



**University of
East London**

SCHOOL OF ARCHITECTURE, COMPUTING & ENGINEERING

INDIVIDUAL CW REPORT

on

Vertical Sector – SMART campus

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1 Abstract

The development of digital infrastructure has happened at a devastating rate, but it lags in the goal of smart campus. The major problem was to change the development of infrastructure with the changing technology, to ensure connectivity need it to centralize the information, and lastly, but most importantly to provide a good user interface by developing a smart application. The reason is the absence of a suitable model or framework for effective transition into smart campus. This coursework designs the overall architecture of smart campus based on the cloud infrastructure. The cloud service provider I will be using – AWS (Amazon Web Services). By using cloud services, we can solve the above-mentioned problems by using pay-as-you-go model we ensure the elasticity of the system, it also provides centralized storage and highly secure and with low latency network to provide an enjoyable experience to the student and make their interaction with the application effortless. This will provide the true experience and transformation to the smart campus much easier and faster than before.

2 Introduction

Over the years, after the development of the internet it has become an inclusive part of society. This has caused involvement of Information technology across the diverse fields of industry, economy, and education. It brings the reality of Smart City closer. With the changing environment, education also needs to change. In recent years, particularly in the last decade, major changes have been seen in education which involves adopting media like Mooc, LMS etc., then the usage of Artificial Intelligence, Artificial Reality, Big Data, Cloud and Internet of Things, and recent evaluations in learning patterns and models. This involvement of big data on people's life has evolved the formation of Smart Campus from digital campus. Smart Campus consists of Big Data, IoT (Internet of Things), Cloud Services which comprise of big data sharing and exchange platform, unified identity management and authentication, one-stop personalized integrated management service system, mobile smart campus, and security design.¹

Every university has tried to achieve the SMART campus to provide best educational experience to students, but due to reasons such as CAPEX investment in traditional hardware's, division into departments which leads to decentralized storage of data and less technical experience in developing a truly integrated smart application. In this coursework, I have developed the AWS based cloud architecture for creating an application for unified information access and identity access based on centralized database. This architecture developed by utilizing the requirements of current as well as future needs of the campuses. The various AWS services used involve Simple Storage Service and DynamoDB for storage, Identity and Access Management (IAM) policies for authentication and authorization, VPC and various other services.

¹ Cao, J., Li, Z., Luo, Q., Hao, Q. and Jiang, T. (2018). *Research on the Construction of Smart University Campus Based on Big Data and Cloud Computing*. [online] IEEE Xplore. Available at: <https://ieeexplore.ieee.org/document/8530431> [Accessed 23 Apr. 2022].

3 Project Plan

(22 March 2022-8 May 2022)

7 WEEKS

Phases of Completion	Finish Time	finish/unfinish	Level of completion	Resource Used
Phase 1				
Collecting data about current functioning of various universities (Including University of East London)	Week 1	finish	100%	Source - https://www.uel.ac.uk/study/postgraduate/postgraduate-open-events?gclid=CjwKCAjwx46TBhBhEiwArA_DjDLOe2zj_8vwPa9adPuAmZCpXEtSE-n0-nKZcvWhBcV0-gplGcuq_RoCddsQAvD_BwE
Analyzing the information and figuring out the reason for divergence from ideal Smart Campus.	Week 2	finish	100%	IEEE Website, Uel Website, Harvard Website

FIG 1.1

Phases of Completion	Finish Time	finish/unfinish	Level of completion	Resource Used
Phase 2				
Figuring out the best Cloud service provider and best solution for smart campus	Week 3	finish	100%	IEEE papers, Google scholar, AWS documentation, Tier1 cloud service providers comparison articles
Selecting the most suitable AWS service	Week 4	finish	100%	AWS Documentation
Phase 3				
Figuring out the architecture	Week 5	finish	100%	AWS Documentation
Implementing the solution in AWS Academic lab	Week 6	finish	100%	AWS Documentation
Calculating the cost (TCO and monthly cost)	Week 7	Finish	100%	AWS Documentation

FIG 1.2

3 Requirements Gathering

3.1 Functional Requirements

Functional Requirements	Metric
Main Requirements for SMART Campus	Unification of Database, reduction in CAPEX cost to upgrade hardware, good application interface
Person managing and responsible for operation of the application	College and AWS cloud technicians
Private Information management	Result and personal information of students must be limited to college teachers and principal.
Central Database	Unique database for all sub-sections of the school
Management tasks	Regular update of the database
Real time updating	central location to update the information for all the
Encryption	Full Encrypted
Load Time	In single digit seconds
Recovery	Should be in 1 minute
Data Transfer	In single digit seconds

FIG 2

3.2 Non-Functional Requirements

Non-Functional	Measure
Authenticity	Automatic by Google, and Outlook API
Secured	Highly secured data transfer, authenticity for user and institution and treating of spam activities
Reliability	Exceptionally reliable with guarantee of AWS
Authorization	Different level access for institutions and student
Storage requirements	Managed with current and fully flexible to incorporate future needs
Scalability	Fully balanced to manage heavy traffic at any instance
elasticity	Fully adaptable to change
management	Fully managed to be run during working hours and update during non-working night hours

FIG 3

3.3 Key characteristics (e.g., risk) of the system

- 1.) Decentralized storage
- 2.) Inability to upgrade hardware with changing technology
- 3) Weak application with average user experience

3.4 cloud computing as a solution

3.4.1 Goal

Centralized Storage System, Rapid and Quick advancement and implementation with the change, and diverse and integrated collaboration by real-time processing,

also to frame architecture to reduce Capex and complexity in adaptation of new system

3.4.2 Result

Cloud computing is the unique solution to achieve the above goals.

4 Choice of cloud platform as solution for the problem domain and rationale for choice

4.1 Why Cloud?

1. can store substantial amounts of data at an individual location
2. pay-as-you-go i.e OPEX can try and utilize technologies in real-time
- 3 low latency network means more speed of data transfer and less load time
4. built-in data encryption, security, and upgradation
5. better connectivity with IoT, Big Data technologies with edge computing and large compute and storage

4.2 Why AWS?

After comparing 1 to 3 tiers of cloud service providers, AWS performs better in terms of number of services, reachability, and market capture. With the largest team of technical experts, AWS offers the best security, uptime guarantee and technical support.

5 Choice of data center and standards

5.1 Datacenter

I have selected AWS datacenter because they are present in over 24 regions with 84 availability zones and offer multiple layers of security at distinct levels from Physical Security to data and application layer.

5.2 Standards-

1 PCI-DSS

2 GDPR

3 FIPS 140-2

6 System Architecture

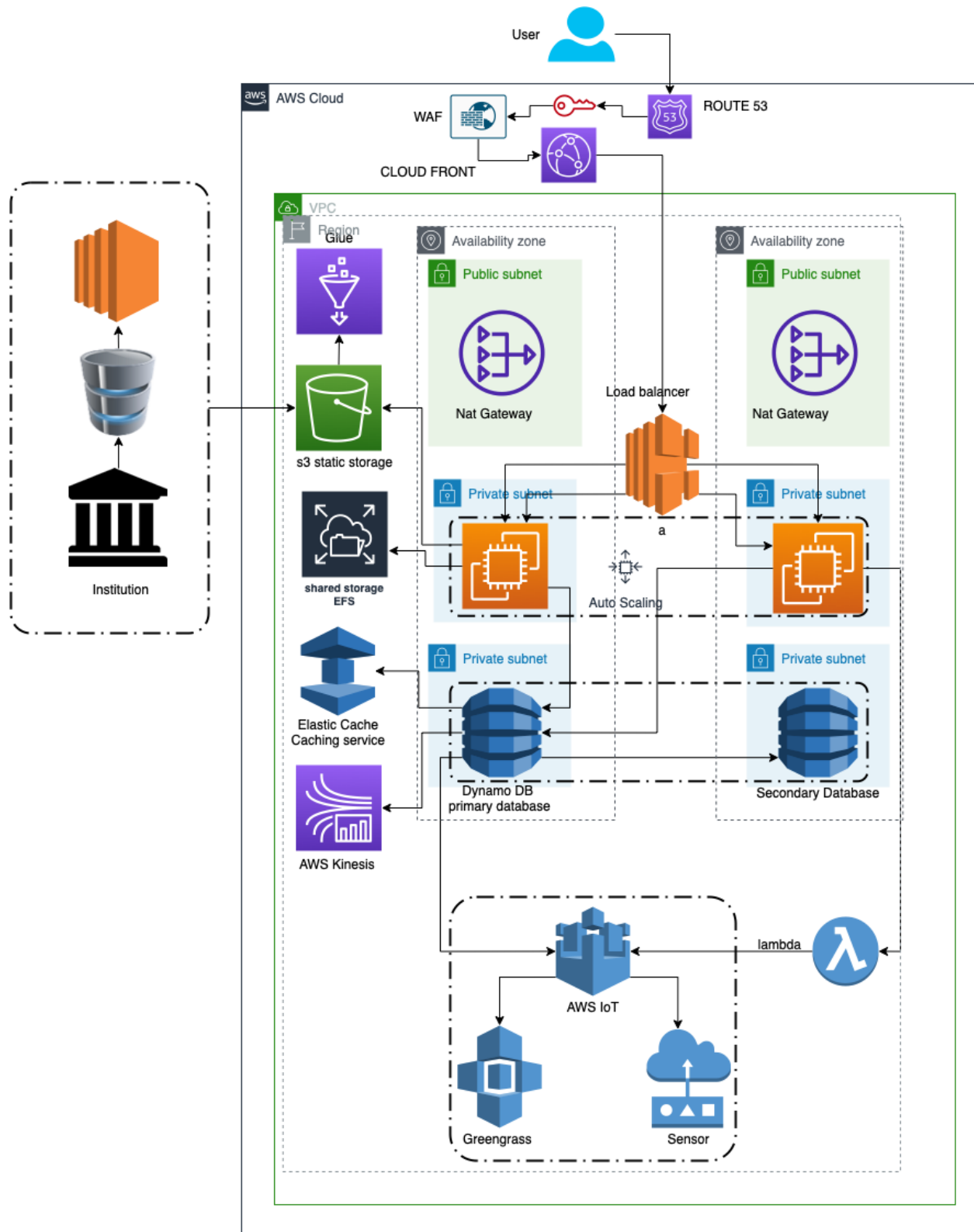


FIG 4

6.1 Description

I have started by considering two users' group one will be students, teachers and other will be institution administrators and higher authorities. Among these main users like students and teachers will get access to the application (EC2 instances) and institution will get access to the storage (S3). To provide secure access to the group one users, we are using Route 53, IAM policies, Web Application Firewall. Next, it will go via Cloud Front, Load Balancer where traffic will be diverted to one of the EC2 instances. EC2 instances are well connected with Dynamo DB, S3 which relates to glue, kinesis and IoT. Other applications connected with EC2 instances are Elastic File Storage, to store and lambda functions to trigger the IoT services as and when required. In IoT services I have selected AWS Green Grass and Sensor which are keen IoT services for our SMART campus architecture. Additionally, there are two public NAT Gateways to provide public internet access to the services.

6.2 AWS VPC

VPC Successfully Created

Your VPC has been successfully created.

You can launch instances into the subnets of your VPC. For more information, see [Launching an Instance into Your Subnet](#).

OK

FIG 5 Virtual Private Cloud, private network to isolate from other public networks.

VPC > Subnets > Create subnet

Create subnet [Info](#)

VPC

VPC ID
Create subnets in this VPC.

vpc-01dce1e09ca02b731 (demo) ▼

Associated VPC CIDRs

IPv4 CIDRs

10.0.0.0/16

Subnet settings
Specify the CIDR blocks and Availability Zone for the subnet.

Subnet 1 of 1

Subnet name
Create a tag with a key of 'Name' and a value that you specify.

public

FIG 6 public subnets – division of IP addresses for access from outside VPC

Associated VPC CIDRs
IPv4 CIDRs
10.0.0.0/16

Subnet settings
Specify the CIDR blocks and Availability Zone for the subnet.
Subnet 1 of 1
Subnet name
Create a tag with a key of 'Name' and a value that you specify.

The name can be up to 256 characters long.
Availability Zone [Info](#)
Choose the zone in which your subnet will reside, or let Amazon choose one for you.

IPv4 CIDR block [Info](#)

Tags - optional

FIG 7 private subnets – division of IP addresses for access from outside VPC

VPC > NAT gateways > Create NAT gateway

Create NAT gateway [Info](#)
A highly available, managed Network Address Translation (NAT) service that instances in private subnets can use to connect to services in other VPCs, on-premises networks, or the internet.

NAT gateway settings
Name - optional
Create a tag with a key of 'Name' and a value that you specify.

The name can be up to 256 characters long.
Subnet
Select a subnet in which to create the NAT gateway.

Connectivity type
Select a connectivity type for the NAT gateway.
☒ Public
☐ Private
Elastic IP allocation ID [Info](#)
Assign an Elastic IP address to the NAT gateway.

FIG 8 NAT gateway (1 for 1 AZ)- (Network Address Translation) for connection outside VPC

VPC > Route tables > Create route table

Create route table [Info](#)

A route table specifies how packets are forwarded between the subnets within your VPC, the internet, and your VPN connection.

Route table settings

Name - *optional*

Create a tag with a key of 'Name' and a value that you specify.

VPC

The VPC to use for this route table.

Tags

A tag is a label that you assign to an AWS resource. Each tag consists of a key and an optional value. You can use tags to search and filter your resources or track your AWS costs.

Key

Value - *optional*

FIG 9 Route Tables – rules for direction of traffic

Inbound rules [Info](#)

Type Info	Protocol Info	Port range Info	Source Info	Description - optional Info
HTTP ▼	TCP	80	Anywh... ▼ 0.0.0.0/0 ✕	<input type="text"/>
<input type="button" value="Delete"/>				
<input type="button" value="Add rule"/>				

Outbound rules [Info](#)

Type Info	Protocol Info	Port range Info	Destination Info	Description - optional Info
All traffic ▼	All	All	Custom ▼ 0.0.0.0/0 ✕	<input type="text"/>
<input type="button" value="Delete"/>				
<input type="button" value="Add rule"/>				

FIG 10 AWS Security group (for controlling the traffic in/out)

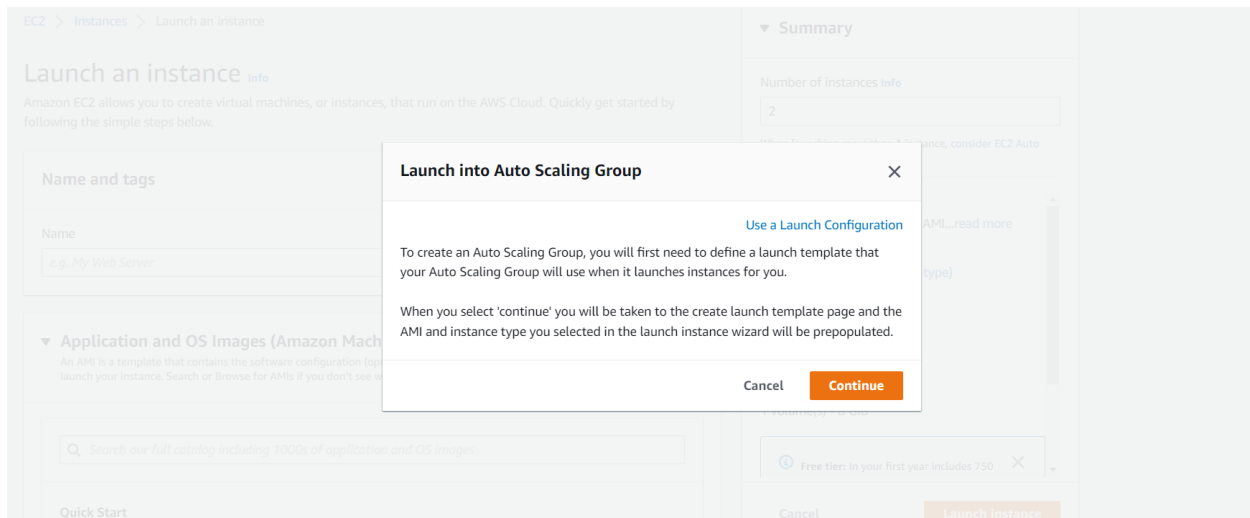


FIG 11 Auto Scaling group for ec2 instance

Instances (2) [Info](#) [Refresh](#) [Connect](#) [Instance state](#) [Actions](#) [Launch instances](#)

<input type="checkbox"/>	Name	Instance ID	Instance state	Instance type	Status check	Alarm status	Availability Zone	Public IPv4
<input type="checkbox"/>	demoprimary	i-027c2955ab3d491ef	Pending	t2.micro	-	No alarms	us-east-1d	ec2-3-91-84
<input type="checkbox"/>	Bastion Host	i-09f9d1532e1f0e874	Running	t2.micro	2/2 checks passed	No alarms	us-east-1a	ec2-52-90-1

Select an instance [Settings](#) [Close](#)

FIG 12 Launched first EC2 instance – primary for computation and application hosting

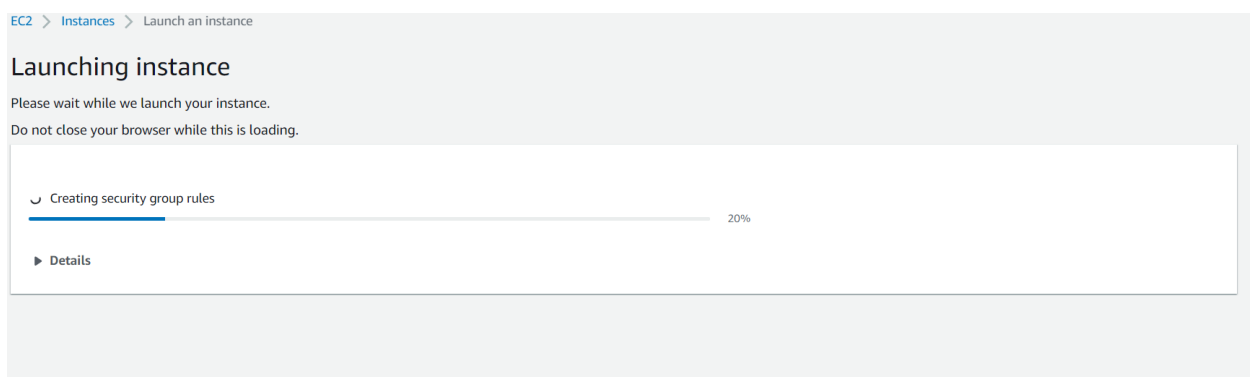


FIG 13 Launching Second EC2 instance – secondary EC2 to support primary

Select load balancer type

A complete feature-by-feature comparison along with detailed highlights is also available. [Learn more](#)

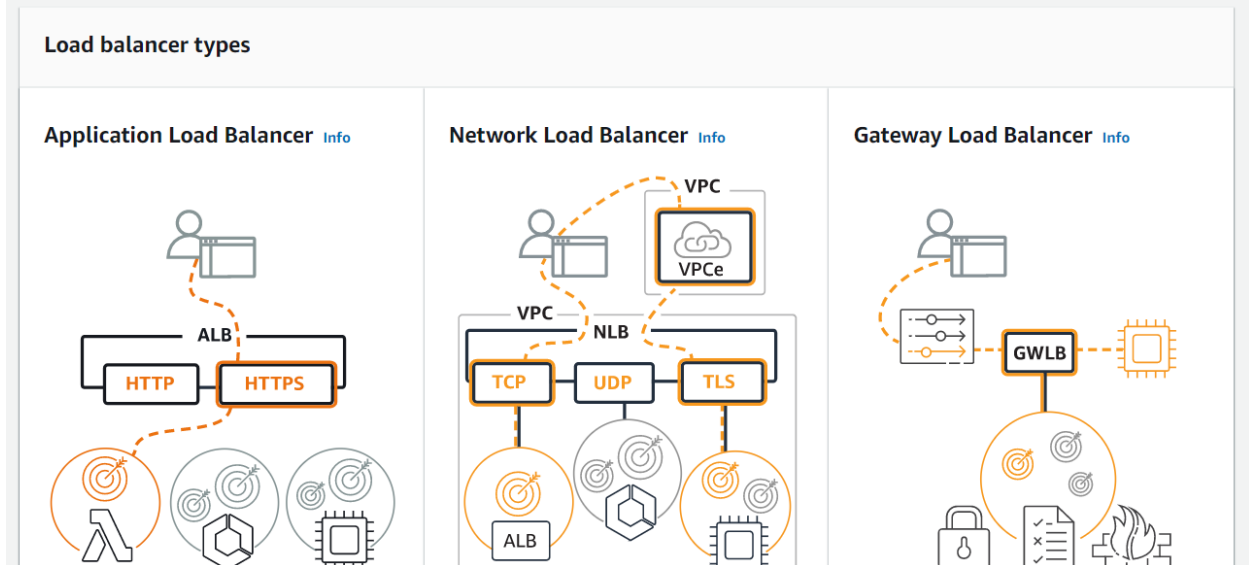


FIG 14 Load Balancer – automatic distribution of traffic across ec2

The new DynamoDB console is now complete, and becomes your default experience
Following the preview phase in which we analyzed and incorporated your feedback, we have completed the new DynamoDB console, making it even easier for you to manage your data and r you think. You can still choose to return to the previous console from the navigation pane.

DAX > Clusters > Create Cluster

Step 1
Choose cluster nodes

Step 2
Configure networks

Step 3
Configure security

Step 4 - optional
Verify advanced settings

Step 5
Review and create

Choose cluster nodes

Cluster name

Cluster name
Provide a meaningful name that uniquely identifies your DAX cluster.

demoprimary

Must be between 1 and 20 characters; begin with a letter; contain only ASCII letters, digits, and hyphens; and not end with a hyphen or contain two consecutive hyphens.

Cluster description - optional

Enter description

Maximum 255 characters.

FIG 15 Launching DB1 – primary Dynamo DB (non-relational database)

Step 4

Configure networks

Step 3

Configure security

Step 4 - optional

Verify advanced settings

Step 5

Review and create

Cluster name

Cluster name

Provide a meaningful name that uniquely identifies your DAX cluster.

demosecondary

Must be between 1 and 20 characters; begin with a letter; contain only ASCII letters, digits, and hyphens; and not end with a hyphen or contain two consecutive hyphens.

Cluster description - optional

Enter description

Maximum 255 characters.

Node families

Choose the type of nodes to run in your clusters. All nodes in each cluster must be of the same type. You cannot modify the node types for a running DAX cluster.

Node type family

☒ All families
Compare all node families.

☐ t-type family
Provides a baseline level of CPU performance with the ability to burst above the baseline when needed. Recommended for use

☐ r-type family
Each node is allocated with fixed resources, for always-ready capacity.

FIG 16 Launching DB2 secondary dynamo DB to support primary DB

AWS Glue Studio > Jobs

Jobs Info

Create job Info

Create

☒ Visual with a source and target
Start with a source, ApplyMapping transform, and target.

☐ Visual with a blank canvas
Author using an interactive visual interface.

☐ Spark script editor
Write or upload your own Spark code.

☐ Python Shell script editor
Write or upload your own Python shell script.

☐ Jupyter Notebook
Write your own code in a Jupyter Notebook for interactive development.

Source

Amazon S3
JSON, CSV, or Parquet files stored in S3.

Target

Amazon S3
S3 bucket by specifying a bucket path as the data target.

FIG 17 AWS Glue (discovering, preparing, and enriching data)

Create bucket [Info](#)

Buckets are containers for data stored in S3. [Learn more](#) [↗](#)

General configuration

Bucket name

fordatacleaningdemosmartcampus

Bucket name must be unique and must not contain spaces or uppercase letters. [See rules for bucket naming](#) [↗](#)

AWS Region

US East (N. Virginia) us-east-1 ▼

Copy settings from existing bucket - *optional*

Only the bucket settings in the following configuration are copied.

[Choose bucket](#)

Object Ownership [Info](#)

FIG 18 S3 bucket (All storing purpose)

Create function [Info](#)

Choose one of the following options to create your function.

Author from scratch



Start with a simple Hello World example.

Use a blueprint



Build a Lambda application from sample code and configuration presets for common use cases.

Container image



Select a container image to deploy for your function.

Browse serverless app repository



Deploy a sample Lambda application from the AWS Serverless Application Repository.

Basic information

Function name

Enter a name that describes the purpose of your function.

workfordemosmartcampus

Use only letters, numbers, hyphens, or underscores with no spaces.

Runtime [Info](#)

Choose the language to use to write your function. Note that the console code editor supports only Node.js, Python, and Ruby.

Python 3.8 ▼

Architecture [Info](#)

FIG 19 Lambda (running code based on EC2 activity)

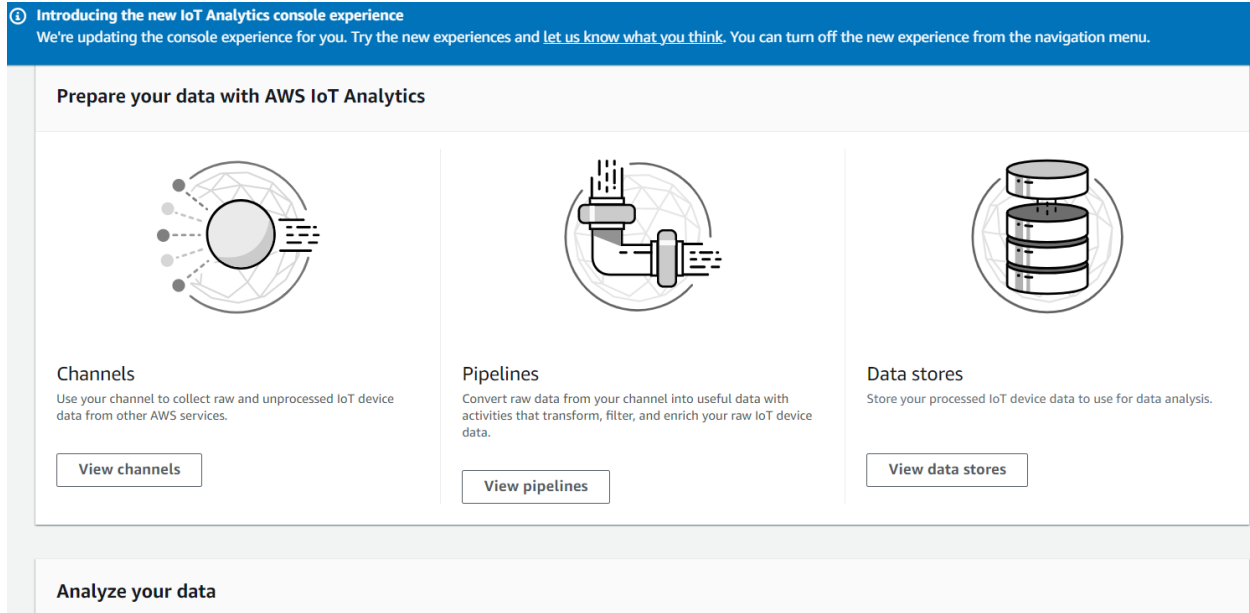


FIG 20 AWS IoT (Each and every task of IoT)

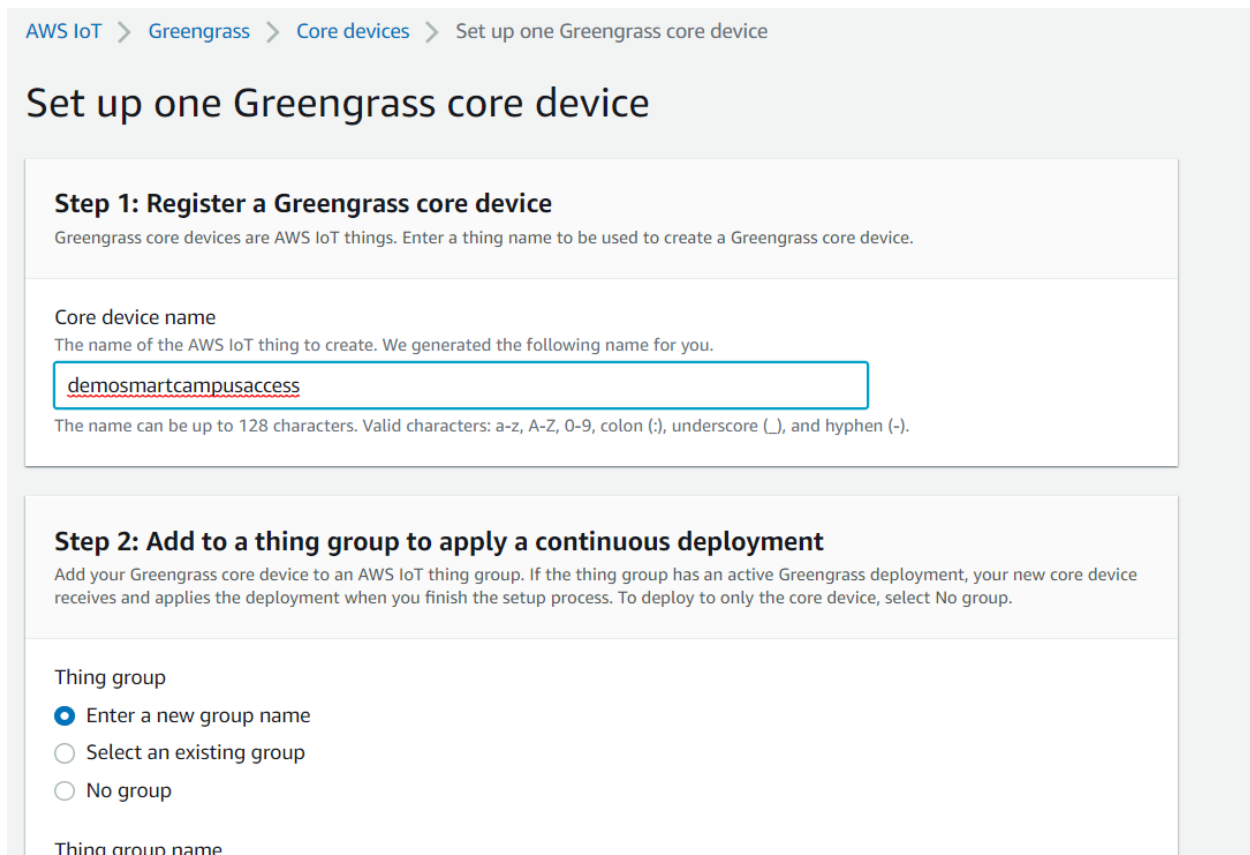


FIG 21 AWS Green grass

Create database [Info](#)

Database configuration

Create and configure a database or create a database with sample data to explore Timestream right away.

Choose a configuration

☒ **Standard database**
Create a new database with custom configuration.

☐ **Sample database**
Create a database and populate it with sample data to get started in a single click.

Name

Specify a name that is unique for all Timestream databases in your AWS account in the current Region. You can not change this name once you create it.

demosenorsmartcampus

Must be between 3 and 256 characters long. Must contain letters, digits, dashes, periods or underscores.

Encryption

All Amazon Timestream data is encrypted by default.

FIG 22 AWS Timestream (for Sensor)

Data stream capacity [Info](#)

Capacity mode

☒ **On-demand**
Use this mode when your data stream's throughput requirements are unpredictable and variable. With on-demand mode, your data stream's capacity scales automatically.

☐ **Provisioned**
Use provisioned mode when you can reliably estimate throughput requirements of your data stream. With provisioned mode, your data stream's capacity is fixed.

Total data stream capacity
By default, data streams with on-demand mode scale throughput automatically to accommodate traffic of up to 200 MiB per second and 200,000 records per second for the write capacity. If traffic exceeds capacity, your data stream will throttle.

Write capacity	Read capacity
Maximum 200 MiB/second and 200,000 records/second	Maximum (per consumer) 400 MiB/second Up to 2 default consumers. Use Enhanced Fan-Out (EFO) for more consumers. EFO supports adding upto 20 consumers, each having a dedicated throughput.

[i](#) On-demand mode has a pay-per-throughput pricing model. See [Kinesis pricing for on-demand mode](#)

Data stream settings

FIG 23 AWS Kinesis (Realtime Analysis of data)

ElastiCache > Memcached clusters > Create

Step 1
Cluster settings

Step 2
Advanced settings

Step 3
Review and create

Cluster settings [Info](#)

Location

Choose whether to host the cluster in the AWS Cloud or on premises.

Location

☒ **AWS Cloud**
Use the AWS Cloud for your ElastiCache instances.

☐ **On premises**
Create your ElastiCache instances on an Outpost (through AWS Outposts). You need to create a subnet ID on an Outpost first.

Cluster info

Use the following options to configure the cluster.

Name

The name is required, can have up to 40 characters, and must begin with a letter. It should not end with a hyphen or contain two consecutive hyphens. Valid characters: A-Z, a-z, 0-9, and - (hyphen).

Description - optional

FIG 24 AWS ElastiCache (for storing cache and support analysis)

Create file system

Create an EFS file system with service recommended settings. [Learn more](#)

Name - optional
Name your file system.

Name must not be longer than 256 characters, and must only contain letters, numbers, and these characters: + - = . _ : /

Virtual Private Cloud (VPC)
Choose the VPC where you want EC2 instances to connect to your file system. [Learn more](#)

demo

Availability and durability
Choose Regional (recommended) to create a file system using regional storage classes. Choose One Zone to create a file system using One Zone storage classes. [Learn more](#)

☒ **Regional** ☐ One Zone

[Cancel](#) [Customize](#) [Create](#)

FIG 25 AWS EFS (Elastic File System)

Step 3

Set rule priority

Step 4

Configure metrics

Step 5

Review and create web ACL

The name must have 1-128 characters. Valid characters: A-Z, a-z, 0-9, - (hyphen), and _ (underscore).

US East (N. Virginia)

US East (Ohio)

US West (N. California)

US West (Oregon)

Asia Pacific (Mumbai)

Asia Pacific (Osaka)

Asia Pacific (Seoul)

Asia Pacific (Singapore)

Asia Pacific (Sydney)

Asia Pacific (Tokyo)

Canada (Central)

Europe (Frankfurt)

US East (N. Virginia)

FIG 26 Web ACL(WAF) Web Application Firewall for additional security

Path pattern

Info

Default (*)

Compress objects automatically

Info

No

Yes

Viewer

Viewer protocol policy

HTTP and HTTPS

Redirect HTTP to HTTPS

HTTPS only

Allowed HTTP methods

GET, HEAD

GET, HEAD, OPTIONS

GET, HEAD, OPTIONS, PUT, POST, PATCH, DELETE

Restrict viewer access

If you restrict viewer access, viewers must use CloudFront signed URLs or signed cookies to access your content.

No

Yes

Cache key and origin requests

FIG 27 CloudFront (for content distribution)

Hosted zone configuration

A hosted zone is a container that holds information about how you want to route traffic for a domain, such as example.com, and its subdomains.

Domain name [Info](#)
This is the name of the domain that you want to route traffic for.

Valid characters: a-z, 0-9, ! " # \$ % & ' () * + , - / : ; < = > ? @ [\] ^ _ ` { | } . ~

Description - optional [Info](#)
This value lets you distinguish hosted zones that have the same name.

The description can have up to 256 characters. 0/256

Type [Info](#)
The type indicates whether you want to route traffic on the internet or in an Amazon VPC.

☒ **Public hosted zone**
A public hosted zone determines how traffic is routed on the internet.

☐ **Private hosted zone**
A private hosted zone determines how traffic is routed within an Amazon VPC.

Tags [Info](#)

FIG 28 Route 53 (for connecting domain name)

Expand all | Collapse all

▼ Select a service Clone Remove

▼ Service close Select a service below Enter service manually

Access Analyzer ?	EventBridge ?	OpsworksCM ?
Alexa for Business ?	EventBridgeSchemas ?	Organizations ?
Amplify UI Builder ?	Firehose ?	Panorama ?
Apache Kafka APIs for MSK ?	Firewall Manager ?	Performance Insights ?
App Mesh Preview ?	Forecast ?	Personalize ?
App Runner ?	Fraud Detector ?	Price List ?
AppIntegrations ?	FreeRTOS ?	Private Marketplace ?
Application Cost Profiler ?	GameSparks ?	Profile ?
Application Discovery ?	Glacier ?	Proton ?
Application Discovery Arsenal ?	GlobalAccelerator ?	Purchase Orders ?

FIG 29 IAM Policies (authorization and authentication)

7 Analysis and Reflection

7.1 AWS Monthly cost

☒ **FREE TIER:** New Customers get free usage tier for first 12 months

Services Estimate of your Monthly Bill (\$ 3070.21)

Choose region: **US East (N. Virginia)** Inbound Data Transfer is Free and Outbound Data Transfer is 1 GB free per region per month

Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers. Amazon Elastic Block Store (EBS) provides persistent storage to Amazon EC2 instances.

Newer versions of the EC2 calculators are available: [Amazon EC2](#), [EC2 Dedicated Host](#), [Elastic Graphics](#), [Elastic IP](#)

Compute: Amazon EC2 Instances:

Description	Instances	Usage	Type	Billing Option	Monthly Cost
<input type="text"/>	2	100 % Utilized/Month	Linux on t3.xlarge	On-Demand (No Cores Reserved)	\$ 487.22
Add New Row					

Compute: Amazon EC2 Dedicated Hosts:

Description	Number of Hosts	Usage	Type	Billing Option
<input type="text"/>	0	100 % Utilized/Month	i3	On-Demand
Add New Row				

Storage: Amazon EBS Volumes:

Description	Volumes	Volume Type	Storage	IOPS	Baseline Throughput	Snapshot Storage
<input type="text"/>	2	General Purpose SSD (gp2)	1 GB	50	128 MBs/sec	0 GB-month of Storage
Add New Row						

FIG 30

- cost for operating essential services for running - 3070.21\$
- equivalent to 2494.50-pound approximately 2500pound (including price conversion rate).

7.2 Analysis and Reflection

AWS graviton application, which makes launching vast range of services on mouse click makes it my first choice. These services are highly advanced and expandable for future needs. As a result, the architecture I designed comes out to be perfect and priced. Thus, it can be used to fulfill SMART Campus needs.

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