EHR HEALTHCARE

6M22 Project – Group 4
(Phase II)

Source: https://services.google.com/fh/files/blogs/master_case_study_ehr_healthcare.pdf

OUR TEAM

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CLOUD MIGRATION

KEITH CHUA

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.

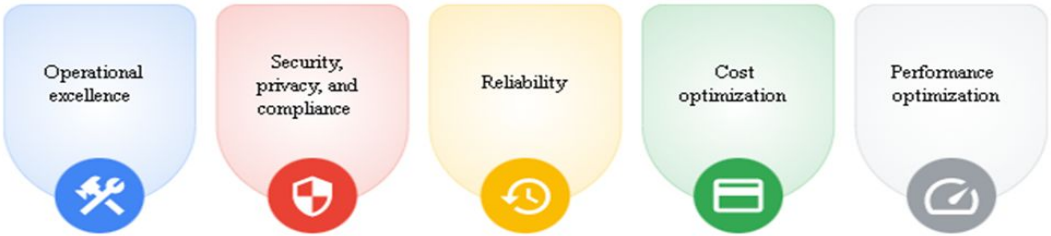
Application:

- 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



CLOUD MIGRATION

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

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.

02

EVOLUTION & SERVICE ADOPTED

DEDDY CRISTIANTO

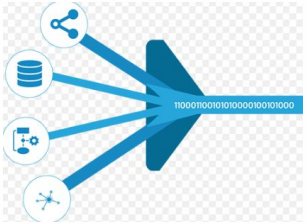
BUSINESS EVOLUTION

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:

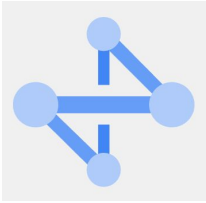
- CPU Utilization
- HTTP(s) Load Balancer capacity
- Cloud Monitoring Metrics

Business Objective

- Less CAPEX
- Effective Business decision making
- Reliable solutions due to SLA
- Flexible budget

AVAILABILITY AND LATENCY

Network



Services and Operations

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

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

Business Objective

Reduced Downtime

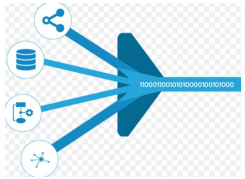
Increased Customer Satisfaction

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

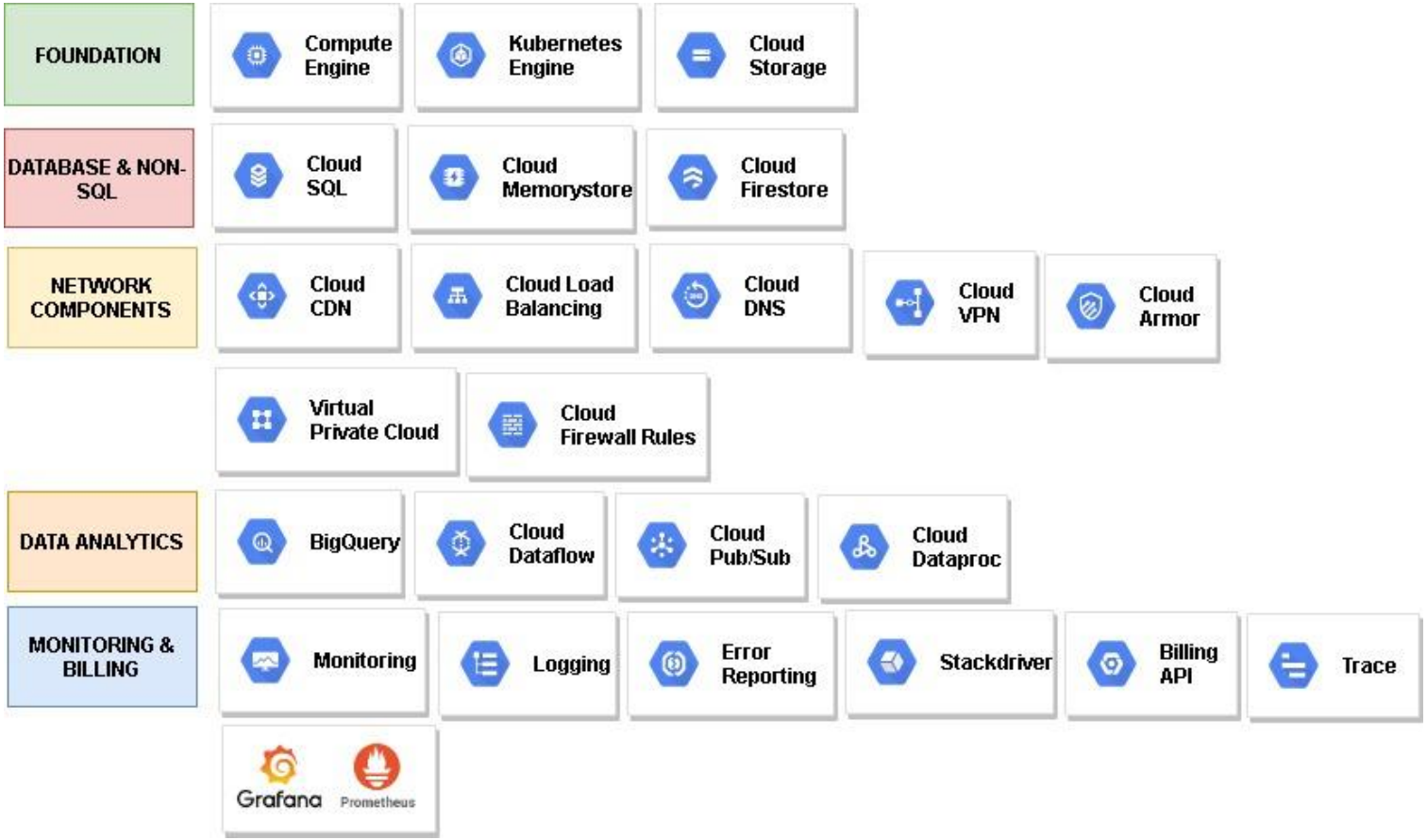
Business Objective:

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 continous delivery tool for Kubernetes, which uses the principle of GitOps

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

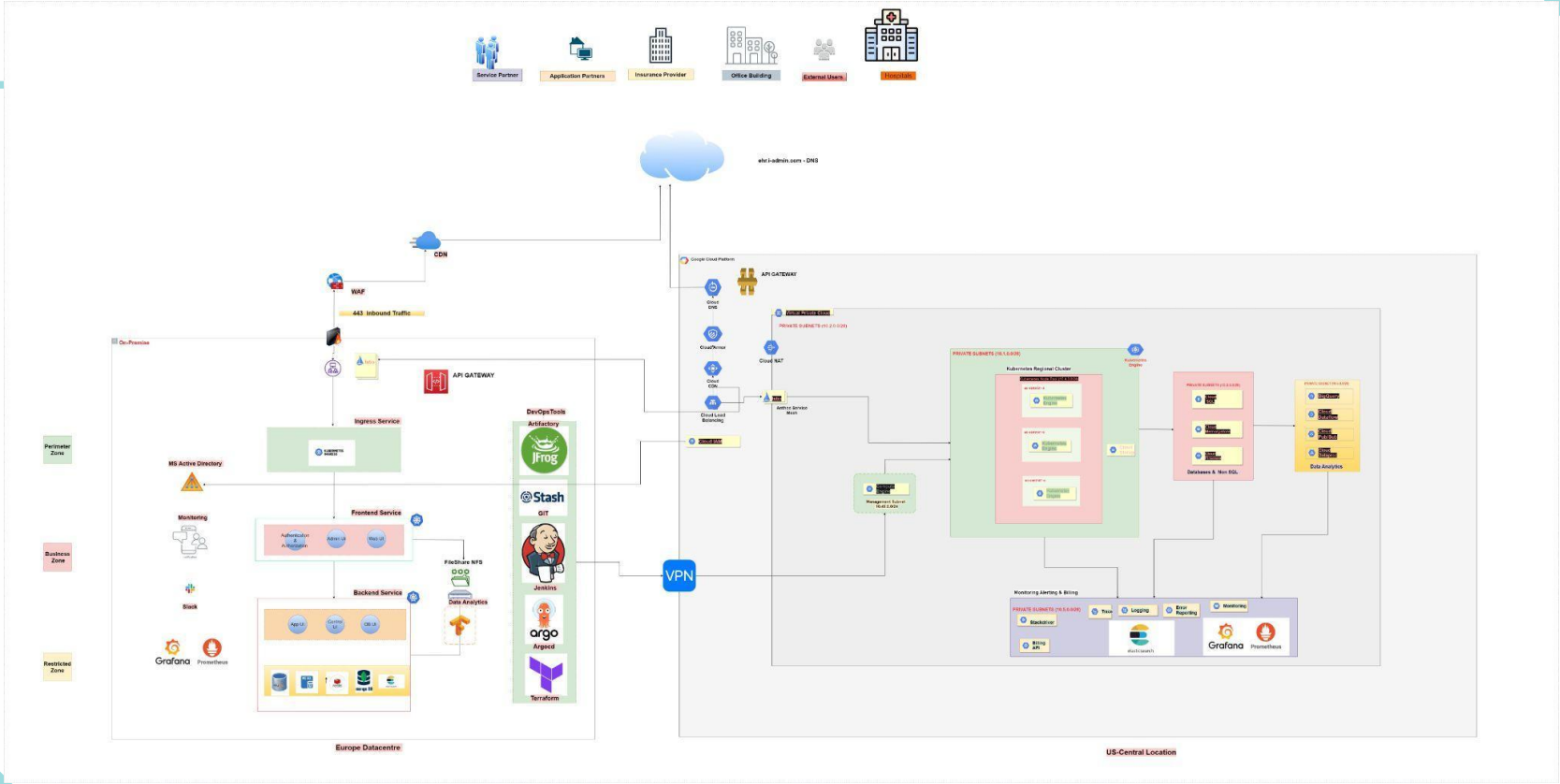
03

CLOUD ARCHITECTURE

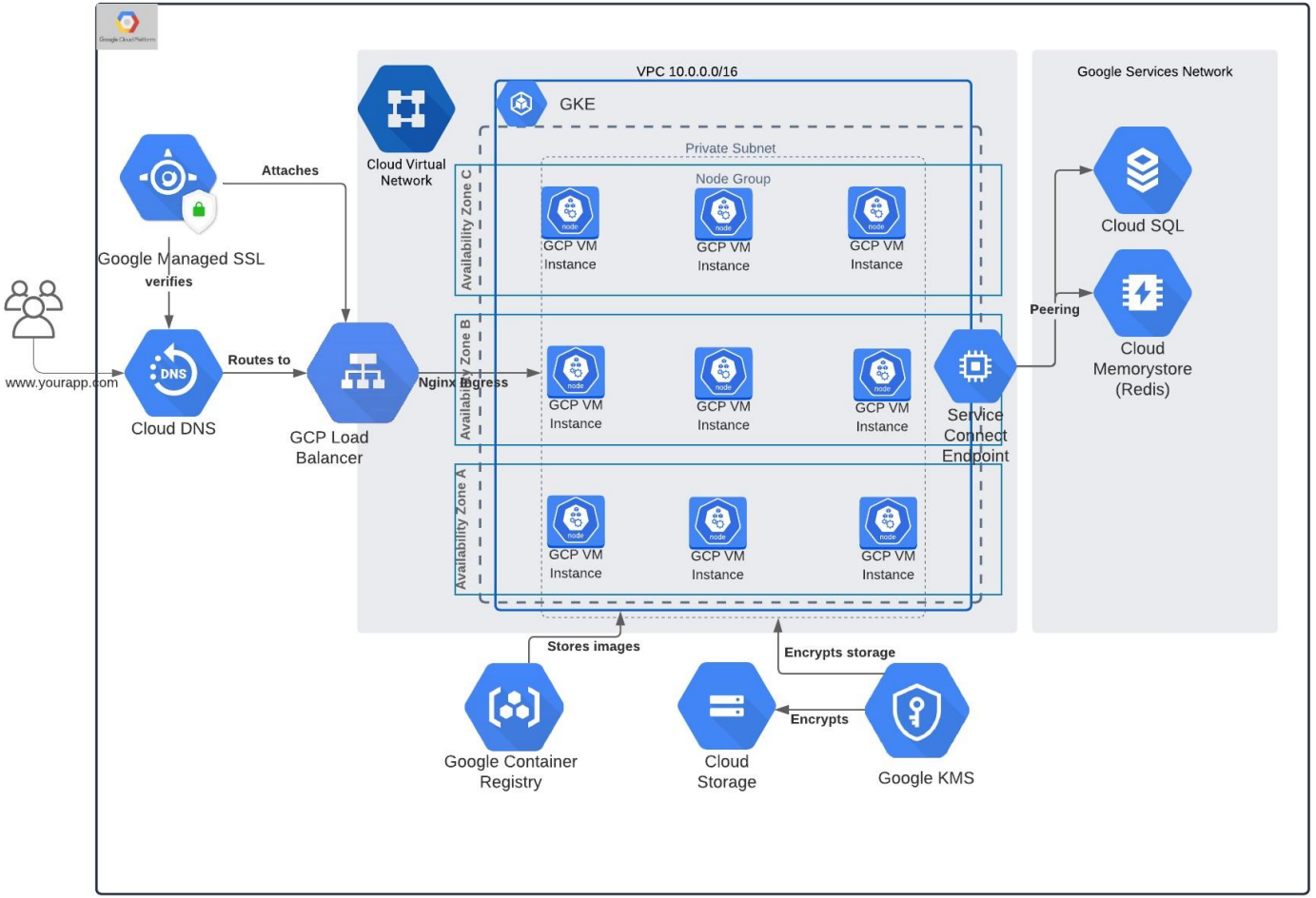
BABY SHALINI

SOLUTION ARCHITECTURE

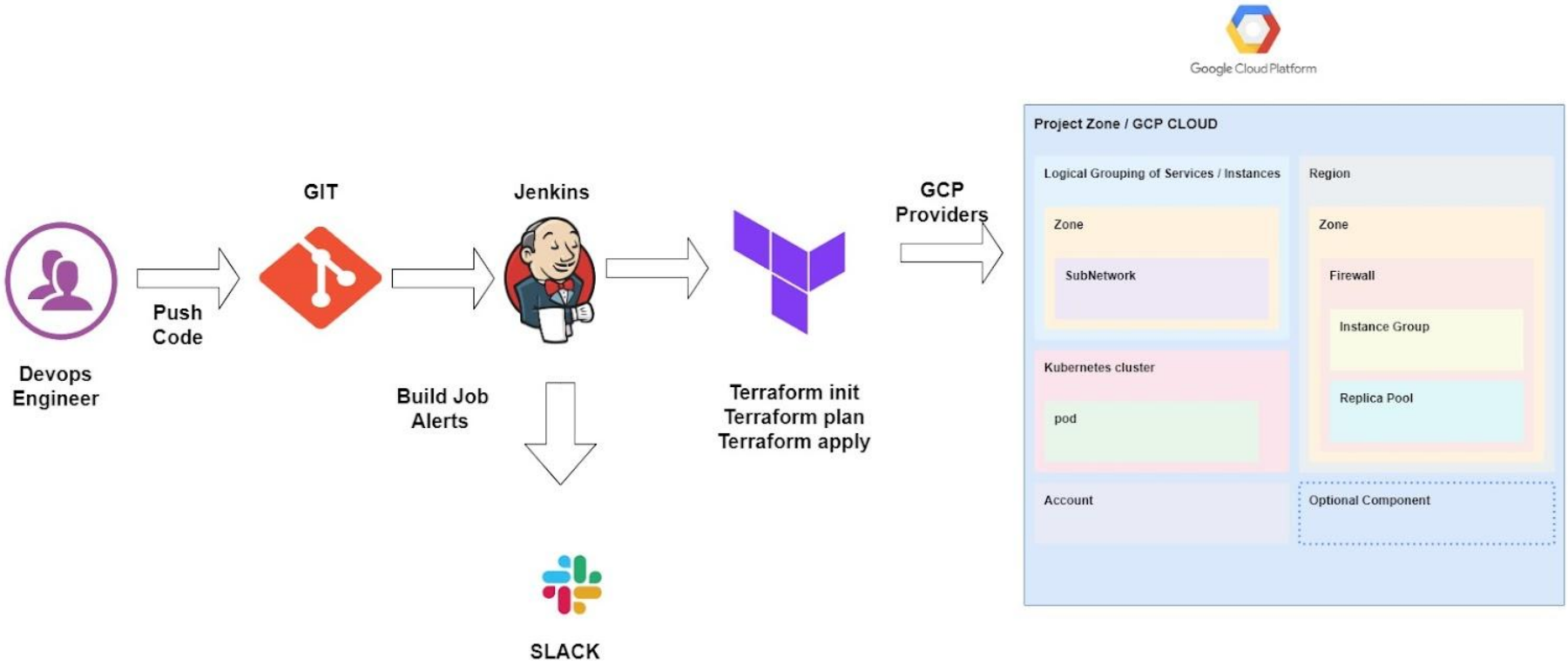
https://mohanawss3.s3.ap-southeast-1.amazonaws.com/Google+ISTIO-Final.jpg



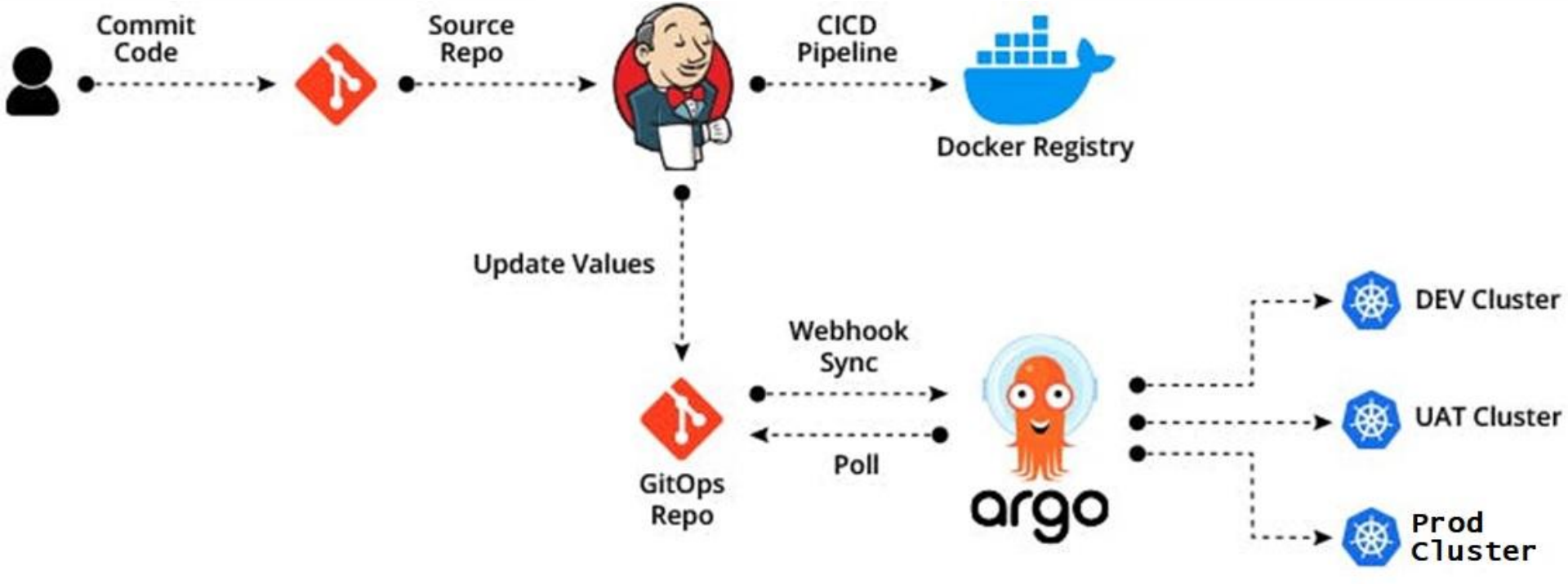
GKE MONOLITHIC ARCHITECTURE



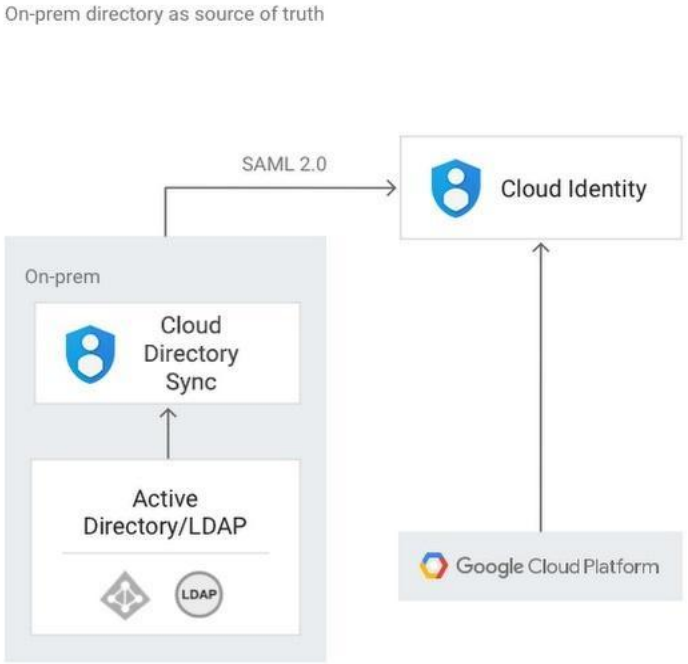
CI/CD FOR IAC


Devops Engineer
Push Code
GIT
Jenkins
Build Job Alerts
SLACK
Terraform init
Terraform plan
Terraform apply
GCP Providers
Google Cloud Platform
Project Zone / GCP CLOUD
Logical Grouping of Services / Instances
Zone
SubNetwork
Region
Zone
Firewall
Instance Group
Replica Pool
Kubernetes cluster
pod
Account
Optional Component

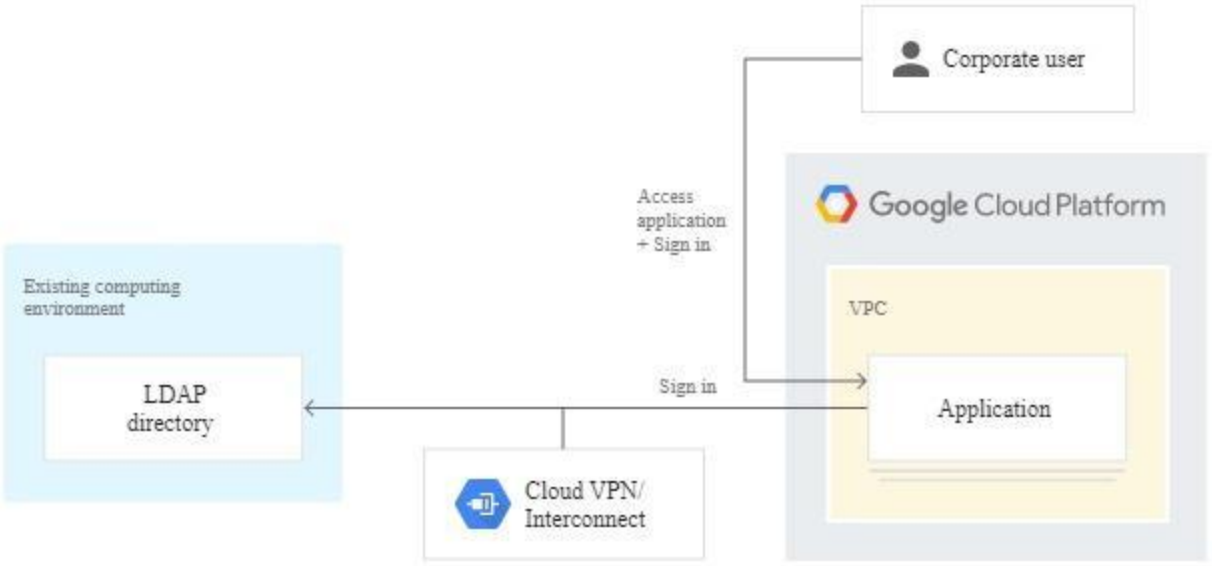
AGRO CD DEPLOYMENT



CLOUD IAM


On-prem directory as source of truth
SAML 2.0
Cloud Identity
On-prem
Cloud Directory Sync
Active Directory/LDAP
LDAP
Google Cloud Platform

CLOUD IAM

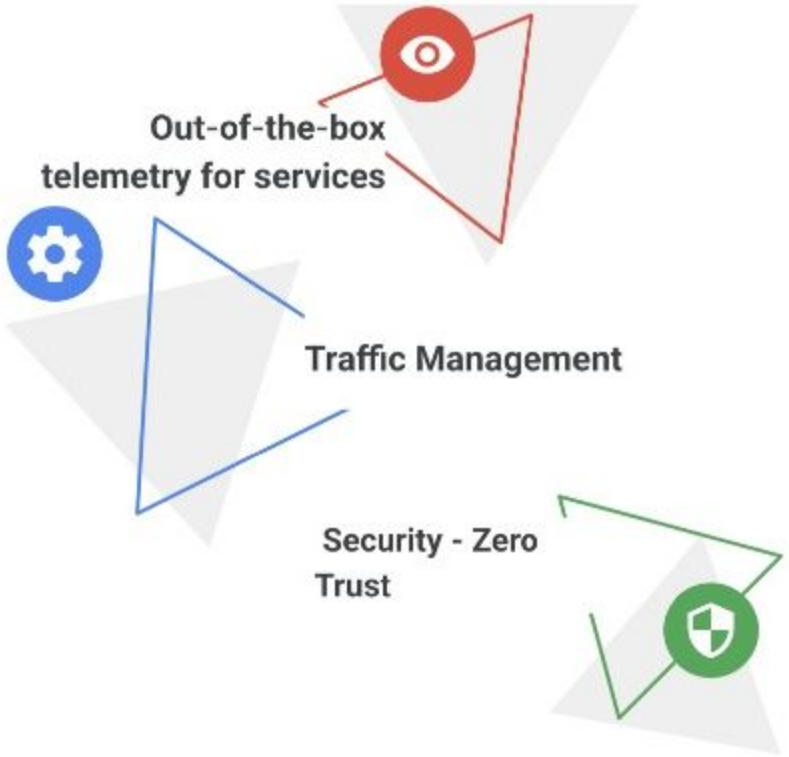

Corporate user
Access application + Sign in
Google Cloud Platform
VPC
Existing computing environment
LDAP directory
Sign in
Application
Cloud VPN/ Interconnect

Anthos Service Mesh for

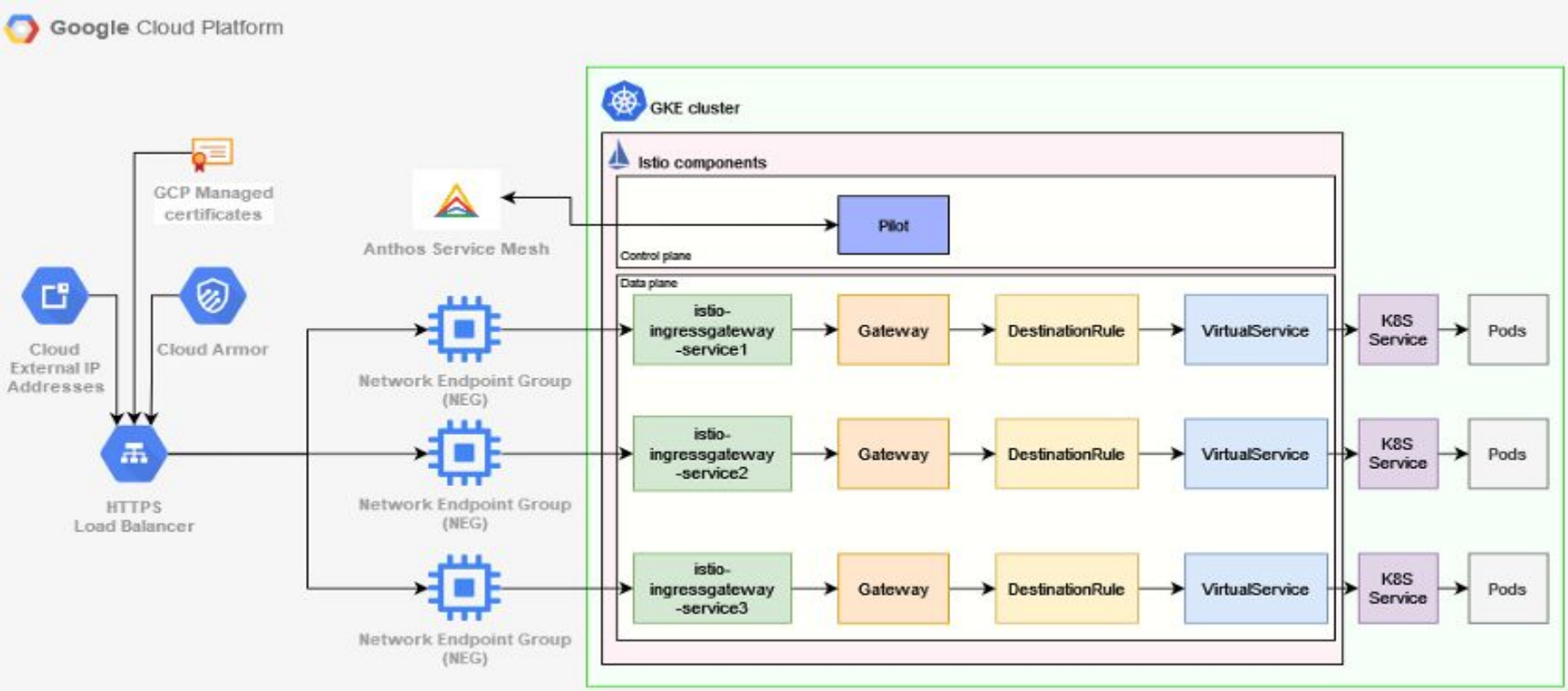
Anthos Service Mesh (ASM) will provide service management and a single pane of glass for

- 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

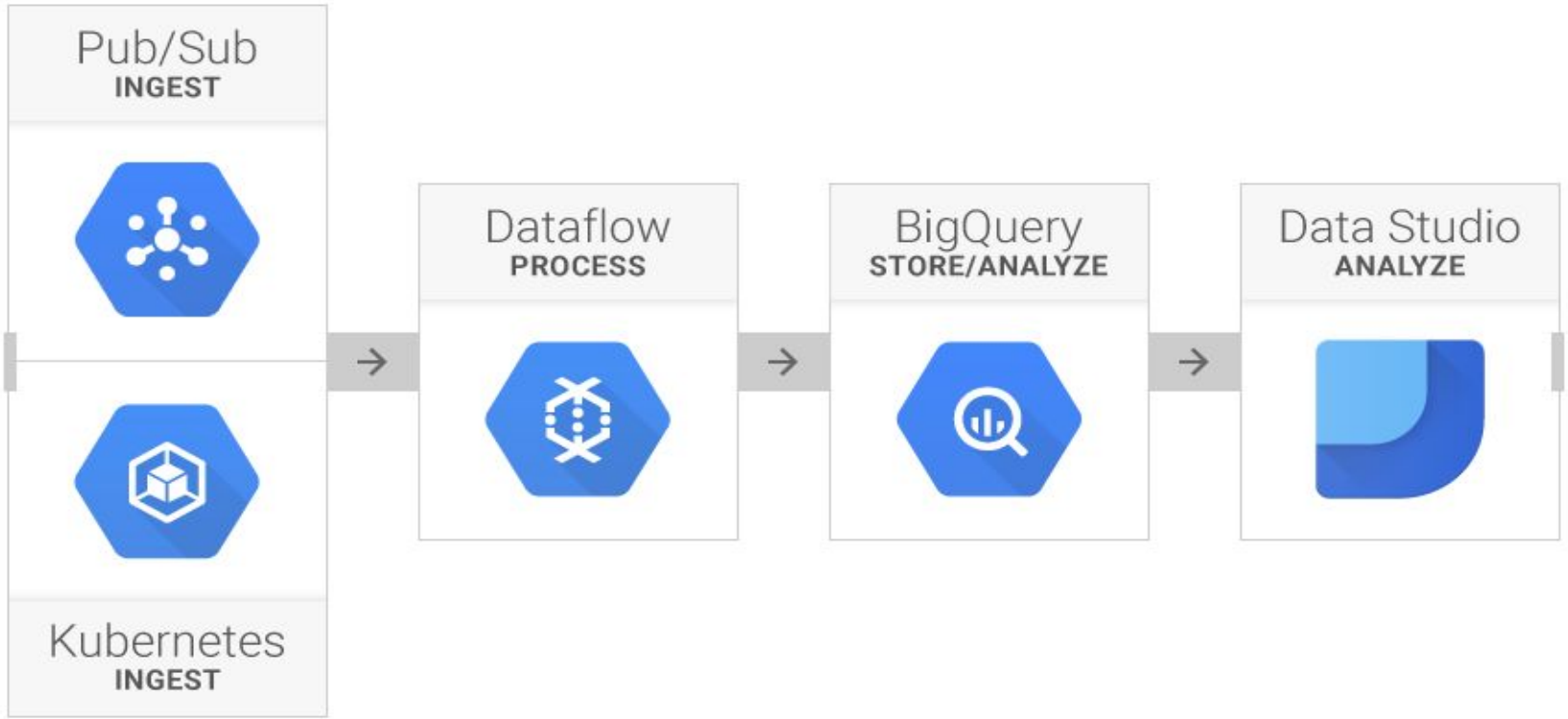
Google Cloud



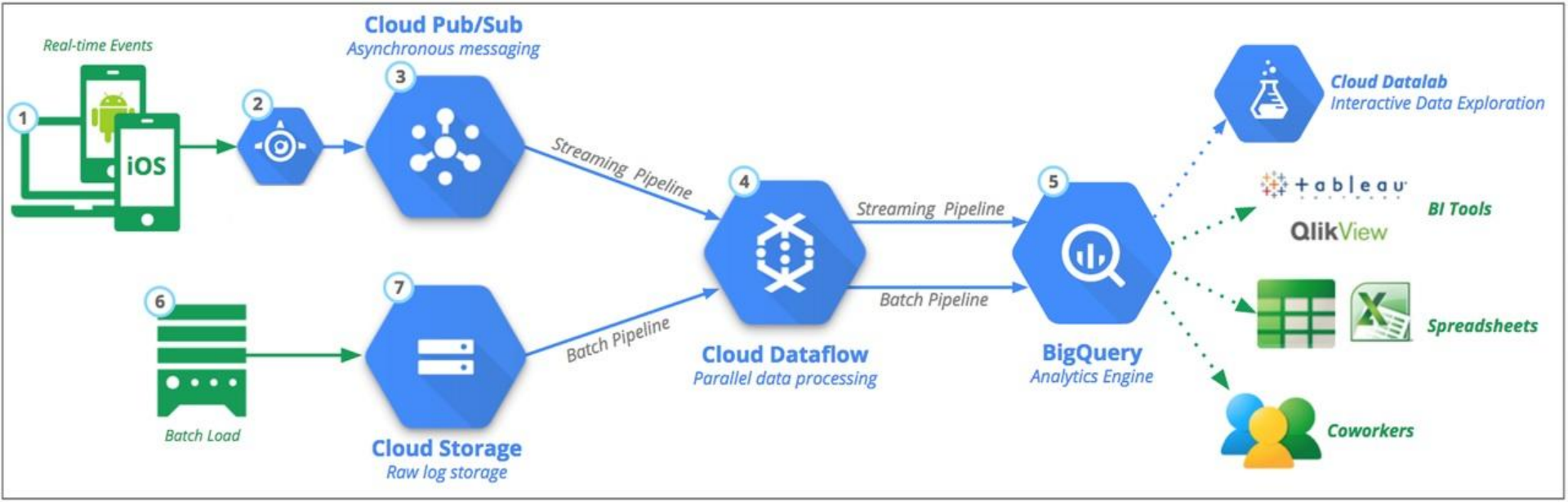
SERVICE MESH



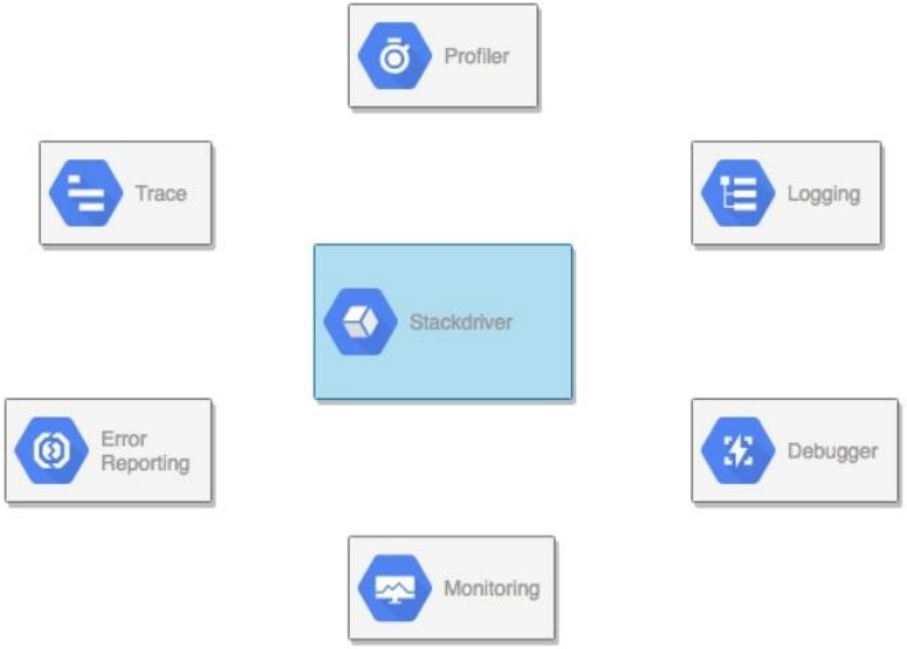
MACHINE LEARNING DATA ANALYTICS



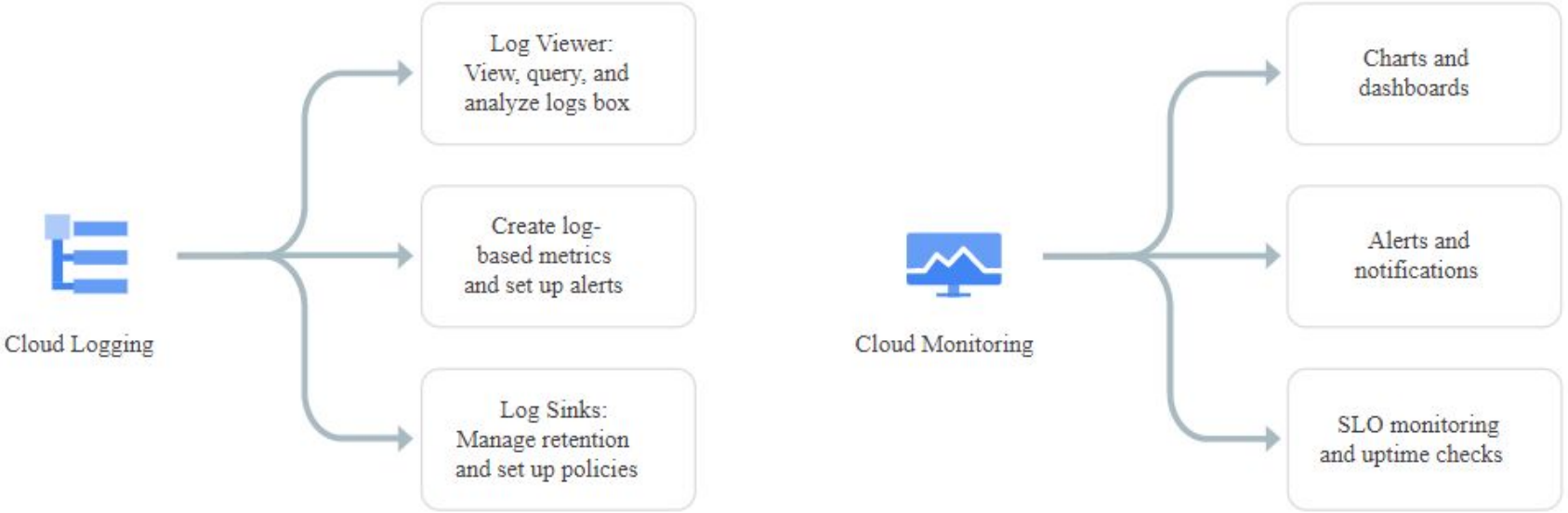
MACHINE LEARNING DATA ANALYTICS



MONITORING


Profiler
Trace
Logging
Stackdriver
Error Reporting
Debugger
Monitoring

MONITORING


Cloud Logging
Log Viewer: View, query, and analyze logs box
Create log-based metrics and set up alerts
Log Sinks: Manage retention and set up policies
Cloud Monitoring
Charts and dashboards
Alerts and notifications
SLO monitoring and uptime checks

04

PRICING

TAN HAN KWONG

ON-PREMISES & CLOUD COMPARISON

Datacenter single tenancy (for compliance)	On-premises: ✔ Public Cloud: X
Highly secure data encryption	On-premises: ✔ Public Cloud: ✔
Customizable hardware, purpose-built systems	On-premises: ✔ Public Cloud: X
Capacity easy to scale up and down	On-premises: X Public Cloud: ✔
Infrastructure requires large, regular investments	On-premises: ✔ Public Cloud: X
Pay-as-you-go, usage-based pricing	On-premises: X Public Cloud: ✔
Complete data visibility and control	On-premises: ✔ Public Cloud: X
Built-in, automated data backups, and recovery	On-premises: X Public Cloud: ✔
Near-zero downtime risk	On-premises: X Public Cloud: ✔

PRICING (ON-PREMISES)

On-Premise data center costs	Hardware	Software	Operations	Maintenance
● Servers ● Rack infrastructure ● Power/ Electricity ● Storage ● Network ● IT Labor	● Hardware specifications ● Hardware maintenance ● New or retired hardware costs (Future hardware refresh)	● Licensing costs ● Support costs ● Purchase dates ● Purchase contracts ● Warranty expiration dates (EOL)	● Contracts ● Labor costs (Monitoring, Alerting) ● Running processes ● Network connections ● System performance data ○ Min/Max/Avg system utilization times ○ Utilized for right sizing cloud resources (auto-scaling)	● Labor ● Contracts ● Application Updates ● System updates (Software version updates and patches)

PRICING (ON-PREMISES)

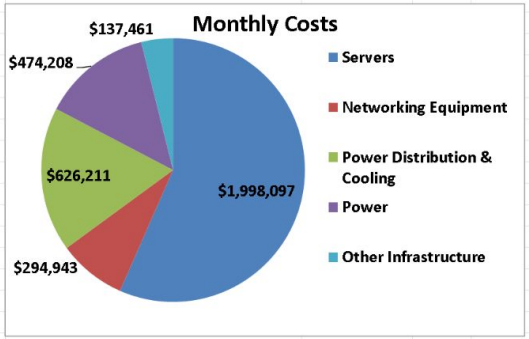
- Data centre Cost
- Number racks and Containers in the data centre
- Power Systems cost , Cooling Equipment
- Server cost
- Storage Cost
- Network Device costs (Switches, Routers, security appliance Firewall, IDS, WAF)
- License cost for vendor Products (VMware, Red hat, netback, window 2019, OpenShift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

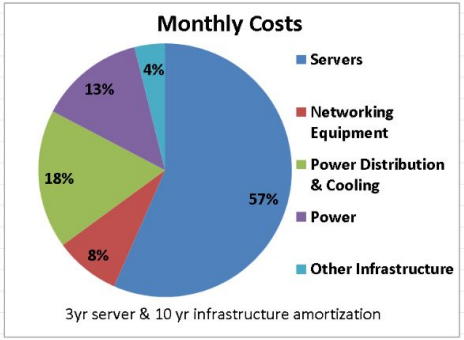
Post-migration costs:

- 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 betwee just under $0.03 and over $0.15 depending upon region]
Cost per critical watt in $/W	$9.00		[Uptime institute says $12.50/W for tier II: http://uptimeinstitute.org/wp_pdf/%28TUI3029A%29CostModelDollarsperkWPlusDollars.pdf]
Facilities Amortization:	120		[10 years]
Watts per Server	165		
Cost/Server ($)	$1,450.00		
Server Amortization (months)	36		[3 years]
Network Amortization (months)	48		[4 years: most use 5 years today but this is trending down with move to commodity net gear and I think it'll be 3 years soon]
Annual Cost of Money (%):	5%		
Average Critical Load Usage (%):	80%		[Average % of provisioned power used]
Power Usage Effectiveness	1.45		
Power and Cooling Infrastrucure (%)	82%		[% of infrastructure that is power & cooling -- Christian Belady @ msft]
[Excluding network egress charges, operating system and application stack costs all of which are workload & approach dependent]			
Derived from Assumptions			
Size of Facility (Total Load):	11,600,000		[MegaWattsCriticalLoad*PUE]
Number of Servers:	45,978		[(CriticalLoad-NetworkLoad)/WattsPerServer]
Total Cost of Facility ($):	$72,000,000		[Critcal 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)*PowerAndCoolikngInfrastructurePercentage]
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]

NETWORKING GEAR

Network Cost & Power

Layer	Equipment	Count	Price	Extended Price	Power	Extended Power	
Border	Cisco 7609	2	$ 362,000.00	$ 724,000.00	5,000	10,000	*[2 border for redundancy]*
Core	Cisco 6509E	2	$ 500,000.00	$ 1,000,000.00	5,000	10,000	*[2 core for redundancy]*
Aggregation	Juniper Ex8216	22	$ 750,000.00	$ 16,500,000.00	10,000	220,000	*[2 10Gig to each rack (2x redundancy)]*
Access	Cisco 3560-48TD	1150	$ 11,995.00	$ 13,794,250.00	151	173,650	
		Net Gear Total:		$ 12,807,300.00		413,650	
		Server Total:		$ 66,667,924.24		7,586,350	
		Net Gear as % of Servers:		19.2%		5.8%	

Assumptions

Servers per rack	40	
Discount Percentage	60%	*[Net gear is typically priced silly high and then aggressively discounted to help enterprise equipment buyers feel they are doing their j*
EX8216 "down" ports:	110	*[128 ports total, used 110 down and the rest up to reduce oversubscription]*

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	63.6898428
E2 Instance Ram running in Americas	11680.00	us-central1	6F81-5844-456A	F449-38EC-A5	CP-COMPUTEENGINE-VMIMAGE-E2-STANDARD-2	0.00292358	34.1468304
Storage PD Capacity	30.00	us-central1	6F81-5844-456A	D973-5D65-BA	CP-COMPUTEENGINE-STORAGE-PD-CAPACITY	0	0
Storage PD Capacity	270.00	us-central1	6F81-5844-456A	D973-5D65-BA	CP-COMPUTEENGINE-STORAGE-PD-CAPACITY	0.04	10.8
Standard Storage US Regional	5.00	us-central1	95FF-2EF5-5EA1	E5F0-6A5D-7B	CP-BIGSTORE-STANDARD	0	0
Standard Storage US Regional	495.00	us-central1	95FF-2EF5-5EA1	E5F0-6A5D-7B	CP-BIGSTORE-STANDARD	0.02	9.9
Network Load Balancing: Forwarding Rule Minimum Service Charge i	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-0EFC-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	015F-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	F17B-412E-CB64	Look up for SK	CP-FIRESTORE-DOCUMENT-READS-US	0	0
Dataproc - 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-E844-38	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-E844-38	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-87	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	5451-0A15-01	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	57D6-8E6B-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-5089	741F-D668-24	CP-DB-CUSTOM-1-3.75	0.0413	30.149
Cloud SQL for MySQL: Zonal - RAM in Americas	2737.50	us-central1	9662-B51E-5089	49E9-5D00-B8	CP-DB-CUSTOM-1-3.75	0.007	19.1625
Cloud SQL for MySQL: Zonal - Standard storage in Americas	100.00	us-central1	9662-B51E-5089	F0A1-2B08-FA	CP-DB-CUSTOM-1-3.75	0.17	17
Cloud SQL for SQL Server	730.00	Iowa		not yet suppo	CP-CLOUDFORSQLSERVER-JOB		495.223
Pub/Sub - Volume	0.01	us	A1E8-BE35-7EBC	Look up for SK	CP-PUBSUB	1176.666667	11.49088542
ManagedZone	1.00	global	FA26-5236-B8B5	8C22-6FC3-D4	CP-CLOUD-DNS-ZONES	0.2	0.2
DNS Query (port 53)	1.00	global	FA26-5236-B8B5	6DFF-5025-A1	CP-CLOUD-DNS-QUERIES	0.4	4.00E-07
Metric Volume	5.57	global	58CD-E7C3-72CA	A924-09D0-8B	CP-STACKDRIVER-MONITORED-RESOURCES-VOLUME	0	0
Prometheus Samples Ingested	734400.00	global	58CD-E7C3-72CA	A4E4-DF03-CD	CP-STACKDRIVER-METRICS-PROMETHEUS-SAMPLES	0.15	0.11016
Log Volume	10.00	global	5490-F7B7-8DF6	143F-A1B0-E0	CP-STACKDRIVER-LOGS-VOLUME-NEW	0	0
Spans ingested	10.00	global	9B82-7518-9D1C	FFCF-0164-9B	CP-STACKDRIVER-TRACE-SPANS	0	0
Balanced PD Capacity	200.00	us-central1	6F81-5844-456A	6AE1-525F-8B	CP-COMPUTEENGINE-STORAGE-PD-READONLY	0.1	20
Storage PD Capacity	6.16	us-central1	6F81-5844-456A	D973-5D65-BA	CP-COMPUTEENGINE-STORAGE-PD-READONLY	0	0
					Total Price:		**17743.68895**

* 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

- 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?