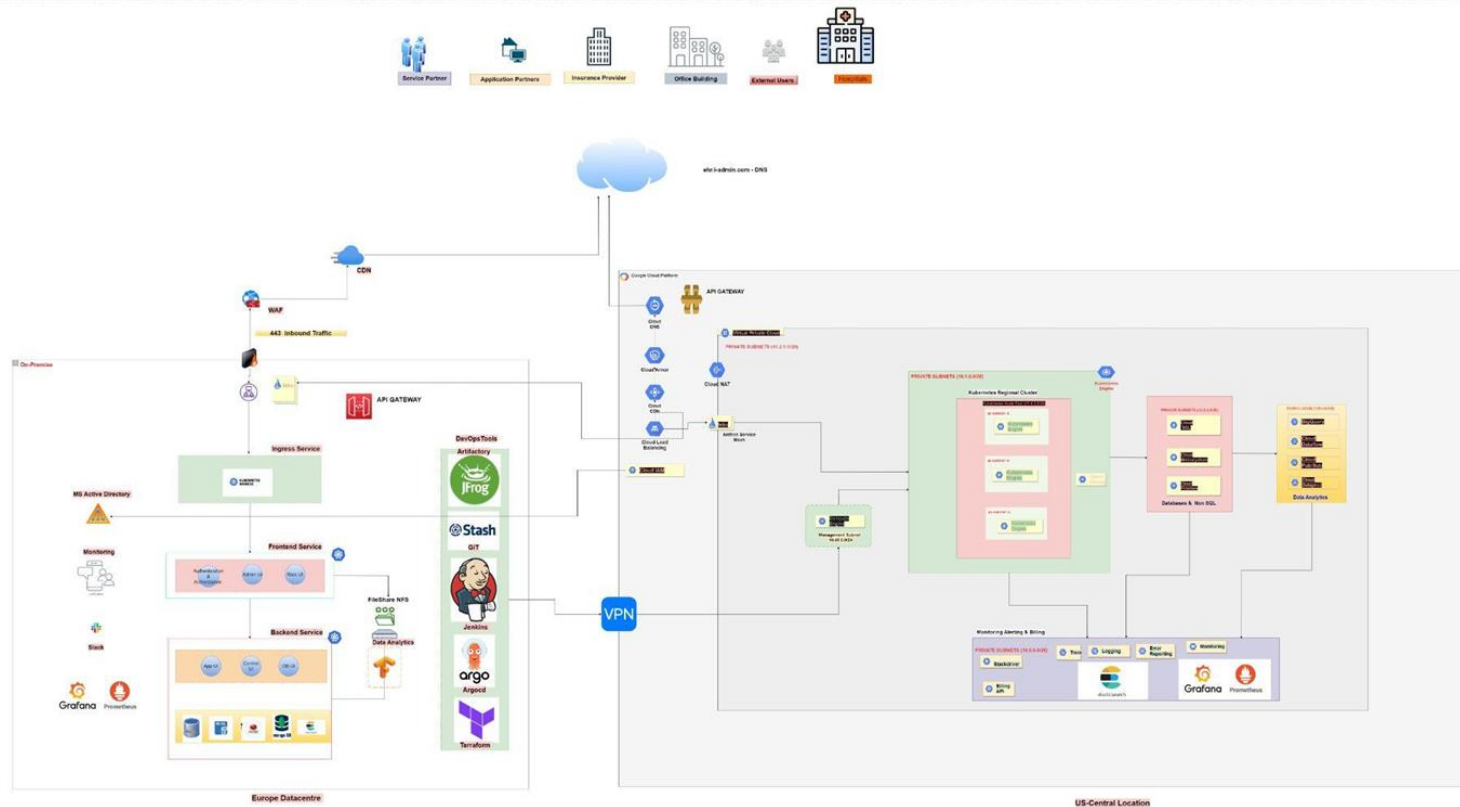


**ARGOCD is a continuous delivery tool for Kubernetes, which uses the principle of GitOps**

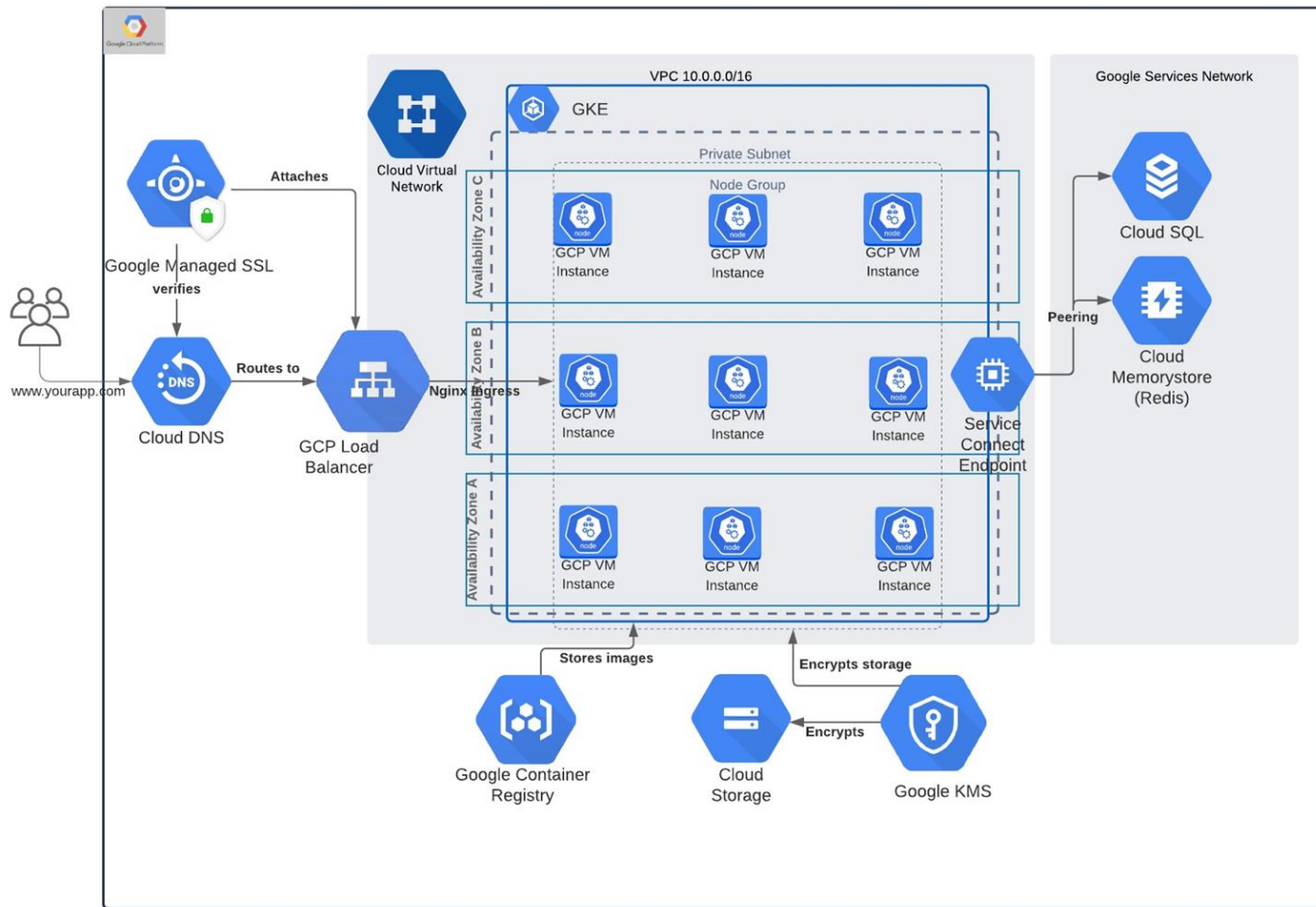


**TERRAFORM is a tool for creating and managing cloud resources with code**

<https://mohanawss3.s3.ap-southeast-1.amazonaws.com/Google+ISTIO-Final.jpg>

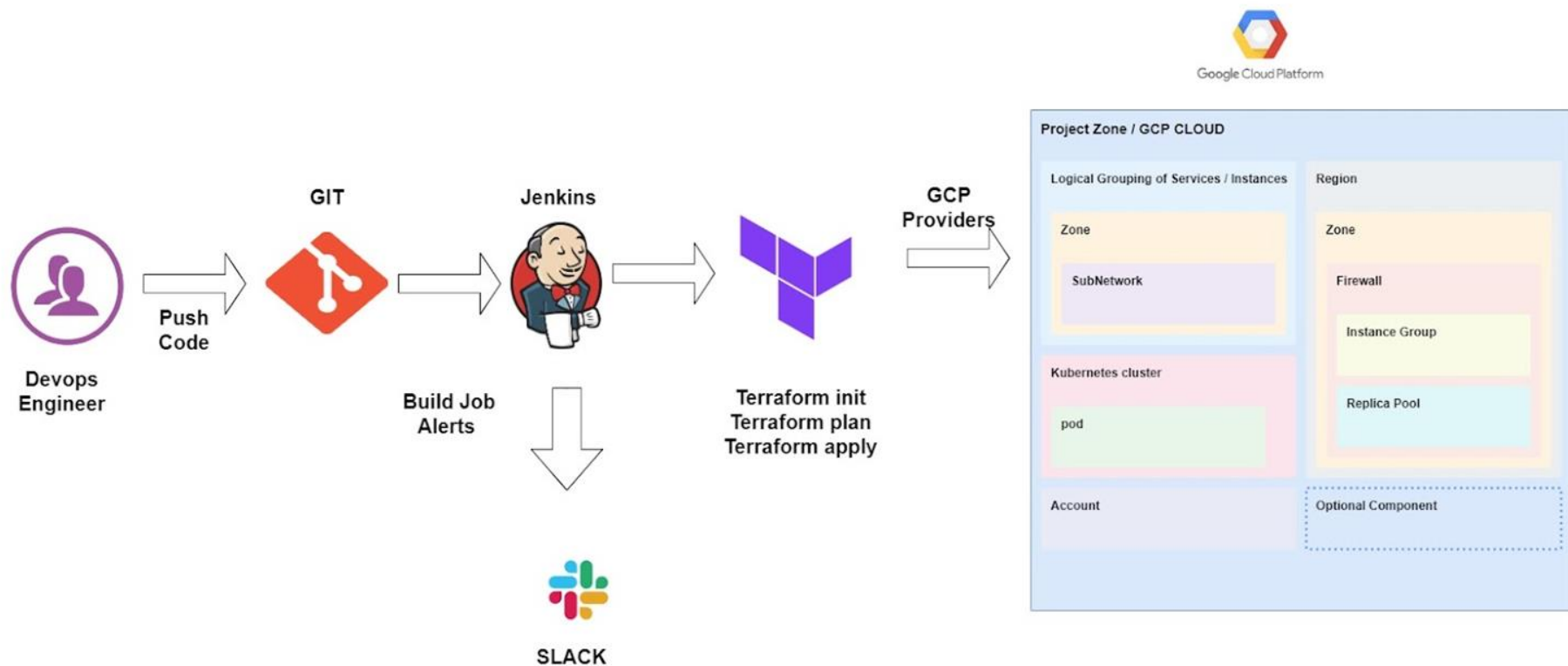


# GKE MONOLITHIC ARCHITECTURE

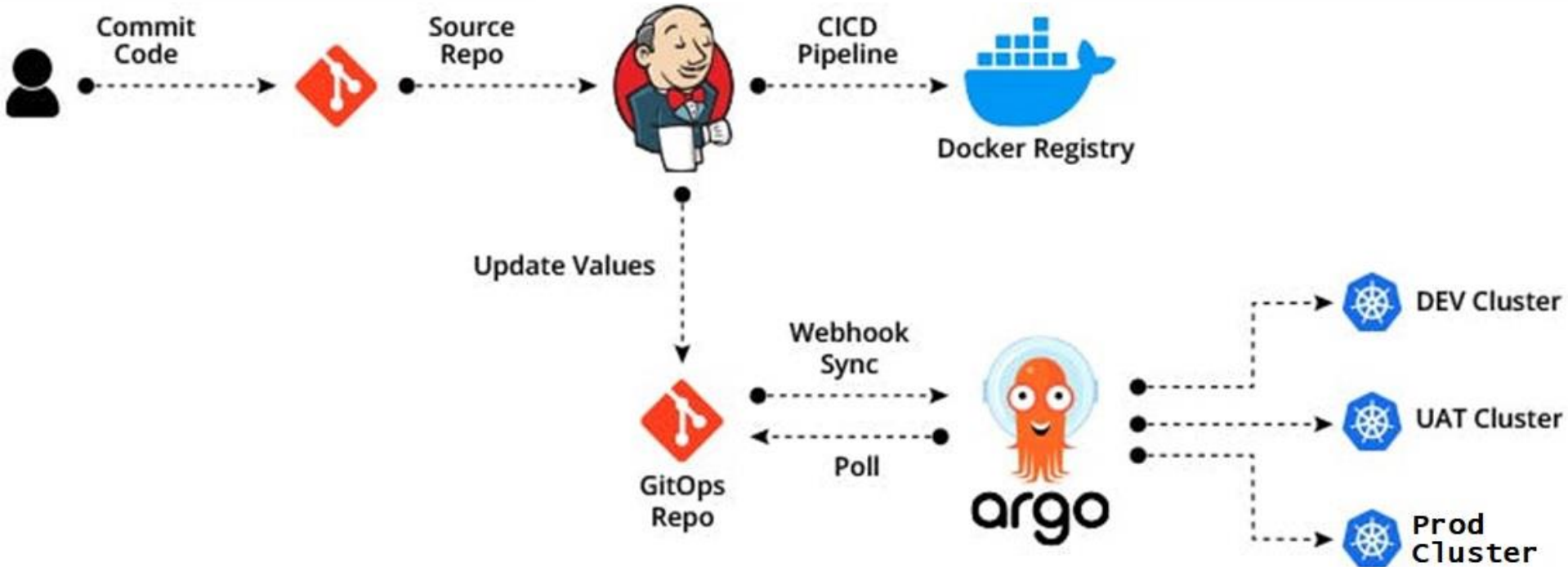




# CI/CD FOR IAC

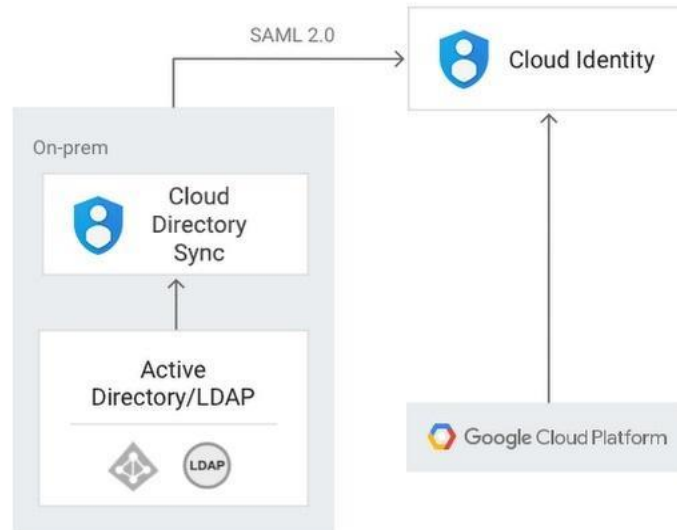


# AGRO CD DEPLOYMENT

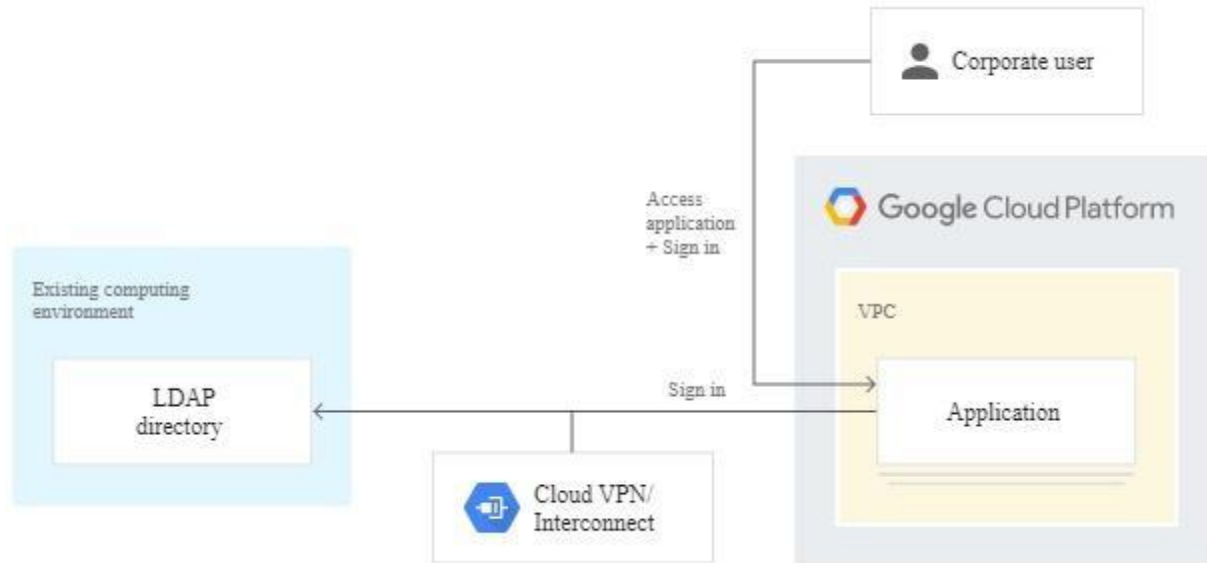


# CLOUD IAM

On-prem directory as source of truth



# CLOUD IAM

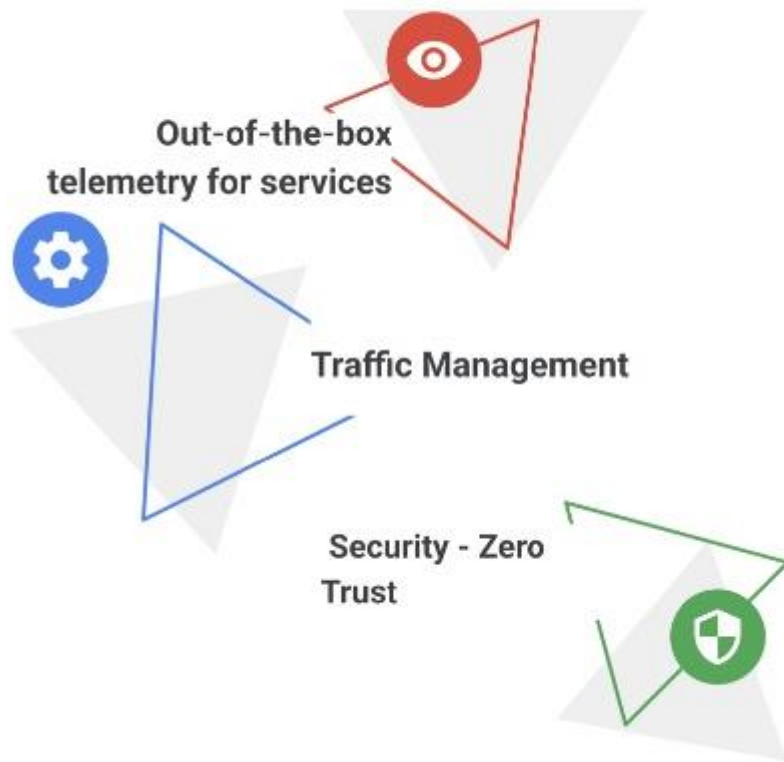




# Anthos Service Mesh for

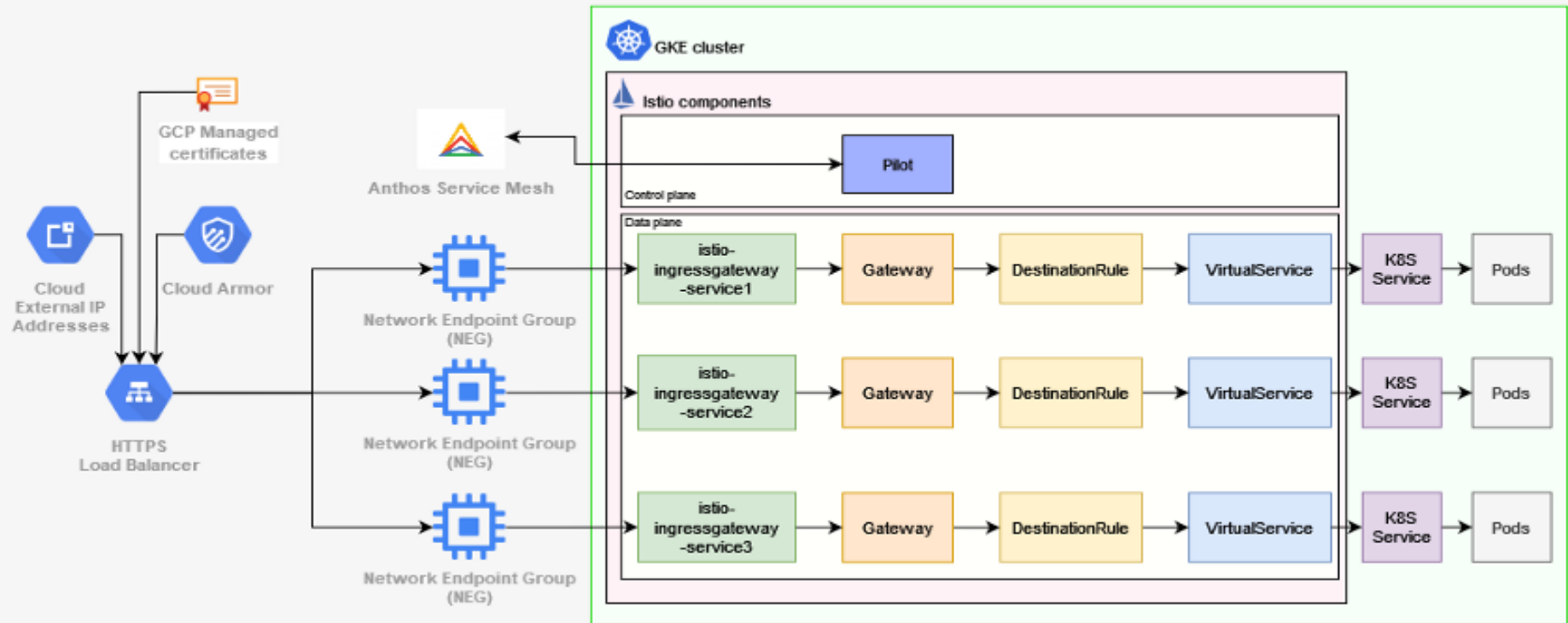
**Anthos Service Mesh (ASM)** will provide service management and a single pane of glass for

- Logging, metrics, and SLO monitoring
- Service identity, AuthN/Z, and encryption
- Traffic management: routing, and load balancing
- AI-driven curated insights, recommendations, and operating analytics

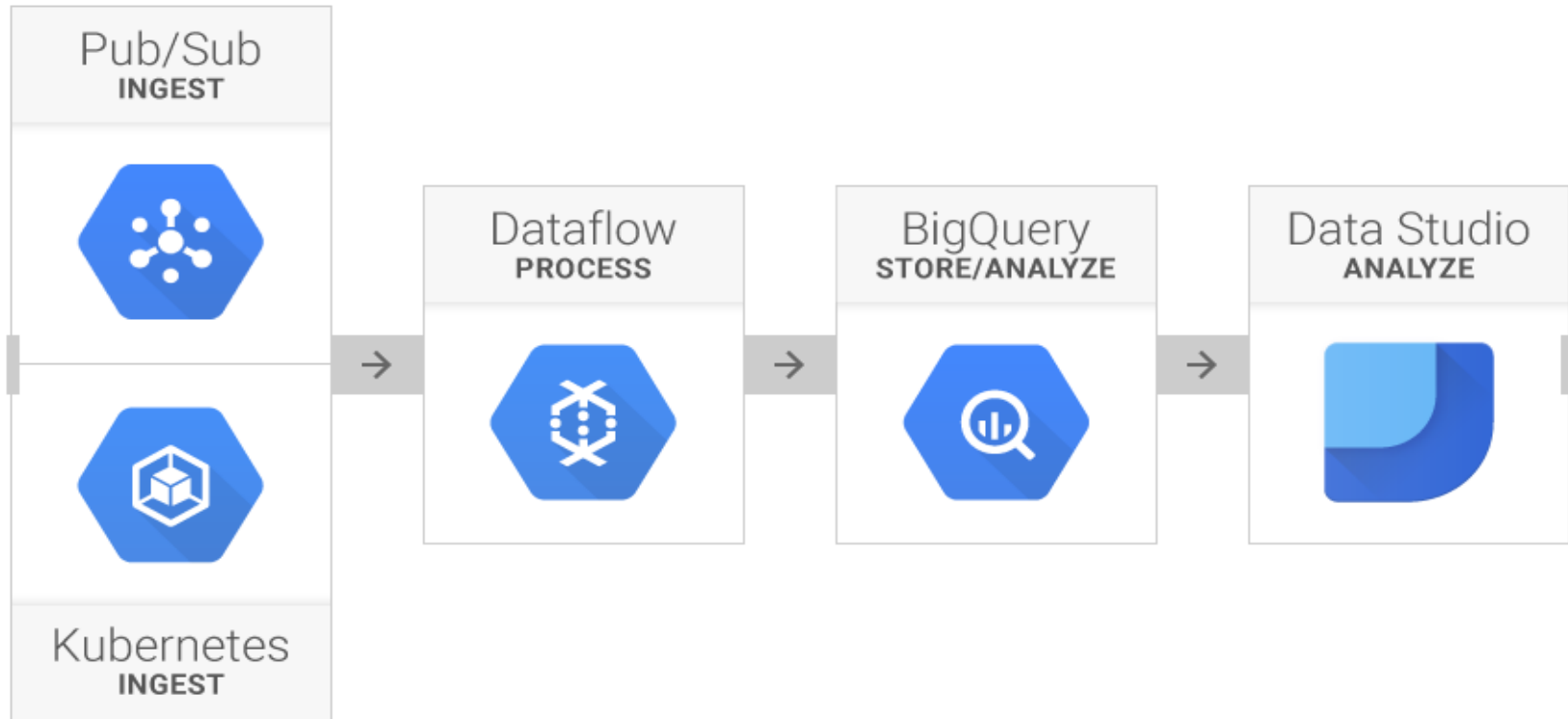


# SERVICE MESH

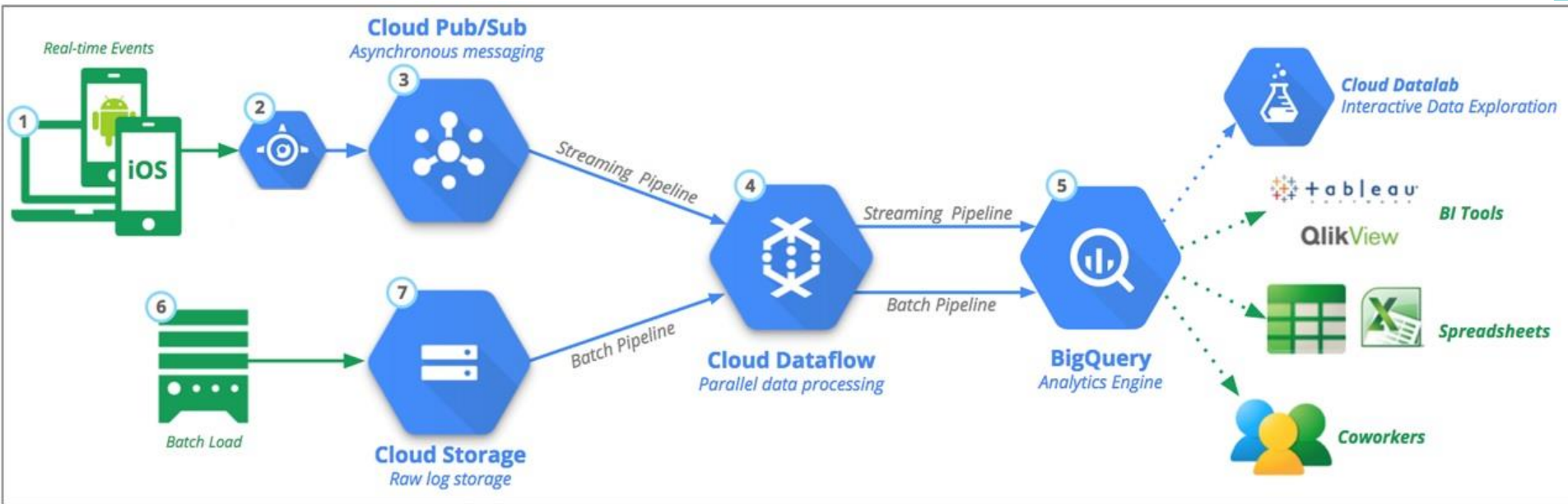
 Google Cloud Platform



# MACHINE LEARNING DATA ANALYTICS

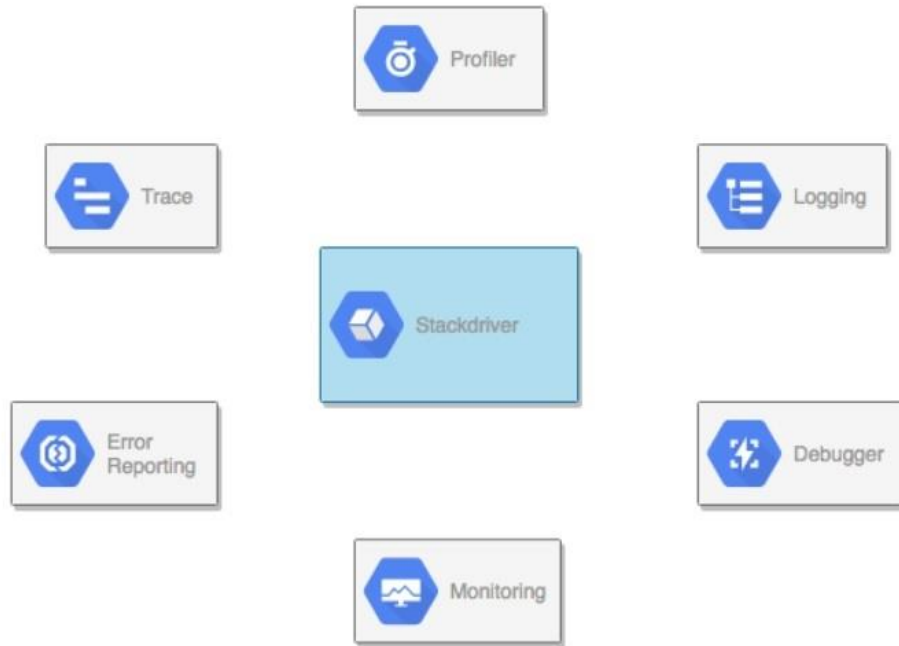


# MACHINE LEARNING DATA ANALYTICS

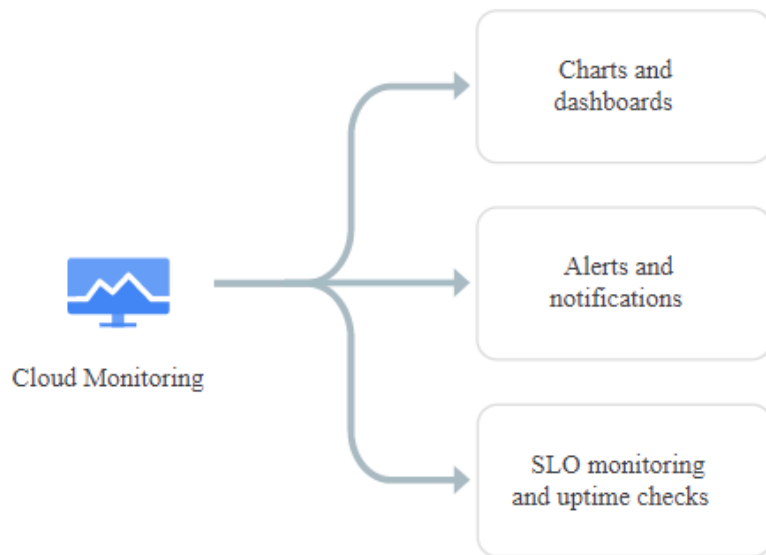
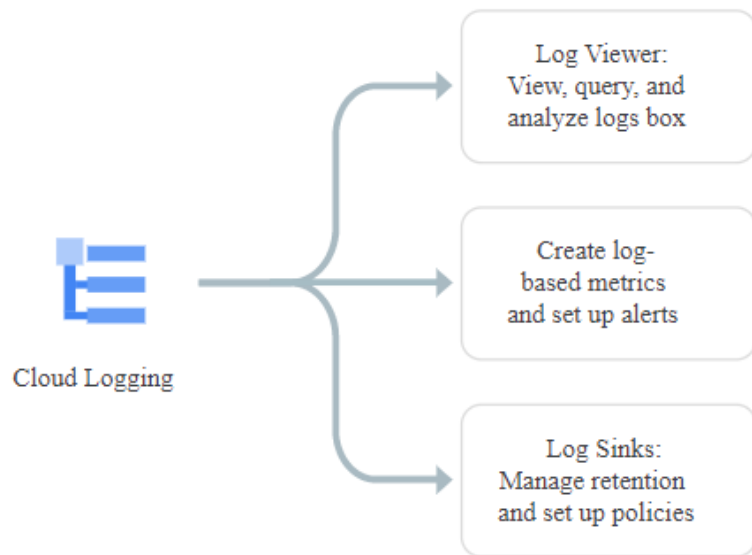




# MONITORING



# MONITORING



# ON-PREMISES & CLOUD COMPARISON

Datacenter single tenancy (for compliance)

On-premises: ✓ Public Cloud: ✗

Highly secure data encryption

On-premises: ✓ Public Cloud: ✓

Customizable hardware, purpose-built systems

On-premises: ✓ Public Cloud: ✗

Capacity easy to scale up and down

On-premises: ✗ Public Cloud: ✓

Infrastructure requires large, regular investments

On-premises: ✓ Public Cloud: ✗

Pay-as-you-go, usage-based pricing

On-premises: ✗ Public Cloud: ✓

Complete data visibility and control

On-premises: ✓ Public Cloud: ✗

Built-in, automated data backups, and recovery

On-premises: ✗ Public Cloud: ✓

Near-zero downtime risk

On-premises: ✗ Public Cloud: ✓

# PRICING (ON-PREMISES)

On-Premise data center costs	Hardware	Software	Operations	Maintenance
<ul style="list-style-type: none"><li>● Servers</li><li>● Rack infrastructure</li><li>● Power/ Electricity</li><li>● Storage</li><li>● Network</li><li>● IT Labor</li></ul>	<ul style="list-style-type: none"><li>● Hardware specifications</li><li>● Hardware maintenance</li><li>● New or retired hardware costs (Future hardware refresh)</li></ul>	<ul style="list-style-type: none"><li>● Licensing costs</li><li>● Support costs</li><li>● Purchase dates</li><li>● Purchase contracts</li><li>● Warranty expiration dates (EOL)</li></ul>	<ul style="list-style-type: none"><li>● Contracts</li><li>● Labor costs (Monitoring, Alerting)</li><li>● Running processes</li><li>● Network connections</li><li>● System performance data<ul style="list-style-type: none"><li>○ Min/Max/Avg system utilization times</li><li>○ Utilized for right sizing cloud resources (auto-scaling)</li></ul></li></ul>	<ul style="list-style-type: none"><li>● Labor</li><li>● Contracts</li><li>● Application Updates</li><li>● System updates (Software version updates and patches)</li></ul>

# PRICING (ON-PREMISES)

- ❖ Data centre Cost
- ❖ Number racks and Containers in the data centre
- ❖ Power Systems cost , Cooling Equipment
- ❖ Server cost
- ❖ Storage Cost
- ❖ Network Device costs (Switches, Routers, security appliance Firewall, IDS, WAF)
- ❖ License cost for vendor Products (VMware, Red hat, netback, window 2019, OpenShift License cost)
- ❖ Remote Technical Support

## **Post-migration costs:**

- ❖ Monthly/Yearly infrastructure and software (licensing/support) costs
- ❖ System maintenance and operation costs
- ❖ Administration
- ❖ Operations
- ❖ Monitoring and Alerting
- ❖ Maintenance
- ❖ Training
- ❖ System updates and Software version updates and patches
- ❖ Direct costs include purchase prices, software licenses and support, operational, maintenance, and administrative expenses.
- ❖ Indirect costs are less obvious expenses such as loss of productivity due to application downtime.

## Overall Data Center Costs

### Assumptions

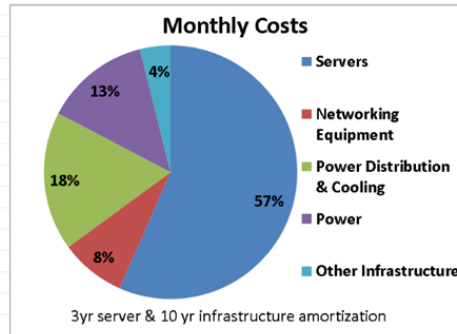
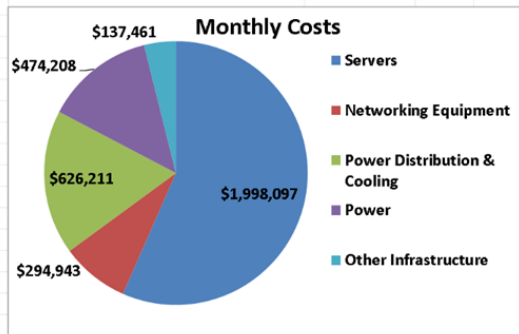
Size of Facility (Critical Load):	8,000,000	[Chosen to get ~50k servers -- As PUE improves, critical load goes up without total load changing]
Cost of power (\$/kwh):	\$0.07	[Can range between just under \$0.03 and over \$0.15 depending upon region]
Cost per critical watt in \$/W	\$9.00	[Uptime institute says \$12.50/W for tier II: <a href="http://uptimeinstitute.org/wp_pdfs/28TUI3029A%29CostModelDollarsperkWPlusDollars.pdf">http://uptimeinstitute.org/wp_pdfs/28TUI3029A%29CostModelDollarsperkWPlusDollars.pdf</a> ]
Facilities Amortization:	120	[10 years]
Watts per Server	165	
Cost/Server (\$)	\$1,450.00	
Server Amortization (months)	36	[3 years]
Network Amortization (months)	48	[4 years: most use 5 years today but this is trending down with move to commodity net gear and I think it'll be 3 years soon]
Annual Cost of Money (%):	5%	
Average Critical Load Usage (%):	80%	[Average % of provisioned power used]
Power Usage Effectiveness	1.45	
Power and Cooling Infrastructure (%)	82%	[% of infrastructure that is power & cooling -- Christian Belady @ msft]
[Excluding network egress charges, operating system and application stack costs all of which are workload & approach dependent]		

### Derived from Assumptions

Size of Facility (Total Load):	11,600,000	[MegaWattsCriticalLoad*PUE]
Number of Servers:	45,978	[(CriticalLoad-NetworkLoad)/WattsPerServer]
Total Cost of Facility (\$):	\$72,000,000	[Critical Load * CostPerCritical Watt]

### Monthly Calculations

Servers	\$1,998,097	57%	[=-PMT(CostOfMoney/12, ServerAmortization, ServerCount*ServerCost, 0)]
Networking Equipment	\$294,943	8%	[=-PMT(CostOfMoney/12, NetworkAmortization, NetworkingCost, 0)]
Power Distribution & Cooling	\$626,211	18%	[=-PMT(CostOfMoney/12, FacilityAmortization, FacilityCost, 0)*PowerAndCoolingInfrastructurePercentage]
Power	\$474,208	13%	[=MegaWattsCriticalLoad*AveragePowerUsage/1000*PUE*PowerCost*24*365/12]
Other Infrastructure	\$137,461	4%	[=-PMT(CostOfMoney/12, FacilityAmortization, FacilityCost, 0)-PowerAndCoolingInfrastructureMonthly]
Total:	\$3,530,920	100%	



### Fully Burdened cost of Power

Infrastructure cost of power/Watt/year	\$1.17	62%	[=-PMT(CostOfMoney,+FacilityAmortization/12,+FacilityCost,0)/+WattsCriticalLoad]
Cost of power/watt/year	\$0.71	38%	[+=PowerCost/1000*PUE*AveragePowerUsage*24*365.25]
Fully Burdened Cost of Power:	\$1.88	100%	[Fully burdened cost of power per watt per year]

[illegible]

# PRICING (CLOUD)

<https://cloud.google.com/products/calculator/#id=9f2bbcee-29a2-4ac9-b010-c136de14c6b3>

name	quantity	region	service_id	sku	product_description	unit_price, USD	total_price, USD
E2 Instance Core running in Americas	2920.00	us-central1	6f81-5844-456A	CF4E-A0C7-E3	CP-COMPUTEENGINE-VMIMAGE-E2-STANDARD-2	0.02181159	63.8898428
E2 Instance Ram running in Americas	11680.00	us-central1	6f81-5844-456A	F449-38EC-A5	CP-COMPUTEENGINE-VMIMAGE-E2-STANDARD-2	0.00292355	34.1468904
Storage PD Capacity	30.00	us-central1	6f81-5844-456A	D973-5D65-B4	CP-COMPUTEENGINE-STORAGE-PD-CAPACITY	0	0
Storage PD Capacity	270.00	us-central1	6f81-5844-456A	D973-5D65-B4	CP-COMPUTEENGINE-STORAGE-PD-CAPACITY	0.04	10.8
Standard Storage US Regional	5.00	us-central1	95FF-2EF5-5EA1	ESF0-6A5D-78	CP-BIGSTORE-STANDARD	0	0
Standard Storage US Regional	495.00	us-central1	95FF-2EF5-5EA1	ESF0-6A5D-78	CP-BIGSTORE-STANDARD	0.02	9.9
Network Load Balancing: Forwarding Rule Minimum Service Charge in Americas	2.00	us-central1	6f81-5844-456A	B16D-040F-F1	FORWARDING_RULE_CHARGE_BASE	18.25	18.25
Network Load Balancing: Data Processing Charge in Americas	10.00	us-central1	6f81-5844-456A	EECF-DEFC-74	CP-NETWORK-SERVICES-LOAD-BALANCING-DATA-PROCESSED-INBOUND	0.008	0.08
Outbound data processed by load balancer	10.00	us-central1	6f81-5844-456A	Look up for SK	CP-NETWORK-SERVICES-LOAD-BALANCING-DATA-PROCESSED-OUTBOUND	0	0
Networking Cloud Nat Gateway Uptime	1.00	global	E505-1604-58F8	32E2-4EFC-EF	CP-NETWORK-SERVICES-CLOUD-NAT-UPTIME-LOW-VM-NUMBER	0.0014	1.022
Networking Cloud Nat Data Processing	10.00	global	E505-1604-58F8	D15F-5732-FF	CP-NETWORK-SERVICES-CLOUD-NAT-TRAFFIC	0.045	0.45
Cloud Armor - Policies	3.00	us	6f81-5844-456A	Look up for SK	CP-NETWORK-SERVICES-CLOUD-ARMOR	5	15
Cloud Interconnect - 10Gbps Dedicated circuit	10.00	Global	6f81-5844-456A	B8C8-2F76-E6	CP-INTERCONNECTVPN-DEDICATED-CIRCUIT-10GB	1699.44	16994.4
Active Storage (us-central1)	10.00	us-central1	24E6-581D-38E5	0018-A5A0-9D	CP-BIGQUERY-GENERAL	0	0
Active Storage (us-central1)	40.00	us-central1	24E6-581D-38E5	0018-A5A0-9D	CP-BIGQUERY-GENERAL	0.023	0.92
Cloud Firestore - Document Reads	30416.67	us	F178-412E-CB64	Look up for SK	CP-FIRESTORE-DOCUMENT-READS-US	0	0
Dataprocc - Cluster size	12.00	us	363B-8851-170D	Look up for SK	CP-DATAPROC	0.03	0.36
N1 Predefined Instance Core running in Americas	12.00	us-central1	6f81-5844-456A	2E27-4F75-95	CP-COMPUTEENGINE-VMIMAGE-N1-STANDARD-4	0.031611	0.379332
N1 Predefined Instance Ram running in Americas	45.00	us-central1	6f81-5844-456A	6C71-E894-38	CP-COMPUTEENGINE-VMIMAGE-N1-STANDARD-4	0.004237	0.190665
N1 Predefined Instance Core running in Americas	12.00	us-central1	6f81-5844-456A	2E27-4F75-95	CP-COMPUTEENGINE-VMIMAGE-N1-STANDARD-4	0.031611	0.379332
N1 Predefined Instance Ram running in Americas	45.00	us-central1	6f81-5844-456A	6C71-E894-38	CP-COMPUTEENGINE-VMIMAGE-N1-STANDARD-4	0.004237	0.190665
Spot Preemptible N1 Predefined Instance Core running in Americas	12.00	us-central1	6f81-5844-456A	D498-1ECA-83	CP-COMPUTEENGINE-VMIMAGE-N1-STANDARD-4-PREEMPTIBLE	0.006655	0.07986
Spot Preemptible N1 Predefined Instance Ram running in Americas	45.00	us-central1	6f81-5844-456A	6451-0A19-01	CP-COMPUTEENGINE-VMIMAGE-N1-STANDARD-4-PREEMPTIBLE	0.000892	0.04014
Dataflow - 1 x n1-standard-1 workers in Batch Mode	1.00	us-central1	57D6-8E68-2DE0	Look up for SK	CP-DATAFLOW-GENERAL	0.07473875	0.07473875
Cloud SQL for MySQL: Zonal - vCPU in Americas	730.00	us-central1	9662-B51E-5D89	741F-D668-24	CP-DB-CUSTOM-M-1-3.75	0.0413	30.149
Cloud SQL for MySQL: Zonal - RAM in Americas	2737.50	us-central1	9662-B51E-5D89	49E9-5D00-88	CP-DB-CUSTOM-M-1-3.75	0.007	19.1625
Cloud SQL for MySQL: Zonal - Standard storage in Americas	100.00	us-central1	9662-B51E-5D89	F0A1-2B08-FA	CP-DB-CUSTOM-M-1-3.75	0.17	17
Cloud SQL for SQL Server	730.00	Iowa	not yet supp	CP-CLOUDFORSQLSERVER-JOB			495.223
Pub/Sub - Volume	0.01	us	A1E8-8E35-7EBC	Look up for SK	CP-PUBSUB	1176.666667	11.49088542
ManagedZone	1.00	global	FA26-5236-88B5	8C22-6FC3-D4	CP-CLOUD-DNS-ZONES	0.2	0.2
DNS Query (port 53)	1.00	global	FA26-5236-88B5	6DFF-5925-A1	CP-CLOUD-DNS-QUERIES	0.4	4.006-07
Metric Volume	5.57	global	58CD-E7C3-72CA	A924-09D0-85	CP-STACKDRIVER-MONITOR-RED-RESOURCES-VOLUME	0	0
Prometheus Samples Ingested	734400.00	global	58CD-E7C3-72CA	A4E4-DF09-C0	CP-STACKDRIVER-METRICS-PROMETHEUS-SAMPLES	0.15	0.11016
Log Volume	10.00	global	5490-F7B7-EDF6	143F-A1B0-E0	CP-STACKDRIVER-LOGS-VOLUME-NEW	0	0
Spans ingested	10.00	global	9882-7513-9D1C	FFCF-0164-98	CP-STACKDRIVER-TRACE-SPANS	0	0
Balanced PD Capacity	200.00	us-central1	6f81-5844-456A	6AE1-525F-9B	CP-COMPUTEENGINE-STORAGE-PD-READONLY	0.1	20
Storage PD Capacity	6.16	us-central1	6f81-5844-456A	D973-5D65-B4	CP-COMPUTEENGINE-STORAGE-PD-READONLY	0	0
Total Price:							17743.68095

\* Sustained use discount (SUD) is not included. You may need to apply discounts separately for each SKU

Prices are in US dollars, effective date is 2022-09-15T13:47:43.319Z.

The estimated fees provided by Google Cloud Pricing Calculator are for discussion purposes only and are not binding on either you or Google. Your actual fees may be higher or lower than the estimate.

Url to the estimate: <https://cloud.google.com/products/calculator/#id=9f2bbcee-29a2-4ac9-b010-c136de14c6b3>



# SUMMARY

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- ❖ EHR Healthcare successful **migrated to the Google cloud** based on their **business and technical requirements**.
- ❖ EHR focused on **security, governance and compliance** regulations on public cloud.
- ❖ Majority of the infrastructure works **converted into DevOps** model.
- ❖ EHR saved significant amount of **cost after migrating** to Google Cloud
- ❖ EHR Healthcare is dedicated to cloud computing, it must maintain its **legacy connections** as well as a **secure and high-performance connection between on-premises systems and GCP**.
- ❖ Attention to **security concerns** is a strong thread throughout the case study, from **protecting patient data** to ensuring **consistent container-based applications**.

# THANK YOU



Do you have any questions?